[The Effects of an Educational Self-Efficacy Intervention on Osteoporosis Prevention and Diabetes Self-Management Among Adults With Type 2 Diabetes Mellitus]

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Abstract:

Background: Prevalence of osteoporosis (OP) is high among Chinese adults with diabetes. Assessment of OP and fracture risk as well as patient education should be included as part of the management of diabetes.

Purpose: The purpose of this pilot study was to test the effectiveness of an educational self-efficacy intervention on knowledge about OP, dietary calcium intake, the importance of physical activity (PA), and glycemic control among Chinese adults with type 2 diabetes residing in Wuhan, China.

Method: A quasi-experimental design with repeated measures was employed. Participants were assigned to either the intervention ($n = 23$) or the control group ($n = 23$). Intervention participants attended 6 weekly 1-hr educational sessions comprising presentations, demonstration, and discussions. Control participants received standard care. Data were collected via questionnaires at pre- and postintervention and at 3-month follow-up, and blood was drawn at preintervention and 3-month follow-up.

Results: Participants in the intervention group had significant improvement in OP knowledge, $F(2, 43) = 11.504$, $p < .001$; OP self-efficacy, $F(2, 43) = 6.915$, $p = .003$; dietary calcium intake, $F(2, 43) = 7.856$, $p = .002$; level of PA, $F(2, 43) = 4.787$, $p = .011$; diabetes self-care activities, $F(2, 43) = 14.009$, $p < .001$; diabetes self-efficacy,$F(2, 43) = 19.722$, $p < .001$; and glycemic control (A1C level; $t = 2.809$, $p = .010$) compared to the control group at the 3-month follow-up.

Conclusion: The results demonstrate the effectiveness of OP prevention education based on self-efficacy theory among Chinese adults with type 2 diabetes.

Keywords: osteoporosis | type 2 diabetes | self-efficacy | diabetes self-management

Article:

Osteoporosis (OP), a disorder of bone metabolism, increases the risk of fracture. People with type 2 diabetes mellitus (T2DM) have a high risk of secondary OP because abnormalities in the metabolism of sugar, protein, and fat may lead to abnormalities in the metabolism of salt, water, and electrolytes as well bone metabolism and formation (Brown & Sharpless, 2004; Chau, Goldstein-Fuchs, & Edelman, 2003; G. Y. Li, 2010; Yamaguchi, 2010). Gregorio, Cristallini, Santeusanio, Filipponi, and Fumelli (1994) reported that both osteoblast levels and bone mineral content (BMC) were decreased in patients with T2DM. Furthermore, research has shown that patients with poorer glycemic control experience greater bone loss than those whose diabetes is under control (Chau et al., 2003; Xu, Cheng, Liu, Shan, & Gao, 2007). According to Gregorio et al., the loss of BMC and the calcium deficit are more severe in patients with poor diabetes control due to the renal calcium leak caused by glucosuric-induced osmotic diuresis. There is also growing evidence that people with T2DM are at increased risk of osteoporotic fracture, not only because of microarchitectural bone qualities but also because of changes in bone geometry related to diabetes (Brown & Sharpless, 2004; Chau et al., 2003; Yamaguchi & Sugimoto, 2011). Studies have shown that patients with diabetes mellitus have longer hospital stays, more costly treatment, and higher risk of infection and mortality from OP-related fractures than do patients without diabetes (Dellenbaugh, DiPreta, & Uhl, 2011; Ganesh et al., 2005).

China has the second largest population with T2DM in the world, and the number is expected to increase from 20.8 million in 2000 to 42.3 million in 2030 (Wild, Roglic, Green, Sicree, & King, 2004). Research has demonstrated that, as is the case more generally, adults with T2DM in China have a higher risk of OP and fracture than do those without diabetes (Xu et al., 2007; Y. Zhou, Li, Zhang, Wang, & Yang, 2010). In a recent study, nearly 30% of Chinese males with T2DM had signs of OP or osteopenia (Xu et al., 2007). Also, Y. Zhou, Li, Zhang,Wang, and Yang, (2010) found that Chinese women with T2DM were especially vulnerable to OP because of impaired bone formation, particularly during menopause. According to the International Osteoporosis Foundation (IOF; 2012b), OP causes approximately 687,000 hip fractures in China each year, with a high incidence of morbidity and mortality. After modification for the risk factors of smoking, body mass index (BMI), calcium and soybean intake, physical activity (PA), and self-reported history of stroke, the hip fracture risk was almost 2-fold higher among Chinese people with diabetes than among those without (Koh et al., 2010). The financial cost of OP-related fractures in China is high. According to the IOF (2009), the cost for OPrelated fractures in mainland China was 1.5 billion USD in 2006 and is expected to rise to 12.5 billion and 264.7 billion USD by 2020 and 2050, respectively.

As a result of their prospective cohort study of 63,257 Chinese individuals in Singapore, Koh et al. (2010) recommend that education about and assessment of OP and fracture risk be part of the management of diabetes. The National Institutes of Health (NIH, 2012) reports that the strategies for OP prevention and treatment are the same among people with and without diabetes. However, along with the supplementing of calcium and vitamin D intake (Montagnani, Gonnelli, Alessandri, & Nuti, 2011) and increase in PA (Vestergaard, 2011) that are important for all patients at risk for OP, patients with diabetes must also include glycemic control as a primary strategy for prevention and control of OP. Investigators have conducted studies involving interventions to promote OP knowledge and healthy behaviors among Chinese women during menopause (W. H. Li, Yang, & Zhou, 2009) and among older adult Chinese immigrants (Qi, Resnick, Smeltzer, & Bausell, 2011). However, little attention has been paid to enhancing knowledge and lifestyle modification for OP prevention among Chinese adults with T2DM. In this pilot study, we tested an educational program to prevent OP by improving OP knowledge, calcium-rich food consumption, regular exercise, and glycemic control among adults with T2DM based on the self-efficacy theory.

