Research Article

Application and Effect of Mobiletype-Bone Health Intervention in Korean Young Adult Women with Low Bone Mass: A Randomized Control Trial

Young-Joo Park, PhD, RN,1 Sook-Ja Lee, PhD, RN,1 Nah-Mee Shin, PhD, RN,1 Hyunjeong Shin, PhD, RN,1 Songi Jeon, MSN, RN,2 Jungwoo Lee, MSN,3 Inhae Cho, MSN, RN2,*

1 College of Nursing, Korea University, Seoul, South Korea
2 Department of Nursing Graduate School, Korea University, Seoul, South Korea
3 Department of Home Economics Education Graduate School Korea University, Seoul, South Korea

Article Info

Article history:
Received 13 September 2016
Received in revised form 10 March 2017
Accepted 10 March 2017

Keywords:
biomarkers
bone density
mobile applications
nutrition assessment
women

Summary

Purpose: This randomized control trial was designed to examine the effect on the self-managing ability for promoting bone health of mobile type—bone health intervention (mobile type—BHI).

Methods: The mobile type—BHI consisted of a mobile application called “Strong bone, Fit body” (SbFb) and group education. A total of 82 college women with low bone mass (Z score < −1) participated. They were assigned randomly to three groups, experimental group I (n = 28), experimental group II (n = 32), and control group (n = 22). This study ran from June 2014 to January 2015. The outcome variables were bone mineral density, minerals related to bone metabolism (calcium, phosphorus, vitamin D), biochemical markers related to bone remodeling (osteocalcin, C-terminal telopeptide, sclerostin), food intake diary by 24 hours recall, and psychosocial variables related to bone health (knowledge, health belief and self-efficacy). Data were analyzed using SAS program and a computer aided nutritional analysis program.

Results: Both the experimental group I, who used mobile type—BHI, and experimental group II, who only received group education, showed outcomes regarding knowledge of the benefits of exercise and calcium as compared with the control group. The two experimental groups also demonstrated results in the serum levels of calcium, vitamin D, and sclerostin compared to those of the control group.

Conclusion: Although both experimental groups exhibited positive outcomes in regards to the promotion of bone health, this study did not show an additional effect of the mobile application on self-management ability for the promotion of bone health. Nonetheless, the SbFb application is very meaningful as it is the first application developed with the aim of improving women’s bone health.

© 2017 Korean Society of Nursing Science, Published by Elsevier Korea LLC. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Introduction

Recently, fragility fractures in patients with osteoporosis have become a major problem that imposes a heavy burden on individual patients and countries around the world [1]. According to the Fourth and Fifth National Health Nutrition Surveys carried out from 2008 to 2011 in Korean individuals 50 years old or older, the incidence of osteoporosis was 38.0% in women and 7.3% in men, and the incidence of osteopenia was 48.7% in women and 46.5% in men. Furthermore, Korean female and male adults aged 20–49 years old had lower bone mineral density (BMD) than did individuals in the same age group in the United States and Japan [2].

Low BMD is a significant risk factor for fracture. Thus, it is quite important to achieve peak bone mass (PBM) during adolescence in order to prevent osteoporotic fractures in adulthood, along with general maintenance of bone health. For example, based on the results of a study that used mathematical modeling to assess the...
relative influence of various causes of bone loss (e.g., PBM, menopause, age), a 10.0% increase in PBM during the adolescent period can postpone the occurrence of osteoporosis for 13 years, whereas a 10.0% increase in BMD at the time of menopause can delay the occurrence of osteoporosis for only 2 years. Therefore, the study emphasizes the importance of achieving appropriate PBM when individuals are young and growing [3]. More than 60.0% of PBM is attributable to genetic factors, but the rest is influenced by risk factors associated with lifestyle, such as calcium and protein intake, vitamin D status, and the regular performance of weight-bearing exercise [4]. Therefore, for maintenance of adequate bone mass and achievement of proper PBM, it is important to adopt lifestyle changes (e.g., adequate nutritional intake of substances such as calcium and protein, increasing intake of vegetables and fruits, maintenance of the recommended amount of vitamin D, taking part in regular weight-bearing exercises, avoiding smoking and excessive drinking of alcohol) [5].

