Effects of Exercise and Nutritional Intervention to Improve Physical Factors Associated with Fracture Risk in Middle-aged and Older Women

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This 1-year intervention study was designed to examine the effects of exercise and nutritional intervention on the improvement of physical factors associated with fracture risk in middle-aged and older women. One hundred twenty-six women aged 55-75 years were divided into one of 3 groups: an exercise group, an exercise and nutrition group, and a control group. Nutritional intervention was designed to encourage women to obtain sufficient daily protein (65g or over) and calcium intake (600mg or over). The setting was center-based and home-based exercise. Measurements were bone stiffness, one-leg stance, whole body reaction time, grip strength, 10m obstacle walk and 30-second chair stand. Results show that exercise intervention can significantly improve physical ability in older women with regard to one-leg stance, whole body reaction time, 10m obstacle walk and 30-second chair stand, suggesting that older women are able to ameliorate fall risk factors by exercise intervention. The exercise and nutrition group had success in modifying bone loss when compared with the exercise group, suggesting that multimodal intervention that includes exercise and nutrition targeted at correcting bone loss should be recommended. The results suggest that exercise and nutritional intervention may be an effective approach to fracture prevention in middle-aged and older women.

Keywords: Fracture, Physical factors, Exercise, Nutrition, Older women

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1. Introduction

With the progression of the aging society, falls and fractures among the elderly are becoming increasingly significant social problems. Fractures can leave the elderly individual bedridden and lead to a deterioration in the QOL of not only the injured individual but also those who provide care, increasing the burden and cost of healthcare. It is, therefore, necessary for the elderly to improve their daily habits and effectively prevent falls and fractures in order to live a healthy and active life.

Osteoporosis and falls have been identified as risk factors for fractures in the elderly (Hanssens & Reginster 2003). Osteoporosis is particularly common in postmenopausal females, whose bone mass decreases rapidly with decreases in estrogen levels. It has been reported that 50% of postmenopausal women suffer from an osteoporosis-related fracture sometime during the rest of their lives, 25% of which suffer spine deformation (Melton, et al., 1989), and 15% of which suffer a femoral neck fracture (Barrett, et al., 1999). It is, therefore, important for postmenopausal women to maintain bone health and physical fitness in order to prevent osteoporosis, falls, and fractures.

Effective prevention of fractures in the elderly can be achieved through prevention of both osteoporosis and falls, which requires medication, nutritional management, and exercise. The importance of
exercise, in particular, has been emphasized in recent years, and the elderly are being encouraged to engage in exercise. The American College of Sports Medicine (ACSM) (Kohrt, et al., 2004) and the American Geriatrics Society (AGS) (2001) have demonstrated the importance of physical activity in the elderly for maintaining bone health and preventing falls, and have issued guidelines for exercise. In 2005, the Japanese Ministry of Health, Labour and Welfare emphasized the importance of exercise, under the new motto for a healthy lifestyle, "Exercise, Healthy Diet, No Smoking, and Medication," and advocated exercise.

Numerous studies conducted in the past decade have suggested that the level of physical activity plays an important role in increasing bone density of people of all ages (Hagberg, et al., 2001; Kemmler, et al., 2003). It has been clarified that weight-bearing exercise contributes to an increase in bone mineral density (BMD) to a greater degree than non-weight-bearing exercise does (Andreoil, et al., 2001; Nelson, et al., 1991). Exercise intervention for the prevention of falls requires the establishment of a program for appropriate exercise that reflects actual physical activities and that includes various physical activity factors such as muscle strength and balance capacity. It is important to consider not only the content, duration, and frequency of exercise but also individual variability when such an exercise program is designed (Skelton & Beyer, 2003).

Various local governments have organized programs for the promotion of exercise and the prevention of falls, adult diseases and osteoporosis, which have proved to be effective in improving vital function in the elderly. Despite its proven benefits for improving physical function, however, the rate of participation in exercise remarkably low (Tsuji, 2004). In addition, few studies on intervention methods from the viewpoint of the prevention of osteoporosis and falls have resulted in a delay in establishing optimal content, intensity, and duration of exercise.