Theoretical Framework

Self-efficacy theory (Bandura, 1994), a central part of social cognitive theory (Bandura, 1977), suggests that an individual’s behaviors are determined by self-efficacy or a judgment of their own capabilities to change their actions. Self-efficacy theory postulates that efficacy expectations are the fundamental determinants for people’s ability to modify behaviors (Bandura, 1977). There are four primary means by which individuals can increase self-efficacy: personal accomplishment, verbal persuasion, vicarious experience, and physiological or affective states.

A growing body of research has identified self-efficacy as a predictor of health behavior Research in the areas of physical exercise and dietary behavior has found positive correlations between self-efficacy and PA and balanced healthy diet. For example, in a study of PA measured objectively by a motion detector, authors concluded that rigorous PA increased 12.6 min per day after self-efficacy improved (Strauss, Rodzilsky, Burack, & Colin, 2001). In another study, researchers found that self-efficacy- enhanced healthy dietary behaviors among Chinese Americans (Doreen, 2004). S. F.Wu and colleagues (2011) found a positive association between self-efficacy and healthy diabetes self-management. In an earlier survey of 145 Chinese patients with T2DM, S. F. Wu et al. (2006) found a positive correlation between self-care behavior and efficacy expectations. Finally, Shi, Ostwald, and Wang (2010) conducted a 1-month long hospital-based clinical intervention among Chinese patients with T2DMand found that a self-efficacy program improved their diabetes self-efficacy and self-care behaviors.

Research has demonstrated that bone formation and strength can be enhanced by PA (Dai, 2005) and calcium intake (Liu, Qiu, Chen, & Su, 2011). A number of surveys have shown, however, that Chinese people lack both sufficient knowledge and self-efficacy regarding OP and, consequently, have little motivation to make lifestyle changes related to bone health (Chen et al., 2004; Guo, Zhou, Yang, & Gao, 2005; Lee & Lai, 2005; X. Wu, Zhang, Geng, Wang, & Zhang, 2009; Yang, 2011). This deficit is likely particularly pointed among adults with diabetes since most health education programs for these patients are limited to diabetes control and self-care practices (Shi, Ostwald, & Wang, 2010; S. F. Wu et al., 2011). A higher level of education has been directly correlated with lower prevalence of OP (Ho, Chen, &Woo, 2005). Y. Q. Zhang (2002) recommended that health education should be considered a fundamental strategy to prevent OP for the Chinese population.

The intervention we conducted in the present study aimed to address this gap in education and self-efficacy by providing an educational program on OP and diabetes self-management based on the four sources of self-efficacy. We fostered participants' sense of personal accomplishment by encouraging individual successes in the mastery of progressive goals. We used verbal persuasion by demonstrating calcium-rich recipes and bone-strengthening exercises that were appropriate for individuals with diabetes as well as leading brainstorming sessions on these topics in group discussions. We used role modeling to strengthen participants' vicarious experiences, a powerful teaching method (Cruess, Creuss, & Sterniert, 2008). Finally, we reinforced physiological and affective states through safeguards related to PA, individualized plans family, and social supports. Figure 1 depicts the study framework.

We tested the following hypotheses: (1) Adults with type 2 diabetes who received a 6-week educational self-efficacy intervention would have higher scores on (a) OP knowledge, (b) OP self-efficacy, (c) diabetes self-care practice, (d) diabetes management self-efficacy, (e) calcium consumption, and (f) PA than adults with type 2 diabetes who did not receive the intervention (control group) at posttest and the 3-month follow-up and (2) Adults with type 2 diabetes who received the 6-week intervention would have lower A1C levels, indicating greater glycemic control at the 3-month follow-up compared to controls.

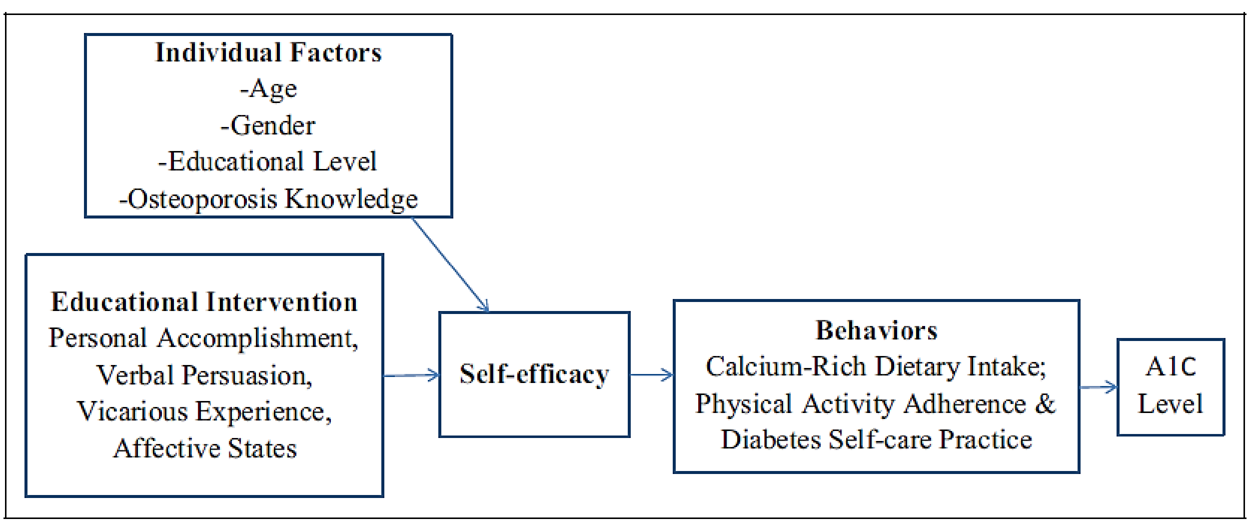

Figure 1. Conceptual framework. An educational intervention on diabetes self-management and osteoporosis prevention was administered to individuals with diabetes to increase self-efficacy

and positively impact health behaviors and, as a result, glycemic control. A1C = measure of glycemic control.