Until now, studies specifically targeting young adult women are relatively rare among all studies on educational intervention or osteoporosis prevention programs related to bone health. Most previous studies assessed and reported the outcomes of measurements of psychosocial variables, which may be linked with bone health-promoting behaviors such as knowledge about osteoporosis, health beliefs, and self-efficacy. Those studies demonstrated inconsistent effects of educational programs on the psychosocial variables. Furthermore, the previous studies could not determine precisely whether the psychosocial variables measured are truly associated with healthy behaviors [6-11].

Therefore, further studies for improving bone health in women in early adulthood are needed to attempt a different approach to interventions and measurement of their effects. When developing interventions that will improve bone health, there is a need to consider alternative approaches that make use of interactive technology, like mobile applications, in addition to conventional and educational interventions. Interactive technology-assisted feedback provides a convenient means for informing, enabling, motivating, and guiding people in their efforts to make lifestyle changes [12]. Therefore, healthcare interventions that utilize mobile applications can enable personalized feedback and motivate changes in an individual’s lifestyle habits. In the end, we can expect to gain substantial positive effects from the use of technology, such as reinforcement of modified behaviors and enhancement of self-managing abilities.

Moreover, there is a need to conduct studies that measure physiological variables reflecting direct and objective effects (e.g., BMD and bone metabolism related to blood markers) on improvements in bone health, rather than measuring indirect effects with psychosocial variables, which only predict bone health changes such as the effects of bone health knowledge, health beliefs, and health-related behavioral changes on improving bone health. Recently, studies on exercise interventions in healthy adult groups have measured serum sclerostin, a glycoprotein that inhibits osteoblast differentiation and bone formation. Sclerostin has been recommended as a highly sensitive variable in mechanical loading. Furthermore, sclerostin inhibition is a promising approach to preserving bone mass. Sclerostin can also play a role as an antagonist of the Wnt/β-catenin signaling pathway, decreasing extinction of osteocytes (bone cells) and improving bone formation following mechanical stimulation such as exercise or other physical activities [13].

This study, a randomized control trial (RCT) was designed to examine the effect of the mobile type—BHI using a mobile application for the promotion of bone health in young adult women with low bone mass in Korea. This is an RCT study designed to examine the effects of mobile type—BHI using the SbFb application developed in the previous study [14] in young adult women with low bone mass in Korea. The theoretical framework of this RCT is illustrated in Figure 1. Mobile type—BHI was illustrated in Figure 1. The theoretical framework of this RCT is shown in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. The theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1. Theoretical framework of this RCT is illustrated in Figure 1.

Methods

Study design

This is an RCT study designed to examine the effects of mobile type—BHI using the SbFb application developed in the previous study [14] in young adult women with low bone mass in Korea. The sample size was estimated based on Cohen’s method [16], and the effect size of .4 in the F test of the independent mean in the three groups was considered, with a significance level of .05, power of .8, and three groups considered, with a significance level of .05, power of .8. The sample size was estimated based on Cohen’s method [16], and the effect size of .4 in the F test of the independent mean in the three groups was considered, with a significance level of .05, power of .8, based on the estimation using G*Power 3.1; the total number of participants was 120. Thus, each group needed 40 subjects, considering an expected dropout rate.

Ethical considerations

This study was approved by the institutional review board ethics committee of the university where the researchers work (IRB No. KU-IRB-14-82-A-1). Study participants voluntarily agreed to...
participate in the study, and the researchers provided them with written informed consent forms containing detailed information including purpose of the study, scope of data use, benefits or risks of participation in the study, confidentiality, procedures for storing and destroying participants’ samples and questionnaires after the research, and the right to withdraw from the study at any time. The consent forms were signed and dated by each study participant prior to her participation in the study. Moreover, the researchers explained that the contents and results of the study would not be used for any other purpose and that medical information obtained from study participants was confidential.

Measurements

BMD

Lumbar BMD of the participants was measured using dual-energy X-ray, which is an accurate, quantitative measurement method that produces few measurement errors. Lumbar BMD was performed at a medical examination center.