In this study, a program was designed for middle-aged and older women with the purpose of increasing awareness of lifestyles and formulating optimal habits of living, exercise, and nutrition in order to prevent falls and fractures. The program was executed in a classroom and at home. Its benefits were assessed by examining the effect of one-year intervention on the risk factors of fractures, focusing on body composition and physical fitness. In order to improve prolonged living habits, it is important to improve lifestyles and diet as a means of securing a nutritional basis for exercise. Regarding diet, it is particularly important to take higher levels of calcium and protein than the standard intake levels. Therefore, we tested the hypothesis that exercise intervention combined with nutritional intervention would have beneficial effects on physical factors associated with fracture risk.

2. Methods

2.1. Subjects

One hundred and fifty-nine women aged between 55 and 75 participated in the program. Of these, 126 postmenopausal women (average age: 65.0±5.1; menopausal age: 49.2±6.9) met the following two conditions for the analysis of this study: 1) female over 1 year since the last menstrual period; and 2) female who participated in all baseline measurements and the follow-up measurement conducted 1 year after the beginning of the program. Applicants for the program were required either to have been advised to seek medical advice based on the results of BMD examination performed by K City or to have experienced the subjective symptom of tripping frequently. Participants with a previous history of heart disease or who were under treatment for heart disease or/and osteoporosis were excluded. Those undergoing treatment for other diseases were considered for inclusion after consultation with their physicians regarding the appropriateness of their participation. Individuals were encouraged to participate in the program by the following methods: 1) requests made by telephone to individuals randomly chosen from among individuals who had been advised to seek medical advice based on the results of osteoporosis examination, 2) notification by mail, and 3) advertisements placed in the City’s information newsletter. Participants gathered through the above-listed methods were randomly divided into two groups; that is, an Exercise Group (average age: 63.9±5.0; n=38), for which intervention would be limited to exercise only, and an Exercise & Nutrition Group (average age: 63.5±4.4; n=40), for which intervention would include both exercise and nutrition (dietary habits). The control group (average age: 68.0±4.6; n=38) was chosen from those who
had been advised to seek medical advise and who were not participating in any programs designed to promote health. Participants received a written explanation of the aim and methods of the study and the potential risks of participation, and were informed that participation in this program was voluntary and that they were free to withdraw from participation at anytime during the study. All participants received medical examinations and engaged in exercise prescribed by study design. Measurements and guidance of this study were performed at the K Prefecture Health Plaza and the Health Promotion Center. This joint research project was conducted by public health nurses employed at the K City Health Guidance Center, nurses, physiotherapists, dietitians, health improvement exercise instructors, and the authors.

2.2. Intervention Program

The participants were required to attend group exercise held at the Health Promotion Center once per week (intensified intervention period: 3 months) and were encouraged to perform exercise individually at home 3 times per week. Following the 3-month period, the participants were required to attend group exercise once per month (general intervention period: 9 months) with exercise at home performed on an individual basis 3 times per week. Individual participation records were checked during both periods to enable program monitoring as necessary.

2.2.1. Exercise Intervention

Focusing on aerobic and antigravity exercise, the program was designed with the aim of having participants consume 300kcal per exercise session. Considering the physical fitness of individual participants, a phased approach was adopted. In group exercise during the intensified intervention period, participants were given instruction on the prevention of osteoporosis and were directed to perform basic exercises, walking, basic classroom exercises (antigravity exercises and circuit training), exercise with a balance ball or a bench step, and footwork training with a ladder or a mini hurdle. In group exercise during the general intervention period, participants performed aerobic exercises (walking and bike ergometer) and antigravity exercises (one-leg stance, sumo-style leg stamping, and lifting with ball) as basic exercise, circuit training, and 7 types of muscle strength training with the use of no equipment (exercise to strengthen abdominal, gluteus maximus, quadriceps femoris, iliopsoas, hip abductor, hip adductor, adductor, and triceps surae muscles). Individual results were recorded in the exercise participation record. As non-group exercise, individual participants performed aerobics and antigravity exercises as basic exercise and circuit training and recorded the results. As the home-based training, participants were to perform exercise three times or more per week and to record the results. Regarding antigravity exercise, participants were encouraged to assume the one-leg stance for 1 set of one minute, 1 set of 20 sumo-style leg stamping, and 1 set of 20 lifting with ball during the intensified intervention period; and 2 sets of one-leg stance, 2 sets of 30 sumo-style leg stamping, and 2 sets of 30 lifting with ball during the general intervention period. Regarding muscle strength training, participants’ own body weight was utilized for training instead of muscle strength training machines in order that participants could perform the training at home. The performance of 1 set of 20 repetitions of 7 types of muscle strength training exercises was encouraged during the intensified intervention period and 2 sets of 20 repetitions of muscle strength training exercises during the general intervention period. Regarding walking, the participants were encouraged to walk 8,000 steps or more during both the intensified and general intervention periods.