Materials and Method

Design, Sample, and Setting

We used a quasi-experimental (nonrandomized) two-group design with repeated measures and collected data pre- and post-intervention and at the 3-month follow-up.

We invited adults with type 2 diabetes who resided in the Wu Chang district in Wuhan, China, to participate in the study. Wuhan has a population of approximately 9.8 million, and its residential areas are divided into three major districts. We conducted the study in the Zhonghua Road area of the Wu Chang district, which comprises approximately 400–450 households in each of its seven communities. Most residents live with their spouse and/or children in apartments. The Zhonghua Road community health center has a large meeting room for health education and health promotion activities.

We utilized convenience sampling to enroll participants, posting flyers describing the study in both the Zhonghua Road health center and each community residential complex. The researcher, medical staff working in the health center, and the complex administrators also informed clients of the study. Enrollment began 3 weeks before the start of the intervention in 2012. Inclusion criteria were (1) having received a diagnosis of T2DM more than 1 year prior to enrollment; (2) aged 50 or older; (3) ability to communicate in Chinese; and (4) at risk of OP as measured by the new IOF's 1-min OP risk tool. Residents were excluded from the study if they self-reported diabetes complications of visual impairment, a deep wound on their foot, or severe cardiac or renal problems. People who indicated a willingness to participate in the study and who met the inclusion criteria, as determined by study personnel, were asked to sign an informed consent form. Group assignment was based on the neighborhood which participants resided. We performed a power analysis to calculate the sample size necessary to ensure statistical power adequate to detect a medium effect size. Our assumption of a medium effect size was based on a review of previously published studies (e.g., Tung & Lee, 2006). We found that an effect size of .35, a significance level of .05, and a sample size of 46 provided 80% power to detect differences between the intervention group and the control group (GPower, version 3.1). Given an expected attrition rate of 10%, we enrolled 50 participants ($n = 25$ in both the intervention and the control groups) in the study. The ethics committee of Wu Han University in China and the Zhonghua Road Health Center approved all study procedures.

Study personnel contacted 79 residents who met the inclusion criteria, and 50 of these agreed to participate and signed the consent form. The total retention rates at posttest and 3-month follow-up were 94% and 92%, respectively, with two participants in the intervention group withdrawing without specifying the reason at posttest and two withdrawing from the control group, one whom we were unable to contact at posttest, and one who had moved away from Wuhan by the 3-month follow-up (Figure 2).

Intervention

Participants in the intervention group received a 6-week educational intervention on diabetes self-management and OP prevention knowledge based on self-efficacy theory. The weekly 1-hr group sessions comprising presentations, demonstrations, and discussions were delivered at the health center by the first author, who is a nurse with years of clinical experience with chronic diseases. We developed an educational booklet based on the Guidelines for Diagnosis, Prevention, and Treatment of OP in Asia (Lau et al., 2006), World Health Organization's (WHO, 2004) Global Strategy on Diet, Physical Activity, and Health: Diet and Physical Activity and the China Guidelines for Type 2 Diabetes (Committee for Prevention and Treatment of Type 2 Diabetes in China, 2010) for use in class and for distribution to participants. As a retention strategy, the first author made biweekly phone calls to participants in the intervention group during the 3-month study period, so that each participant received a total of six phone calls. The calls lasted an average of 15 min and primarily involved answering participants' questions and reinforcing the educational content of the intervention.