Biochemical markers related to bone metabolism

Using a blood test, the following biochemical markers were measured: (a) minerals related to bone metabolism (calcium,
phosphorus, and vitamin D), (b) osteocalcin, as a bone formation marker, (c) CTX, as a measure of bone resorption, and (d) sclerostin, as identification of changes or health of individual physical activities [17]. At the medical examination center, we obtained the blood samples from the participants and analyzed the biochemical markers on the day of the blood test. In young adult women, normal ranges of each marker are as follows: (a) serum levels of osteocalcin, 8.8–39.4 ng/mL; (b) CTX, 0.57 ng/mL; (c) calcium, 8.1–10.5 mg/dL; (d) phosphorus, 2.5–5.0 mg/dL; (e) vitamin D (10 ng/mL, deficient; 10–30 ng/mL, insufficient; 30–100 ng/mL, optimal; > 100 ng/mL, excess), and (f) sclerostin, 67–300 pg/mL. Low levels of serum sclerostin indicate high levels of physical activities.

Body composition and BMI
With a body composition analyzer (InBody330, InBody, Seoul, Korea), the following parameters were measured: (a) muscle mass; (b) total body water content; (c) body fat mass; (d) free fat mass; (e) body fat percentage; (f) waist/hip ratio; and (g) BMI. To measure BMI, a height measuring instrument (DS-102, Dong Sahn Jenix Co., Seoul, Korea) was used.

Nutrients
The participants in this study were asked to keep a daily food diary by 24-hour recall and record the type and amount of food they had consumed over a period of 3 days (2 weekdays and 1 weekend day) using a retrospective method [18]. Furthermore, nutrient intake evaluation was performed by the Computer Aided Nutritional analysis program (CAN-pro 4.0, The Korean Nutrition Society, Seoul, Korea) professional edition, which was provided by the Korean Nutrition Society.

Bone health-related knowledge, health beliefs, and self-efficacy
To assess participants’ knowledge related to bone health, a total of 35 items on a questionnaire were used. The source of the questionnaire was the Osteoporosis Knowledge Test [19]. Among the questions of the Osteoporosis Knowledge Test, a few that might lead to incorrect health behaviors in young adult women even though they may provide correct information on the prevention of osteoporosis (e.g., “taking calcium supplements can reduce the risk of osteoporosis”) were removed. Moreover, based on the previous research analysis [15], questions with a low level of difficulty were excluded from the questionnaire. Thus, in the end, the questionnaire consisted of 35 items. A correct answer was given 1 point, and an incorrect answer was given 0 points. The scores ranged from 0 to 35.

The Osteoporosis Health Belief Scale was in this study to measure participants’ health beliefs about bone health [20]. This scale consisted of seven subscales (sensitivity and seriousness of osteoporosis, the benefits of exercise, the benefits of calcium intake, barriers related to doing exercise and taking calcium, and health motivation) and was composed of a total of 42 items. The possible responses to questions on the Osteoporosis Health Belief Scale ranged from 1 (strongly disagree) to 5 (strongly agree). The score in each subscale ranged from 6 to 30, and the higher the score, the stronger the health beliefs. In this study, the internal reliability, Cronbach α of each subscale was as follows: sensitivity, .83; seriousness, .76; benefits of exercise, .77; benefits of calcium intake, .64; barriers related to exercise, .72; barriers related to calcium intake, .74; and health motivation, .80.

To measure self-efficacy associated with bone health, the Osteoporosis Self-Efficacy Scale was used [21]. This scale is a visual analog scale consisted of a total of 21 items, 10 items of self-efficacy related to exercise and 11 items of self-efficacy related to calcium intake. The possible responses were equally divided into 10 parts from a score of 1 (not at all confident) to a score of 10 (very confident). Thus, the total score ranged from 21 to 210, and the higher the score, the higher the self-efficacy of a participant. The Cronbach α of the scale was .95 (self-efficacy related to exercise, .97; self-efficacy related to calcium intake, .95).

General characteristics, health lifestyles and health history
A questionnaire composed of 13 items assessed the participants’ sociodemographic characteristics, health-related lifestyle habits, and history of bone health in the participants and their parents.

Experiment application and data collection
Pre-experiment and postexperiment data collection
Pre-experiment data collection consisting of answers to the questionnaires, blood tests, and measurements of BMD were conducted from June 23rd to July 1st, 2014. The postexperiment data collection was performed from November 25th, 2014 to January 9th, 2015. The measurements of BMD and blood tests were taken at a medical examination center. For blood tests, collected blood from participants was analyzed at the Seegene Medical Foundation, Seoul, Korea. Researchers distributed the questionnaires to the participants and collected the completed questionnaires at the medical examination center.