2.2.2. Nutritional Intervention

The participants were directed to keep a daily diet record during the first and last weeks of the intensified intervention period, for one week after the intensified intervention, and for one week after one year from the beginning of the intensified intervention. Dietary habits were surveyed utilizing interview sheets in order to encourage better diet among the participants. The participants were encouraged to take at least 600mg of calcium, ideally 800mg, on a daily basis, together with a daily intake of 65g or more of protein. During the intensified intervention period, the participants were required to fill in a diet check sheet to be checked by dietitians, who advised them individually according to their diet records. During the general intervention period, the participants were required to fill in the diet check sheet for one week every month. These records were then utilized by dieticians to advise participants. The
Exercise & Nutrition Intervention Group was given instruction on cooking specifically designed for the prevention of osteoporosis during the intensified intervention period. As group guidance, all the participants were given a lecture on osteoporosis and diet during the intensified intervention period.

2.3. Measurements for Evaluation and Survey

Measurements for evaluation were conducted at the beginning of the intensified intervention (before the execution of any interventions) and after one year from the first measurement.

1) Physical measurements
   Body height, weight, and body fat percentage (with the use of a body fat scale, TANITA BF-210) were measured and BMI was calculated for each participant.

2) Bone fitness
   With the use of an ultrasonic bone evaluation apparatus (ALOKA, AOS-100), the speed of sound (SOS) in the right heel was measured by ultrasonic pulse transmission method.

3) Physical performance
   One-leg stance, grip strength, and 10-meter obstacle walk were measured with the use of the new physical tests formulated by the Ministry of Education, Culture, Sports, Science, and Technology (1999).

   Whole body reaction time: The individual participants were instructed to stand on the mat of a general reaction measuring device (Takei Co.: TKK126b) and to jump upright as quickly as possible when the lamp set 2 meters in front of the mat was lighted. The reaction time was measured 5 times, from which the maximum and minimum times were excluded in order to calculate the average time of the remaining three.

   30-second chair stand test (CS-30 test): The individual participants were instructed to sit on a 40 centimeter-high chair with their feet shoulder-width apart and arms crossed on the chest. At the signal “go,” the participant rises to a full standing position (body erect and straight) and then returns to the initial seated position. The participant is encouraged to complete as many full stands as possible within a 30-sec time limit. The score is the total number of stands executed correctly within 30 seconds.

4) A questionnaire on living habits, health consciousness, and exercise habits was conducted.

2.4. Statistical Processing

Values of each measurement item were expressed as mean value ± standard deviation. Interaction (time x group) was analyzed by two-way repeated ANOVA. The differences of the baseline values of measurement variables between groups were examined using one-way analysis of variance. Mean values of measurements before and after the interventions was compared using a paired t-test. The criterion for statistical significance was set at an alpha level of .05. In order to study the sensitivity to significant change of measurement variables, Effect Size (ES) was analyzed. An effect size of 0.2 to 0.49 was considered small; 0.5 to 0.79, moderate; and greater than 0.8, large (Thomas & Nelson, 1996).

3. Results

3.1. Comparison of the Exercise & Nutrition Group, the Exercise Group, and the Control Group at baseline, regarding Physical and Nutritional Characteristics and Physical Performance (Table 1, 2)

In terms of physical characteristics, there were significant differences in age and bone stiffness between the Control Group and the Intervention
Groups. Bone stiffness in the Intervention Groups was comparatively low. However, the Intervention Groups were significantly superior to the Control Group for CS-30 test, 10-meter obstacle walk and whole body reaction time. For the one-leg stance, the Exercise Group was significantly superior to the Exercise & Nutrition Group and the Control Group. For grip strength, the Control Group was significantly lower than the Exercise & Nutrition Group.

### 3.2. Changes in the Physical and Nutritional Characteristics of the Intervention Groups and of the Control Group after One Year Intervention Program (Table 1)

Compared before and after interventions, there was a significant decrease in body weight, body fat percentage, and BMI in the Exercise Group but not in the Exercise & Nutrition Group or the Control Group. Regarding bone strength, the Exercise & Nutrition Group showed a significant increase, while the Control Group showed a significant decrease. Calcium intake significantly increased 10.5% in the Exercise & Nutrition Group. In terms of total energy and protein intake, none of the groups showed significant change. In an analysis results of interaction with the use of two-way repeated ANOVA, significant interaction between body weight ($F=4.12, p<0.05$) and body fat percentage ($F=5.41, p<0.01$) was revealed, indicating the interposition of interacted factors among the groups and between the two measurements.