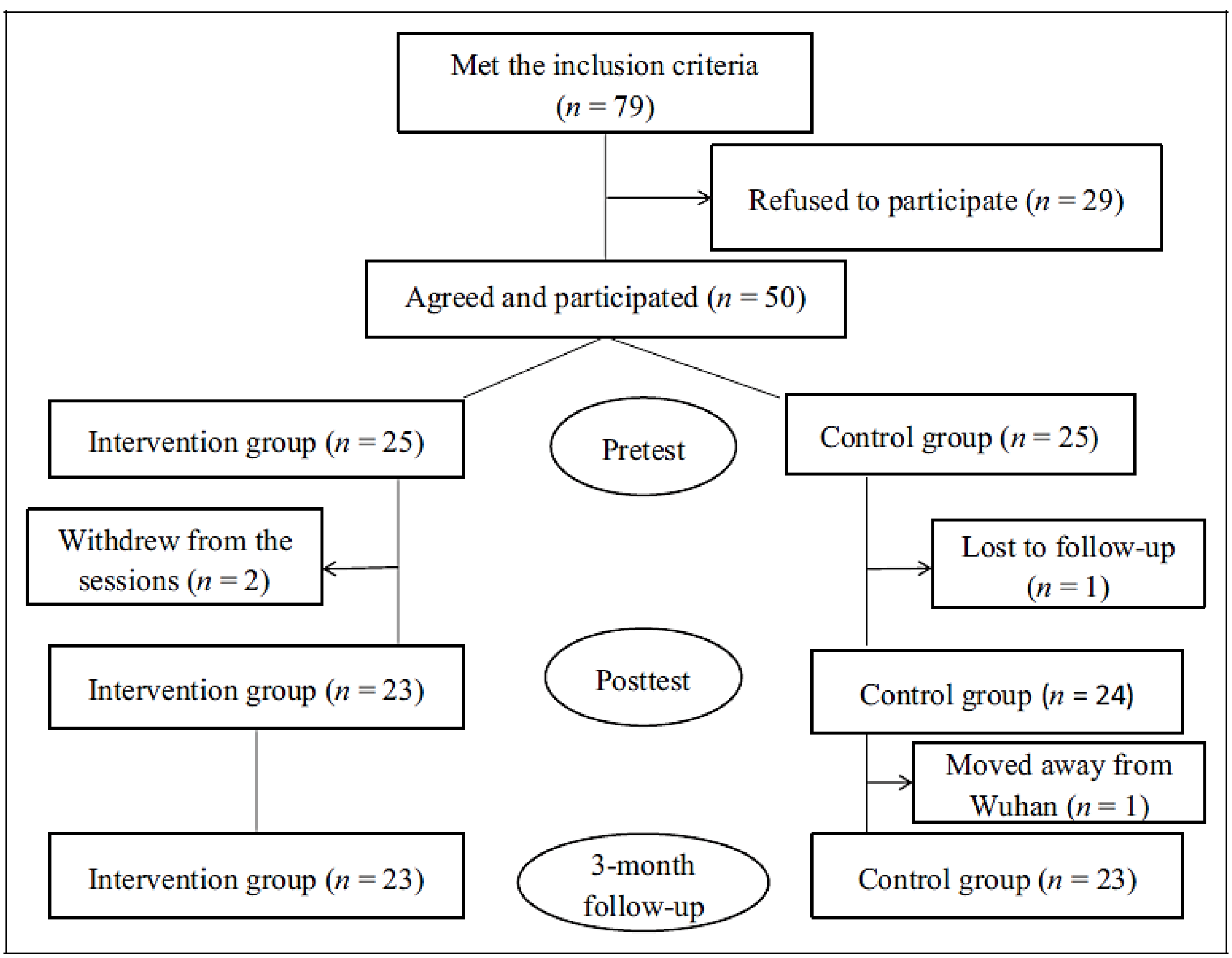

Figure 2. Participant recruitment and retention and data collection. We made arrangements for participants to make up any missed sessions at a time convenient to them. Table 1 provides descriptions of how we integrated the four sources of self-efficacy into the educational intervention.

The control group received standard care during the study period. After the 3-month follow-up, we provided control participants with a 1-hr presentation and booklets and pamphlets on OP knowledge and diabetes self-management. We also provided them with the first author's telephone number, so that control participants could follow up with any questions they might have.

Measures

Demographic Questionnaire. We administered a demographic questionnaire at pretest only. Data collected included participants' age, gender, BMI, educational level, household income, marital status, health insurance, family history of fracture, use of calcium and vitamin D supplements, duration of diabetes diagnosis, use of antidiabetic medications, and diabetes-related health problems. We obtained BMI by measuring weight with a scale and height with a wall tape measure and dividing weight (measured in kilograms) by the square of height (measured in meters; NIH, 1998). We used previously established definitions for Chinese people to determine BMI categories, with BMI < 18.5 kg/m2 indicating underweight, 24–27.9 kg/m2 indicating overweight, and ≥28 kg/m2 indicating obesity (WHO Western Pacific Region, the International Association for the Study of Obesity, and the International Obesity Task Force, 2000; B. Zhou & the Cooperative Meta-AnalysisWorking Group on Obesity in China, 2002). We collected BMI data because previous studies have verified positive correlations between BMI and uncontrolled glycemic levels in individuals with type 2 diabetes (Mendez, Covas, Marrugat, Vila, & Schröder, 2009; Y. Wang, Shi, & Dai, 2004) and inverse correlations between BMI and the risk of OP (IOF, 2012c).

The New One-Minute Osteoporosis Risk Test, Chinese Version. We used the IOF's (2012a) new One-Minute Osteoporosis Risk Test to screen potential participants for OP risk. The new test, which includes 19 questions (15 general, 3 for women, and 1 for men), was adapted from the original version, which included 10 questions (7 general, 2 for women, and 1 for men). Any positive answer indicates that an adult has a risk factor that may lead to OP and fractures. High scores indicate a high risk for OP. The most reliable and informative of the questions are (1) Have either of your parents been diagnosed with OP or broken a bone after a minor fall? (2) Have you broken a bone after a minor bump or fall? (3) Have you ever taken corticosteroid tablets for more than 3 consecutive months? and (4) Have you lost more than 3 cm in height? Povoroznyuk and Dzerovych (2008) tested the validity of the original tool among postmenopausal women and found a significant correlation between the answer to Question 1 and bone mineral density (BMD) of the femoral neck ($r = -.27$; $p = .025$), between the answer to Question 2 and BMD of the spine ($r = -.29$; $p = .012$), between the answer to Question 3 and

BMD of the femoral neck ($r = -.32$; $p = .005$), and between the answer to Question 4 and BMD of the spine ($r = .29$; $p = .047$). Application of the IOF new One-Minute Osteoporosis Risk Test helped determine the structural–functional changes in bone.

Table 1. Self-Efficacy Educational Intervention Modules.

Informational Source of Self-Efficacy	Intervention Strategies	Teaching Methods
Performance accomplishment	1. Progressive goal setting for physical activity, consumption of calcium-rich food, and diabetes self-management; 2. Documentation of the goals and health care guidance based on participants' physical status, glycemic control, calcium consumption, previous physical activity, and preferences; 3. Strategizing about meal planning, foot care, regular activity, weight control, administration of insulin or oral medications, and self-monitoring of blood glucose; 4. Discussion of the benefits of sun exposure; 5. Instruction about physical activities, especially weight-bearing activities; 6. Sharing tactics for increasing exercise fitness	1. Progressive goal setting; 2. Record diet and physical activity log; 3. Demonstrations of exercise safety; 4. Review previous content; 5. Answer participants' questions; 6. Self-monitoring of blood sugar
Verbal persuasion	1. PowerPoint presentations about diabetes self-care, osteoporosis prevention, physical activity, and a calcium-rich diabetic diet; 2. Discussion of osteoporosis, recommendations regarding healthy lifestyles, and diabetes control; 3. Discussion of benefits of and barriers to glycemic control, physical activity, and calcium consumption; 4. Positive reinforcement in	1. Provide in-class presentations; 2. Include humor; 3. Promote discussion; 4. Questions and answers; 5. Review previous content; 6. Use repetition of important topics and be aware of pacing; 7. Feedback from participants on sessions; 8. Provide positive reinforcement