Experimental groups
In this study, all participants of the experiment were informed of their lumbar BMD after completion of the preliminary examination. After randomization, experimental group I received mobile type—BHL, consisting of the SfB application and group education. Experimental group II received only group education.

Group education
The participants in experimental groups I and II chose a date from July 3rd to 5th, 2014 to participate in the educational sessions. The group education consisted of three sessions. Each session was composed of lecture and demonstration for 50 minutes. The topic of the first session was “Women’s bone health: keeping bone health in this way”. Using powerpoint, the first session progressed in the following order: (a) current state of bone health in women; (b) basic knowledge of bone structure; (c) definition of and risk factors for osteoporosis; (d) how to maintain bone health. The topic of the second session was “Women’s bone health: nutrition”. In the second session, information on the following topics was provided: (a) average daily intake levels of young adult women based on our previous study results; and (b) energy adequacy ratio/distribution of macronutrients, priority of nutrients, nutrition goals of dietary composition, categorization of food groups, and examples of foods with high calcium and vitamin D suggested by The Korean Nutrition Society [22]. Furthermore, standard portions of food were demonstrated using replicas of common dishes. The third session was on the topic, “Women’s bone health: exercise”. In this session, an exercise program developed by the research team for promotion of bone health was introduced in a video and each exercise was demonstrated. The exercise program was composed of weight-bearing high-force exercises, which have been reported to be effective in increasing bone mass, nonweight-bearing high-force exercises, and static weight-bearing exercises which are done in a static position [23]. For weight-bearing high-force exercise, power walking (40 minutes) and foot stomping were suggested. Nonweight-bearing high-force exercise consisted of 10 movements involving the whole body (arms, legs, trunk, etc.) with 100% resistibility using a 1.7 kg extension band. Static weight-bearing exercises standing was exercise that stands on one leg for 1 minute.
Application of the SbFb application

The SbFb application was introduced only to the participants in experimental group I after group education. For this group, we explained how to use the application followed by questions and answers. The participants used the application from July 7th to November 24th, 2014 (20 weeks). The SbFb application had been revised based on the preliminary results from a previous study [14], and changes were the directories of the application, the means of inserting. Specifically, exercise/nutrition/checking of healthy life in the diary was altered from “inserting in an order” to “inserting appropriate items”. Also, a “sun” figure was added and participants were required to record the length of time for which they did the activities in clear daylight. In nutritive status, food items categorized into food groups were expanded from 33 types to 55 types. If the participants ate food not listed in the application, they were asked to record this information by themselves. Thus, calcium and vitamin D intake were recorded accurately. Moreover, given the results of previous research [14], the modified final SbFb application used an interaction model to provide feedback regarding exercise, nutrition, and healthy lifestyle habits. Secondly, the application was modified to calculate an achievement score for each section regarding exercise, nutrition intake, and healthy living habits.

To calculate exercise achievement scores, the concept of an osteogenic index has been introduced both domestically and overseas. The osteogenic index is an index of osteogenesis that considers types of activity/exercise as an indirect measure of the effectiveness of bone health promotion programs. In the nutritional intake section, 55 foods familiar to young adult women and contain high levels of calcium and vitamin D were suggested along with images and standard serving sizes. Moreover, in addition to the previous bone health-related educational materials (knowledge related to bone health, exercise, nutrition, and healthy lifestyle habits), certain contents such as examples of menus, useful tips regarding nutritional intake and exercise videos were developed.

Data analysis

For statistical analysis, the SAS program for Windows (version 9.1.3, SAS Institute, Cary, NC, USA) was used. The CAN-pro 4.0, professional edition, was applied to the nutritional analysis of the food diaries. Per protocol analysis, mainly focusing on participants who completed the pre-experiment and postexperiment, was applied to the study.

The differences in all variables (BMD, minerals and biochemical markers associated with bone metabolism, bone health knowledge, scores of health beliefs and self-efficacy, and values of nutrients) among the three groups were tested by analysis of covariance and orthogonal contrasts with a covariance of pre-scores. The similarity analysis of general characteristics and all variables among the three groups were performed by analysis of variance. The general characteristics of the participants and the distributive characteristics of all variables were compared and are presented with the descriptive statistics such as mean, standard deviation, frequency, and percentage.