### 3.3. Changes in the Physical Performance of the Intervention Groups and the Control Group after One Year Intervention Program (Table 2)

None of the groups showed any significant change in grip strength. For one-leg stance the Exercise & Nutrition Group showed a significant increase with the rate of increase being 58.0%. The Exercise Group also showed a significant rate of increase at 15.7%, while the Control Group showed no significant increase. For Whole body reaction time, the Exercise & Nutrition Group showed a significant decrease (9.5%), as did the Exercise Group (6.9%), while the Control Group showed no significant change. For 10-meter obstacle walk time, the Exercise & Nutrition Group showed a significant decrease (13.9%), as did the Exercise Group (12.9%), while the Control Group showed no significant change. In the CS-30 test, the Exercise & Nutrition Group showed a significant increase (46.7%), as did the Exercise Group (29.7%) and the Control Group (21.3%). There was significant interaction among the CS-30 test ($F=13.02, p<0.001$), 10-meter obstacle walk time ($F=7.92, p=0.001$), and one-leg stance ($F=5.14, p<0.01$).

### 3.4. Effect Size (Table 3)

In the Exercise & Nutrition Group and the Exercise Group, the ESs of the CS-30 test and of the 10-meter obstacle walk were moderate, while the ESs of the other variables which showed significant change were small. In the Control Group, the ESs of all the variables which showed significant change were small.

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Table 1: Demographic and nutrition variables at baseline and 1-year measurement.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exercise + nutrition group</th>
<th>Exercise group</th>
<th>Control group</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n=40$</td>
<td>$n=48$</td>
<td>$n=38$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
<td>Postintervention</td>
<td>Baseline</td>
<td>Postintervention</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>53.0</td>
<td>6.4</td>
<td>52.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>29.5</td>
<td>5.5</td>
<td>29.0</td>
<td>5.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.2</td>
<td>2.5</td>
<td>23.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Bone stiffness (m/sec)</td>
<td>1531.8</td>
<td>15.1s</td>
<td>1539.5</td>
<td>14.3***</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>647.0</td>
<td>166.0</td>
<td>715.0</td>
<td>160.0*</td>
</tr>
<tr>
<td>Proteint (g)</td>
<td>71.6</td>
<td>13.5</td>
<td>74.0</td>
<td>10.9</td>
</tr>
<tr>
<td>Total energy (kcal)</td>
<td>1793.8</td>
<td>305.0</td>
<td>1807.0</td>
<td>263.0</td>
</tr>
</tbody>
</table>

Note. # $p<.05$, ## $p<.01$: significant group by time interaction between groups; n.s.: interaction not significant at $p>.05$;
* $p<.05$, ** $p<.01$*** $p<.001$: significant difference between postintervention and baseline;
S: $p<.05$, differences between exercise + nutrition group and control group at baseline.
Table 2  Physical performance variables at baseline and 1-year measurement.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Exercise + nutrition group</th>
<th></th>
<th>Exercise group</th>
<th></th>
<th>Control group</th>
<th></th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 40</td>
<td>n = 48</td>
<td>n = 38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline (M, SD)</td>
<td>Postintervention (M, SD)</td>
<td>Baseline (M, SD)</td>
<td>Postintervention (M, SD)</td>
<td>Baseline (M, SD)</td>
<td>Postintervention (M, SD)</td>
<td>P</td>
</tr>
<tr>
<td>CS-30 test (times)</td>
<td>18.2 (3.4)†††</td>
<td>26.7 (5.9)***</td>
<td>19.5 (4.2)‡‡‡</td>
<td>25.3 (5.2)***</td>
<td>15.5 (2.9)</td>
<td>18.8 (2.9)***</td>
<td>.001</td>
</tr>
<tr>
<td>10m obstacle walk (sec)</td>
<td>7.2 (0.9)†††</td>
<td>6.2 (0.8)***</td>
<td>7.0 (0.7)‡‡‡</td>
<td>6.1 (0.7)***</td>
<td>7.9 (1.1)</td>
<td>7.7 (1.1)</td>
<td>.99</td>
</tr>
<tr>
<td>Whole body reaction time (msec)</td>
<td>450.9 (74.4)††‖</td>
<td>408.2 (59.3)***</td>
<td>439.3 (62.5)‡‡‖</td>
<td>409.2 (42.5)***</td>
<td>503.7 (95.8)</td>
<td>472.8 (70.8)</td>
<td>.05</td>
</tr>
<tr>
<td>One-leg stance (sec)</td>
<td>68.1 (45.7)s</td>
<td>104.2 (30.8)***</td>
<td>93.9 (39.3)‡‖</td>
<td>108.6 (26.6)**</td>
<td>67.8 (45.1)</td>
<td>80.1 (44.4)</td>
<td>.001</td>
</tr>
<tr>
<td>Grip strength (kg)</td>
<td>24.3 (3.6)†</td>
<td>24.1 (3.1)†</td>
<td>23.6 (4.4)</td>
<td>24.2 (3.7)</td>
<td>22.7 (2.5)</td>
<td>22.3 (3.4)</td>
<td>.05</td>
</tr>
</tbody>
</table>