	response to participants' concerns; 5. One-on-one instruction; 6. Demonstration of calcium and energy content in different food products; 7. Instruction about nutrition labels on different brands of milk; 8. Provided researcher's cell phone number so that participants could call with questions between sessions	
Vicarious experience/role modeling	1. Teaching of balance/stability-enhancing postures and activities; 2. Share stories of successful experiences of better glycemic control, regular physical activity, and calcium-rich food consumption among participants; 3. Share stories about fractures among participants	1. Role play; 2. Provide successful examples; 3. Peer modeling; 4. Encouragement
Physiological/affective states	1. Discuss positive physiological and psychological responses to glycemic control, physical activity, and a calcium-rich diet; 2. Utilize the pamphlet Exercise and Osteoporosis (National Osteoporosis Society, n.d.) and provide exercise safety tips for home use; 3. Encourage support from family members or significant others	1. Use ice-breaking exercises; 2. Assess each participant's physical and affective status at baseline; 3. Make use of body language and eye contact; 4. Exhibit empathy and caring; 5. Incorporate problem-solving activities; 6. Promote discussion

Osteoporosis Knowledge Test (OKT), Chinese Version. We used the OKT, revised by Chen, Liu, and Cai (2005) from the original English version (Kim, Horan, & Gendler, 1991), to measure knowledge of OP at pre- and posttest and 3-month follow-up, particularly regarding preventive strategies related to calcium and exercise. The 26-item test includes calcium (Items 12–18) and exercise (Items 19–26) subscales as well as items focusing more generally on overall OP risk factors (Items 1–11). The respondent rates each item as ML = more likely, LL= less likely, NT = neutral, and DK = don't know. For Items 1–11, the responses neutral and don't know are considered incorrect. For Items 12–26, don't know is considered incorrect. Total score ranges from 0 to 26, with higher scores indicating greater knowledge of OP. Scores for the exercise subscale range from 0 to 7, and scores for the calcium subscale from 0 to 8. An example of a question in the exercise subscale is “How many days a week do you think a person should exercise to strengthen the bones?” One of the questions addressing knowledge of calcium intake is “How much milk must an adult drink to meet the recommended amount of calcium?” Cronbach’s α of the OKT total, exercise, and calcium subscales were .87, .84, and .83, respectively. In the present study, Cronbach’s αs of the OKT total, exercise, and calcium subscales were .84, .77, and .78, respectively.

Osteoporosis Self-Efficacy Scale, Chinese Version (OSES). We used the OSES, revised by Chen and Liu (2005) from the original English version (Horan, Kim, Gendler, Froman, & Patel, 1998), to measure self-efficacy for exercise and for consumption of calcium-rich food at pre- and posttest and 3-month follow-up. The 12-item survey consists of two subscales of 6 items each, an OP self-efficacy exercise scale and an OP self-efficacy calcium scale. Respondents rate each item on an 11-point bipolar scale, with 10 indicating extreme confidence and 0 indicating no confidence at all. Items related to self-efficacy for exercise address such issues as, for example, confidence in changing exercise habits. Similarly, items related to self-efficacy for calcium consumption address issues such as confidence in increasing calcium intake. Cronbach’s α of the OSES total, self-efficacy for exercise, and self-efficacy for calcium rich food consumption subscales were .93, .90, and .94, respectively (Chen & Liu, 2005). In the present study, Cronbach’s α of the OSES total, self-efficacy for exercise, and self-efficacy for rich calcium food subscales were .88, .75, and .75, respectively.

Summary of Diabetes Self-Care Activities, Chinese Version (SDSCA). The SDSCA, revised by Q. Q. Wang, Shang, Lai, and Pan (2008) from the original English version (Toobert, Hampson, & Glasgow, 2000), is a self-report measure of the frequency of completing different activities over the preceding 7 days, which we administered at pre- and posttest and 3-month follow-up. The instrument’s 11 items focus on regular diet, diabetic diet, exercise, monitoring of blood sugar, foot care, and insulin. Respondents rate each item from 0 to 7 based on the number of days on which he or she performed that activity, with higher scores indicating better self-management. An example of an item is “[On] how many of the last SEVEN DAYS have you followed a healthy eating plan?” Cronbach’s α of the SDSCA was .62, and test–retest reliability coefficient was .83 (Q. Q. Wang, Shang, Lai, & Pan, 2008). In the present study, the Cronbach’s α coefficient of SDSCA was .86.

Chinese Version of the Diabetes Management Self-Efficacy Scale (C-DMSES). We used the C-DMSES, revised by S. F. Wu et al. (2006) from the English version (McDowell, Courtney, Edwards, & Shortridge-Baggett, 2005), to measure diabetes self-management self-efficacy at pre- and posttest and 3-month follow-up. This self-administered scale comprises 20 items and assesses the extent to which respondents are confident that they can manage their blood sugar, diet, and exercise. Items are summed to give a total score ranging from 0 to 200, with higher scores representing more confidence. The C-DMSES has an average content validity index score of .86 (S. F. Wu et al., 2006). Cronbach's α for all items on the C-DMSES is .93. The Cronbach's α in the present study was .90.

The Chinese Food Frequency Questionnaire (FFQ). The FFQ (Y. Li, 2005) has been used to measure dietary calcium intake in mainland China. Participants in the present study completed the questionnaire at pre- and posttest and 3-month follow-up. The FFQ contains 71 items consisting of a question and four possible answers that assess consumption of calcium-rich food during the past 3 months. An example of one of the items is "Over the past 3 months, how often did you drink soy milk? How much did you drink each time?" Responses are coded and reported in the form of calcium content in foods, using a food composition database provided by the Chinese Food Nutrition Network (2010). Validity was tested by comparing the results of the FFQ and 24-hr recall (Y. Li, 2005). Pearson's correlation coefficients and intraclass correlation coefficients were .68 and .67 for calcium, and .69 for square-root-transformed data, suggesting good agreement between the FFQ and 24-hr recall. Validity was further tested by comparing the results regarding calcium of an initial in-person administration of the FFQ and a later repeated in-person administration of the test. Good concordance was found both in absolute intake values and subject rankings, with intraclass correlation coefficient values of rraw = .79, rtransformed = .78, $p < .001$. The reliability coefficient (α) of the FFQ in the present study was .82.