Results

Comparison of general characteristics and study variables among the three groups at baseline

There were no statistically significant differences between the three groups at baseline in relation to the following variables: (a) the participants’ general characteristics (age, residence, economic status, smoking status, alcohol use, history of digestive tract disease, regularity of dietary intake, amount of coffee consumed per day, regularity of the menstrual cycle, and taking steroids); (b) BMD; (c) minerals and biochemical markers associated with bone metabolism (calcium, phosphorus, vitamin D, osteocalcin, CTX, sclerostin); (d) bone health knowledge, health beliefs and self-efficacy; and (e) values of nutrient intake (Table 1).

Primary outcome analysis among the three groups

In this RCT, primary outcome analysis variables verified changes in bone health, knowledge about bone health, health beliefs and self-efficacy, and nutrient intake. First, in the psychosocial variables associated with bone health, there were statistically significant differences in the benefits of exercise (F = 3.88, p = .025) and in the benefits of calcium intake (F = 7.63, p = .001). Regarding the benefits of exercise, the scores of the experimental groups I and II were 25.75 and 25.70, respectively, both of which are higher than the score of the control group (23.72). In the orthogonal analysis used for comparison between groups, there was a statistically significant difference between groups when combining the two experimental groups versus the control group (F = 7.29, p = .008), between experimental group I and the control group (F = 7.34, p = .008), and between experimental group II and the control group (F = 3.86, p = .025). Regarding the benefits of calcium intake, the scores of experimental groups I and II were 23.89 and 23.77, respectively, are significantly higher than that of the control group (21.31). In the orthogonal analysis for between-group comparison, there was a statistically significant difference between the two experimental groups combined versus the control group (F = 15.23, p = .0002), between experimental group I and the control group (F = 12.50, p = .0007), and between the experimental group II and the control group (F = 11.45, p = .001) (Table 2).

Regarding the analysis of changes in nutrient intake, the amount of calcium intake in the experimental group I (492.53 mg) and experimental group II (497.00 mg) was higher than that in the control group (440.99 mg). After the experiment, however, this difference was not statistically significant (Table 3).

Outcome analysis among the three groups

To analyze the outcomes of this study, changes in BMD, biochemical markers of bone remodeling and minerals related to bone metabolism were verified. The analysis of changes in body composition and BMI showed that there was no statistical significance among the three groups in the following variables: body fat mass, fat-free mass, muscle mass, total body water, body fat percentage, waist-hip ratio (WHR) and BMI.

Except for phosphorus which was found to be one of the minerals associated with bone metabolism, there was a statistically significant difference in serum calcium (F = 4.03, p = .02) and vitamin D (F = 6.14, p = .003). The serum calcium levels in the experimental groups I and II were 10.21 and 10.19, respectively, and both were higher than that in the control group (9.90). In the orthogonal analysis for the between-group comparison, there was a statistically significant difference between the two experimental groups combined and the control group (F = 8.00, p = .005), between experimental group I and the control group (F = 5.81, p = .01), and between experimental group II and the control group (F = 6.83, p = .001). The serum vitamin D levels of experimental groups I and II were 12.24 and 13.02, respectively. Both were higher than that in the control group (8.44). In the orthogonal analysis for between-group comparison, there was a statistically significant difference between the two experimental groups combined and the control group (F = 12.10, p = .0008), between experimental group I and the control group (F = 8.51, p = .004),
and between experimental group II and the control group (F = 10.69, p = .001).

Among the biochemical markers of bone remodeling, there was a statistically significant difference in the serum sclerostin levels (F = 4.78, p = .011). The levels of the experimental group I and II were 76.08 and 77.35, respectively, which are both lower than that in the control group (110.09). In the orthogonal analysis for between-group comparison, there was a statistically significant difference between the two experimental groups combined and the control group (F = 9.56, p = .002), between the experimental group I and the control group (F = 7.73, p = .006), and between the experimental group II and the control group (F = 7.38, p = .008). However, there was no statistically significant difference in osteocalcinOS or CTX among the three groups (Table 4).