Note. † † †: p < .05; † † † †: p < .001: significant group by time interaction between groups; n.s.: interaction not significant at p > .05;
** p < .01, *** p < .001: significant difference between postintervention and baseline;
$: p < .01, $$: p < .001: differences between exercise + nutrition group and exercise group at baseline;
††: p < .05, † † †: p < .001, differences between exercise + nutrition group and control group at baseline;
‡‡‡: p < .01, ‡ ‡ ‡ ‡: p < .001, differences between exercise group and control group at baseline.

Table 3  Effect Size of significant changes in variables in 1-year measurement within group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exercise + nutrition group</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>-</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>-</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>-</td>
</tr>
<tr>
<td>Bone stiffness (m/sec)</td>
<td>0.25</td>
</tr>
<tr>
<td>CS-30 test (times)</td>
<td>0.66</td>
</tr>
<tr>
<td>10m obstacle walk (sec)</td>
<td>0.51</td>
</tr>
<tr>
<td>Whole body reaction time (msec)</td>
<td>0.30</td>
</tr>
<tr>
<td>One-leg stance (sec)</td>
<td>0.42</td>
</tr>
</tbody>
</table>

small.

4. Discussion

In this study, we have demonstrated that a 1-year exercise intervention combined with nutritional intervention undertaken by middle-aged and older women can safely improve physical factors associated with fracture risk.

Both the Exercise & Nutrition Group and the Exercise Group showed a significant increase in one-leg stance times with eyes open (58.0%, 15.7%), while the Control Group showed no significant change. According to Judge, et al., (1993), the subjects of their study, elderly women, underwent combined training; that is, lower leg muscle training (knee extension and leg-press), walking, and exercises including Tai chi three times per week for 6 months, resulting in an improvement in one-leg stance times by 17%. The results of this study confirm the results of the earlier study by Judge, et al. In studies which showed improvement in balance in the elderly, improvement of lower leg muscle strength was also exhibited (Judge, et al., 1993; Lord, et al., 1994). Showing improvement in one-leg stance times with eyes open and lower leg muscle strength in both the Exercise & Nutrition Group and the Exercise Intervention Group, this study produced the same results as earlier studies. For the assessment of lower leg muscle strength, the CS-30 test was the only test employed in this study. The CS-test, however, was reported by Jones, et al., (1999) as having high reliability and reproducibility and as being an appropriate method for the assessment of lower leg muscle strength in elderly people. Reporting that the CS-30 test showed high correlation...
with reproducibility, Nakatani, et al., (2002) also said that there was a significant correlation between the CS-30 test results and knee extension strength and that the CS-30 test was easy and effective as a test to assess lower leg muscle strength in healthy elderly Japanese individuals in the field. Based on the foregoing, the CS-30 test was used in this study. Results yielded by the CS-30 test showed a significant increase in all groups. The initial test values for the Intervention Groups were higher than those for subjects in the study by Nakatani, et al., (2002). An increase in post-intervention test values suggests that the intervention in exercise contributed to the improvement. As for the improvement in the CS-30 test in this study, the Exercise Group increased by 29.7%, while the Exercise & Nutrition Group increased by 46.7%, being remarkably higher than the improvement rate (13.5%) in the study by Cao, et al., (2005). It is speculated that this difference may be attributable to the difference in duration of exercise intervention (one year vs. three months). This seems to suggest that it is more effective for the elderly to perform exercise continuously for a prolonged period. Those subjects who were unable to undergo measurement of lower leg muscle strength due to knee pain were excluded from the data. It is considered important to advise individuals to concentrate their awareness on their hip joints and to assume a position that is not stressful for knees when undergoing such a measurement.