*The Chinese Version of the International Physical Activity Questionnaire, Long Form(IPAQ-LC).*We used the Chinese version of the IPAQ-LC (IPAQ, 2002), which was originally developed by the International Consensus Group in 1998. The instrument is a selfreport PA questionnaire with 27 questions, such as, for example, "How much time do you usually spend in one day doing vigorous physical activities in the garden or yard?" The metabolic equivalent of tasks (MET) is used to calculate activity level, with 1 hr of light, moderate, or vigorous exercise equivalent to 3.3 MET, 4 MET, or 8 MET, respectively. Participants in the present study completed the IPAQ-LC at pre- and posttest and 3-month follow-up. The instrument had good test–retest reliability for group activities, with intraclass correlation coefficients ranging from .74 to .97 for vigorous, moderate, walking exercise and total PA and small between-test effect sizes (<.49; Macfariane, Chan, & Cerin, 2010). Spearman correlation coefficients were significant for vigorous PA ($r = .28$), moderate + walking PA ($r = .27$), and overall PA ($r = .35$), when compared with accelerometry-based criterion measures. The IPAQ-LC thus demonstrated adequate reliability and showed sufficient evidence of validity in assessing overall levels of habitual PA to be used among Chinese adults. The Cronbach's α coefficient of IPAQLC in the present study was .83.

Hemoglobin A1C. A1C is a measure of weighted average blood glucose level over the preceding 2–3 months (Lebovitz, 1998). Laboratory staff at the Zhonghua Road community health center collected 2-ml venous blood specimens from participants at pretest and 3-month follow-up. The Wuhan Labway Laboratory performed the A1C analysis.

Data Analysis

Baseline demographic characteristics of age, gender, BMI, education level, household income, marital status, health insurance, family history of fracture, calcium and vitamin D supplementation, and duration of diabetes diagnosis were described using frequency, means, constituent ratios, and standard deviations (SDs). Independent sample t-tests for continuous variables and chi-square tests for categorical variables were used to examine differences between the two groups in demographic characteristics and major study variables at baseline. Repeated measures analysis of variance was used to assess differences between the groups in OP knowledge, diabetes self-care, self-efficacy for exercise, calcium consumption, PA, and calcium-rich diet pre- and post-intervention and at 3-month follow-up. A paired t-test was used to examine differences in A1C between pre-intervention and 3-month follow-up within groups. A two-sided p value $< .05$ was considered statistically significant.

Results

Scores on the One-Minute Osteoporosis Risk Test ranged from 1 to 7 with a mean of 3.26 (SD 1.426). All participants had at least one risk factor for OP. The mean age of the participants was 69 (SD 7.5) with a range of 50–82 years. The mean BMI for all participants was 24.2 (SD 3.1) kg/m2; for females it was 23.7 (SD 3.0) kg/m2 and for males, 24.9 (SD 3.1) kg/m2. The majority of participants were female (60%), married (74%), with a middle school education or less (60%), had health insurance (88%), and no family history of fractures (92%) and took no calcium or vitamin D supplements (86%). Approximately 44% of participants reported household incomes below 2,000 RMB/month in Chinese currency (US$340/month). The average duration of diabetes was 8.56 (SD 5.68) years, and half of the participants had diabetes for at least 5 years. Most participants took oral medicines (72%) for their diabetes, and 38% also took medicines for other health problems. The majority of participants (82%) reported diabetes complications including coronary heart disease, retinopathy, and renal damage. We found no significant differences between the two groups for the major study variables at baseline: They had similar mean scores on OP knowledge, OP self-efficacy, diabetes self-care, diabetes self-efficacy, PA, and calcium consumption.

Participants in the intervention group had significant improvements in OP knowledge, $F(2, 43) = 11.504$; $p < .001$, OP self-efficacy, $F(2, 43) = 6.915$; $p = .003$, diabetes self-care activities, $F(2, 43) = 14.009$; $p <.001$, diabetes self-efficacy, $F(2, 43) = 19.722$; $p < .001$, dietary calcium intake, $F(2, 43) = 7.856$; $p =.002$, and level of PA, $F(2, 43) = 4.787$; $p = .011$, from pretest to the 3-month follow-up, while there were no significant changes in these variables over time in the control group (Tables 2 and 3). The amount of moderate or vigorous PA did not change significantly from pretest to 3-month follow-up in either group. Additionally, participants in the intervention group had significantly decreased A1C levels at the 3-month follow-up compared to pretest levels ($t = 2.809$, $p = .010$), while those in the control group showed no significant change in these levels ($t = 0.249$, $p = .806$; Figure 3).

Discussion

In the present study, adults with type 2 diabetes who participated in a 6-week educational self-efficacy intervention on OP knowledge showed improvements in OP knowledge, self-efficacy, and preventive behavior (i.e., consumption of calcium-rich foods and PA) as well as diabetes self-efficacy, self-care activities, and control (i.e., A1C levels). Intervention participants were provided opportunities to develop diabetes management skills, learn about bone health modification, ask individual questions, and watch demonstrations of exercises that help to prevent OP. As part of the intervention, we also discussed barriers to and benefits of diabetes control and OP prevention behaviors and encouraged participants to share successful lifestyle modification experiences.

Table 2. Repeated Measures Analysis of Variance on Major Study Variables.