Regarding nutritional intake, the levels of vitamin D intake increased from 4.06 μg to 4.27 μg after experiment in the experimental group II, and from 2.62 μg to 2.87 μg in the control group. On the other hand, they decreased from 4.20 μg to 3.48 μg in the experimental group I. The levels of fat, carbohydrate, and calcium intake decreased in all three groups. Changes after experiment in other nutrient intakes are described in (Table 3).

**Discussion**

This study is an RCT designed to examine the effects of mobile type–BHI using the SbFb application developed in the previous study [14] in young adult women with low bone mass. As the primary outcomes of this study, the effect of mobile type–BHI on the following psychosocial variables, bone health-related knowledge, health belief, self-efficacy, and nutrient intake, as well as physiological variables, BMD, biochemical markers of bone remodeling, and serum levels of minerals related to bone metabolism were assessed. The results of the study were as follows: both experimental group I who received mobile type–BHI, and experimental group II who only received group education showed outcomes regarding health belief related to the benefits of exercises and calcium intake as compared with the control group. Both experimental groups showed higher level in the serum levels of calcium, vitamin D, and Sclerostin compared to the control group. Previous studies [6–11] conducted with groups in their early adulthood usually used educational interventions including information on nutrient intake or exercise for bone health. The effects of the interventions have been verified using psychosocial variables (knowledge about osteoporosis, health beliefs, self-efficiency, etc.) in previous studies. Thus, the current study measured variables that were direct reflections of bone health (BMD, biochemical markers of bone remodeling, and levels of minerals related to bone metabolism), in addition to the conventional indirect measurements. Therefore, the findings of this study enabled us to infer relationships between BMD and psychosocial variables related to bone health.

The findings showed that the serum calcium levels in the two experimental groups were significantly higher than in the control group and were within the normal range. Although the vitamin D levels in the two experimental groups remained "insufficient", they improved over the course of the study, and it was at a higher level than that of control group ("deficient"). Regarding serum levels of sclerostin, those of the two experimental groups were significantly lower than that of the control group. These results indicate that the participants in the experimental groups performed more physical activities that stimulated bone formation than did their counterparts in the control group. These positive findings on the serum levels of calcium, vitamin D, and sclerostin can be understood to be meaningful results of health beliefs about the benefits of exercise and calcium intake. In other words, the levels of serum calcium increased in both experimental groups while that of the control