Variable and Effect	Num df, Den df[a]	Wilks' Λ	Effect Size[b] (η2)	F	pValue
OP knowledge					
Group	1, 44		0.107	5.277	.026*
Time	2, 43	0.950	0.153	7.976	.001**
Group x Time	2, 43	0.992	0.207	11.504 <.001**	
OP self-efficacy					
Group	1, 44		0.203	11.188	.002**
Time	2, 43	0.978	0.202	11.144	<.001**
Group x Time	2, 43	0.873	0.136	6.915	.003**
Calcium consumption					
Group	1, 44		0.078	3.731	.060
Time	2, 43	0.991	0.238	13.716	<.001**
Group x Time	2, 43	0.897	0.151	7.856	<.002**
Physical activity, total					
Group	1, 44		0.051	2.385	.130
Time	2, 43	0.297	0.031	1.419	.247
Group x Time	2, 43	0.783	0.098	4.787	.011*
Physical activity, moderate or vigorous					
Group	1, 44		0.074	3.532	.067
Time	2, 43	0.091	0.002	0.139	.871
Group x Time	2, 43	0.272	0.091	2.921	.059
DM self-care activity					
Group	1, 44		0.093	4.521	.039*

Time	2, 43	0.993	0.211	11.752	<.001**
Group x Time	2, 43	0.998	0.241	14.009	<.001**
DM self-efficacy					
Group	1, 44		0.039	1.792	.188
Time	2, 43	0.999	0.313	20.074	<.001**
Group x Time	2, 43	0.999	0.310	19.722	<.001**

Note. Den = denominator; DM = diabetes mellitus; Num = numerator; OP = osteoporosis. [a]There are two degrees of freedom: one for the numerator (Num) and one for the denominator (Den). [b]Explanation of effect size: 0.02 = small; 0.15 = medium; 0.35 ¼ large (Cohen, 1988, pp. 477–478).*p < .05. **p < .01.

We found at baseline that the Chinese adults with type 2 diabetes who participated in the study lacked both OP knowledge and self-efficacy, which is consistent with the findings of other studies (Chen et al., 2004; Qi et al., 2011; X. Wu et al., 2009). They also consumed insufficient amounts of dietary calcium (434 mg/day, on average), which, again, is similar to the findings of previous studies (H. H. L. Chan et al., 1996; He et al., 2007; X. H.Wang, Yan, Han, & Liu, 1999). Only a few of our participants (14%) took calcium and vitamin D supplements to compensate for the insufficient dietary calcium and vitamin D intake, which was similar to the findings of Liang, Lee, and Binns (2009).

Table 3. Pairwise Comparisons of Outcomes by Time and Group.

	M(SD)			
Variable	Intervention Group	Control Group	t-Value	p Value
OP knowledge				
Time 1	10.4 (3.9)	10.3 (3.7)	0.037	.970
Time 2	13.5 (3.9)	10.2 (3.0)	3.279	.002*
Time 3	4.2 (4.1)	10.6 (3.5)	3.241	.002*
OP self-efficacy				
Time 1	66.4 (17.7)	59.5 (15.7)	1.451	.153
Time 2	80.1 (16.2)	62.9 (14.7)	3.814	<.001*
Time 3	80.5 (14.5)	61.6 (15.0)	4.338	<.001*
Calcium consumption (mg/day)				
Time 1	426.9 (140.3)	441.8 (176.7)	-0.328	.744
Time 2	495.1 (126.8)	445.7 (172.1)	1.115	.271
Time 3	596.7 (108.2)	446.6 (117.1)	4.516	<.001*
Physical activity, total (METs/hr/week)				
Time 1	145.8 (23.5)	148.1 (34.5)	-0.241	.810
Time 2	156.1 (41.0)	141.4 (36.2)	1.304	.199
Time 3	171.2 (37.7)	141.4 (29.7)	2.978	.005*
DM self-care activity				
Time 1	38.9 (11.2)	40.1 (9.7)	-0.364	.718
Time 2	47.7 (9.0)	39.4 (9.0)	3.159	.003*

Time 3	49.3 (9.3)	39.9 (9.7)	3.359	.002*
DM self-efficacy				
Time 1	121.7 (34.2)	127.4 (30.6)	-0.619	.539
Time 2	146.9 (24.6)	130.4 (25.6)	2.252	.029
Time 3	152.6 (20.4)	131.6 (24.3)	3.177	.003*

Note. DM = diabetes mellitis; OP = osteoporosis. Bonferroni correction applied (.017 significance level). Time 1 = pretest; Time 2 = posttest; Time 3 = 3-month follow-up. *p < .017.