---

### Table 1 Comparison of General Characteristics among Three Groups at Baseline (N = 82).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Categories</th>
<th>EG I (n = 28)</th>
<th>EG II (n = 32)</th>
<th>Control (n = 22)</th>
<th>χ² or F (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td></td>
<td>24.03 ± 2.16</td>
<td>24.78 ± 2.87</td>
<td>23.18 ± 1.89</td>
<td>2.89 (.061)</td>
</tr>
<tr>
<td>Residence</td>
<td>Own home</td>
<td>15 (53.6)</td>
<td>16 (50.0)</td>
<td>13 (59.1)</td>
<td>0.43 (.805)</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>13 (46.4)</td>
<td>16 (50.0)</td>
<td>9 (40.9)</td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>High</td>
<td>3 (10.7)</td>
<td>5 (15.6)</td>
<td>1 (4.6)</td>
<td>3.92 (.416)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>21 (75.0)</td>
<td>26 (81.3)</td>
<td>18 (81.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>4 (14.3)</td>
<td>1 (3.1)</td>
<td>3 (13.6)</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>No smoking</td>
<td>25 (89.3)</td>
<td>30 (93.8)</td>
<td>21 (95.5)</td>
<td>2.87 (.579)</td>
</tr>
<tr>
<td></td>
<td>Quit smoking</td>
<td>2 (7.1)</td>
<td>2 (6.3)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smoking</td>
<td>1 (3.6)</td>
<td>0 (0.0)</td>
<td>1 (4.6)</td>
<td></td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>Yes</td>
<td>20 (71.4)</td>
<td>19 (59.4)</td>
<td>11 (50.0)</td>
<td>2.43 (.296)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>8 (28.6)</td>
<td>13 (40.6)</td>
<td>11 (50.0)</td>
<td></td>
</tr>
<tr>
<td>Gastric disorders</td>
<td>Yes</td>
<td>6 (21.4)</td>
<td>11 (34.4)</td>
<td>5 (22.7)</td>
<td>1.53 (.465)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>22 (78.6)</td>
<td>21 (65.6)</td>
<td>17 (77.3)</td>
<td></td>
</tr>
<tr>
<td>Eating regularity</td>
<td>Yes</td>
<td>6 (21.4)</td>
<td>6 (18.8)</td>
<td>5 (22.7)</td>
<td>0.13 (.933)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>22 (78.6)</td>
<td>26 (81.3)</td>
<td>17 (77.3)</td>
<td></td>
</tr>
<tr>
<td>Coffee intake (cups/day)</td>
<td>0</td>
<td>5 (17.9)</td>
<td>9 (28.1)</td>
<td>7 (31.8)</td>
<td>3.33 (.766)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>10 (35.7)</td>
<td>9 (28.1)</td>
<td>8 (36.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2–3</td>
<td>9 (32.1)</td>
<td>9 (28.1)</td>
<td>3 (13.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 4</td>
<td>4 (14.3)</td>
<td>5 (15.6)</td>
<td>4 (18.2)</td>
<td></td>
</tr>
<tr>
<td>Menstrual regularity</td>
<td>Yes</td>
<td>19 (67.9)</td>
<td>21 (65.6)</td>
<td>15 (68.2)</td>
<td>0.05 (.975)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>9 (32.1)</td>
<td>11 (34.4)</td>
<td>7 (31.8)</td>
<td></td>
</tr>
<tr>
<td>Steroid</td>
<td>Yes</td>
<td>1 (3.6)</td>
<td>1 (3.1)</td>
<td>1 (4.6)</td>
<td>0.07 (.963)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>27 (96.4)</td>
<td>31 (96.9)</td>
<td>21 (95.5)</td>
<td></td>
</tr>
<tr>
<td>Body composition &amp; BMI</td>
<td>Free fat</td>
<td>38.75 ± 3.93</td>
<td>37.09 ± 3.23</td>
<td>37.84 ± 7.76</td>
<td>1.55 (.219)</td>
</tr>
<tr>
<td></td>
<td>Body fat</td>
<td>14.40 ± 3.93</td>
<td>13.75 ± 3.93</td>
<td>14.59 ± 3.83</td>
<td>0.24 (.784)</td>
</tr>
<tr>
<td></td>
<td>Muscle</td>
<td>35.98 ± 5.39</td>
<td>34.85 ± 3.04</td>
<td>33.56 ± 4.74</td>
<td>1.47 (.236)</td>
</tr>
<tr>
<td></td>
<td>Body fluid</td>
<td>28.39 ± 5.11</td>
<td>27.16 ± 2.36</td>
<td>27.70 ± 6.70</td>
<td>1.60 (.208)</td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>20.15 ± 2.86</td>
<td>19.86 ± 2.16</td>
<td>20.22 ± 2.79</td>
<td>0.19 (.829)</td>
</tr>
<tr>
<td></td>
<td>Body fat ratio</td>
<td>26.44 ± 2.79</td>
<td>26.66 ± 5.38</td>
<td>27.27 ± 1.98</td>
<td>0.14 (.867)</td>
</tr>
<tr>
<td>AFR</td>
<td>0.78 ± 0.99</td>
<td>0.79 ± 0.02</td>
<td>0.78 ± 0.57</td>
<td>0.48 (.620)</td>
<td></td>
</tr>
</tbody>
</table>