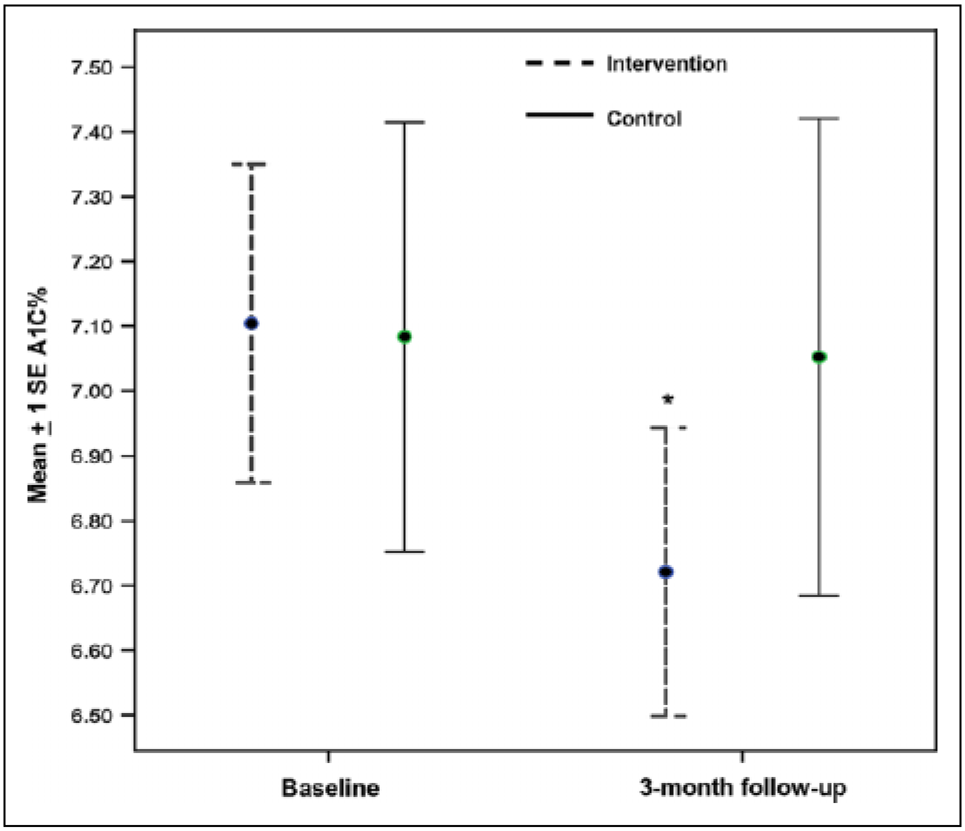

Figure 3. Blood glucose level (A1C) in the two groups at baseline and 3-month follow-up. *Significant change from baseline.

The Food and Agriculture Organization of the United Nations/World Health Organization's (Chen et al., 2001) recommendations on daily calcium intake vary among countries. For China, they recommend a daily calcium intake of 1,200 mg for females (1,300-mg postmenopause), 1,000 mg for male adults, and 1,300 mg for older adults. Participants in the intervention group in the present study increased their dietary calcium intake to an average of 597 mg/day by the 3-month follow-up, which was a significant improvement, though still far less than the FAO/WHO recommendations.

Our findings of significant improvements in both diabetes and OP self-efficacy and self-care activities in the intervention group add to the growing body of literature suggesting that self-efficacy is a predictor of health behavior. Bandura (1994) defined self-efficacy as an individual's confidence in his or her ability to initiate behavioral changes. People with a higher degree of self-efficacy, therefore, would be more likely to perform beneficial health behaviors. Our findings in the present study are consistent with those of previous investigators. Shi et al. (2010) administered a monthlong self-efficacy intervention in which they provided education on diabetes skill mastery, role modeling, and group discussion in weekly sessions. They reported differences in both diabetes self-care activities and self-efficacy between the intervention group and the control group immediately after the intervention and at the 4-month follow-up. Likewise, S. F. Wu et al. (2011) delivered four weekly diabetes education sessions focusing on goal setting, empowerment, role modeling, and peer support and found improved diabetes self-care activities and self-efficacy in the intervention group at the 3- and 6-month follow-ups.

Although participants in the intervention group in the present study expended more energy in total PA than in those in the control group at the 3-month follow-up, there was no significant difference in moderate or vigorous PA between the groups. Participants preferred light physical activities, such as walking, ballroom dancing, ordinary cleaning, sweeping, and so on, perhaps due to chronic medical conditions, poor fitness for intense exercise, and/or perceived physical limitations (Nelson et al., 2007). In addition, common wisdom in traditional Chinese medicine is that modest PA is the best route to maintaining health (M. Zhang, 2009), which may partially explain the lack of participation in more vigorous activity among study participants. Finally, it is also possible that our small sample size limited our ability to detect significant findings.

The average A1C at baseline in the present study was 7.3%. The International Diabetes Federation (2005) advises that people with diabetes maintain an A1C below 6.5% to minimize the risk of diabetes-related complications. At the 3-month follow-up, the average decrease in A1C was 0.4% among participants in the intervention group, indicating that the intervention had a positive effect on glycemic control. According to the United Kingdom Prospective Diabetes Study (1998), a reduction of 1% in A1C in adults with T2DM decreases the risk of microvascular diseases by 35%.

Our high retention rate may be due to the fact that A1C tests were provided at no charge at pretest and 3-month follow-up. Additionally, we used strategies to minimize attrition. For example, participants were allowed to make up sessions missed at an alternate time. The first author’s cell phone number was available to each participant, and, at the third and fifth sessions for the intervention group and at posttest for the control group, we offered finger-stick glucose tests at no charge, so that participants could test blood glucose level 2 hr after breakfast.

Limitations

This pilot study had several limitations. Because of the convenience sampling and small sample size, the sample may not have been representative of the broader population of adults with type 2 diabetes. Additionally, self-reported data may have been biased by potential desirability. Finally, study duration may have been too short to see all the effects of the intervention. For example, there was little change in moderate or vigorous PA over time in either group. Longer follow-up studies might be needed to identify all the benefits of such an intervention.

Conclusion

Diabetes has recently become a major public health concern in China. Nurses must be made aware of the risk of OP and fracture among patients with diabetes. It is imperative for nurses, as both health educators and health care providers, to deliver OP educational programs for these patients. Such programs should highlight the benefits for preventing OP and controlling diabetes of consuming a low-calorie, calcium-rich diet, regularly performing diabetes self-care practices and participating in physical activities that improve bone health such as tai chi chun, which has been reported as an effective way to delay bone loss (K. M. Chan et al., 2004).

Despite the limitations of the present study, the results demonstrate the effectiveness of self-efficacy-based OP prevention education in improving the OP preventing behaviors of dietary calcium intake, PA, and diabetes control among adults with type 2 diabetes who are at high risk of OP. Using strategies for knowledge reinforcement, skills development, confidence improvement, problem solving, and physiological and psychological feedback can improve OP knowledge, self-efficacy, dietary calcium intake, PA, diabetes self-care practice, diabetes management efficacy, and glycemic level in adults with T2DM.

Further studies are needed to explore the effects of nurse-led moderate-to-vigorous exercise interventions and education on the long-term consumption of calcium-rich diets on OP prevention and diabetes control for adults with type 2 diabetes.

Declaration of Conflicting Interests

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