Note: AFR = abdominal fat ratio; BHI = bone health intervention; BMI = body mass index; EG I = experimental group I (mobiletype_BHI); EG II = experimental group II (group education only); SES = socioeconomic status.
ANCOVA on Mean Difference of Primary Outcome Variables (Psychosocial Variables Related to Bone Health) among Three Groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>EG 1 (n = 22)</th>
<th>EG 2 (n = 28)</th>
<th>Control (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
</tr>
<tr>
<td><strong>M ± SD</strong></td>
<td><strong>M ± SD</strong></td>
<td><strong>M ± SD</strong></td>
<td><strong>M ± SD</strong></td>
</tr>
<tr>
<td><strong>F (p)</strong></td>
<td><strong>F (p)</strong></td>
<td><strong>F (p)</strong></td>
<td><strong>F (p)</strong></td>
</tr>
<tr>
<td><strong>Benefit Ca</strong></td>
<td>21.42 ± 2.53</td>
<td>23.89 ± 2.73</td>
<td>21.50 ± 2.19</td>
</tr>
<tr>
<td><strong>Benefit Ex</strong></td>
<td>21.50 ± 2.19</td>
<td>23.89 ± 2.73</td>
<td>21.50 ± 2.19</td>
</tr>
<tr>
<td><strong>Barriers Ca</strong></td>
<td>16.53 ± 3.76</td>
<td>16.07 ± 4.41</td>
<td>15.03 ± 3.97</td>
</tr>
<tr>
<td><strong>Barriers Ex</strong></td>
<td>16.60 ± 2.67</td>
<td>16.40 ± 3.25</td>
<td>17.05 ± 3.51</td>
</tr>
<tr>
<td><strong>Bone health</strong></td>
<td>20.32 ± 8.06</td>
<td>20.04 ± 6.09</td>
<td>20.64 ± 3.69</td>
</tr>
<tr>
<td><strong>Nutrition</strong></td>
<td>79.10 ± 10.09</td>
<td>72.25 ± 14.05</td>
<td>79.10 ± 10.09</td>
</tr>
</tbody>
</table>

Note: ANCOVA = analysis of covariance; barriers Ca = barriers of calcium intake; barriers Ex = barriers of exercise; SES = self-efficacy for exercise.
daily caloric intake, but sodium intake was more than the recommended value [22]. These results suggest that there is a need to modify dietary intake patterns for the health of these women. Understanding the relationship of dietary intake of not only calcium and vitamin D, but all other nutrients might be an important step toward bone health. Furthermore, it is necessary to provide various programs or strategies including effective health behavior change techniques such as self-monitoring and self-regulation for healthy eating habits [27].

Findings of this study showed that the outcomes from the experimental group I were not noteworthy compared with those of experimental group II. Providing tailored feedback through interactive technology like mobile applications or tablet PCs can be a useful tool to motivate young adult women to change their lifestyle habits, and reinforce health behaviors and self-management abilities. Interventions using smartphones have been developed for long-term health problems such as mental health or chronic diseases that require patient self-management [28–30]; studies on those interventions reported positive results. However, in the current study, a feedback system seems not to contribute to improvement in self-management abilities. Prior to this study, we modified the SbFb application developed in our previous study so that the participants could record daily exercise and diet in more detail. Participants in the present study might feel bothersome to input detailed information on exercise and dietary intake daily. Also, the feedback responses might not be sensitive to their behaviors because actual changes in calcium and vitamin D intake were by a very tiny amount even though the participants tried to have calcium-rich or vitamin D–rich foods in abundance. In the future studies, more sensitive feedback strategies and easier input systems need to be constructed.

There were no significant differences among the three groups in lumbar BMD, measured by dual-energy X-ray as one of the outcomes of the study. Bone density measurement has been recognized as a general test and it is recommended that individuals be given a follow-up test depending on their clinical situations at 1–2 year intervals [24]. However, in the present study, the period between the first and last examinations was just 20 weeks; it would be unreasonable to expect dramatic changes in BMD. Therefore, there is a need for a longer-term study in the future.
Conclusions

In conclusion, the RCT showed that the experimental group I and the experimental group II showed positive outcomes regarding health belief related to exercise and calcium intake than did the control group. In addition, the two experimental groups also demonstrated positive results in the serum levels of calcium, vitamin D, and sclerostin compared to the control group. Although the experimental group I, which used mobile type—BH1, consisted of the SbFb application and group education, and the experimental group II, who received only group education, both exhibited positive outcomes in regard to the promotion of bone health, this study did not show any additional effect of the SbFb application on self-management ability for the promotion of bone health. Nonetheless, the SbFb application is very meaningful as it is the first application developed with the aim of improving women’s bone health. Secondly, the results of this study suggest that the contents and fusions of the application should be modified to achieve an improvement in self-management ability. In addition, various interventions, such as education, should be provided for young adult women to enable them to form healthy behaviors and achieve PBM.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Acknowledgment

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea funded by the Ministry of Science, Information and Communications Technologies and Future Planning (no. NRF-2012R1A1A3013540) and the Nursing Research Institute of Korea University.

References