The Control Group also showed an improvement in lower leg muscle strength. While increased, however, the mean value of this group after one year was 18.8, a value equivalent to the starting values of the Exercise & Nutrition Group and the Exercise Group. The Control Group improved by 3, while the Exercise & Nutrition Group and the Exercise Intervention Group increased by 8 and 6, respectively. Furthermore, the increase in the lower leg muscle strength of the Control Group from 15.5 ±2.9 to 18.8±2.9 was low, compared with the results of the earlier study by Nakatani, et al., (2002), whose subjects were women of the same age. The Control Group consisted of individuals who had undergone all measurements both times and whose answers to the questionnaire showed no increase in the amount of exercise. The increase in the muscle strength of the Control Group may reflect the possibility that the initial lower leg muscle strength of the Control Group subjects were underestimated merely because of their lack of confidence. Haff (2005) has reported that elderly women tend to have little confidence in using their full capability due to their non-active lifestyles.

In 10-meter obstacle walk, both the Exercise & Nutrition Group and the Exercise Group showed significant improvement, while the Control Group remained the same. Nishijima, et al., (2003) have reported that the middle-aged and elderly individuals, who participated in muscle strength training with the use of machines and in aerobic training by step exercise with the aim of improvement in walking capacity, improved in 10-meter obstacle walk significantly. He has also been reported that the 10-meter walking with hurdles test is appropriate as a simplified measurement item because the test requires participants to use their muscle strength of femoral and iliopsoas muscle groups fully. In the exercise program designed for this study, training for abdominal, gluteus maximus, quadriceps femoris, iliopsoas, hip abductor, hip adductor, and triceps surae muscles was conducted. The results of 10-meter obstacle walk indicate the possibility that this muscle strength training contributed to the improvement of walking capacity.

Regarding bone stiffness, only the Exercise & Nutrition Intervention Group of the two Groups showed a significant difference after one year from the beginning of the intensified intervention. The Control Group also showed a significant difference. Numerous Japanese epidemiological studies have shown that body weight and BMI have a significant positive correlation with bone mass (Miyamura, et al., 1994). Nakata, et al., (2002) have reported in their study of middle-age women that the bone mass of the study subjects decreased with their loss of body weight. In this study, body weight and in BMI in the Exercise Intervention Groups decreased significantly, which is believed to have contributed to a decrease in bone stiffness of this Group. In terms of exercise intensities, exercise programs designed for earlier studies were not always in accord. The exercise program designed for this study was categorized as comparatively light exercise, which could be too light to contribute to increasing bone strength. The American College of Sports Medicine (ACSM) (2004) has suggested that the bone mass of both the males and the females over the age of 40 years decreases by 0.5% or greater every year. It is, therefore, important for postmenopausal women, that is, middle-aged and elderly women, to minimize
the loss of bone mass through the performance of exercise. Though bone stiffness in the Exercise Groups in this study decreased, the rate of decrease was only 0.2%. From the viewpoint of minimizing bone mass decrease, the exercise intervention of this study can be regarded as effective. It is speculated from the results of this study that it is more effective for an intervention program for osteoporosis prevention (i.e., maintenance or increase of bone mass) for postmenopausal women to include not only exercise intervention but also nutritional intervention.

This agrees with the results of a study by Wu, et al. (2006) on exercise, nutrition, and BMI. A significant increase in bone stiffness was also observed in the Control Group. Unfortunately, because the diet of the Control Group was not surveyed in this study, it is impossible to clarify the direct cause of the increase in SOS of this Group. Considering the fact that there was no increase in the amount of exercise of the participants of the Control Group, it is speculated that the above results are attributable to their improvement in diet.

Based on a study by Sirado, et al., (1998) reporting that exercise treatment can be effective only if patients continuously participate in the treatment, it was determined that frequency of exercise should be examined in this study. The exercise program designed for the Intervention Groups consisted of walking 8,000 or more steps and 20 or more sessions of muscle strength training in both the intensified and general intervention periods, and one set of antigravity exercise in the intensified period and 2 sets in the general intervention period. A set of antigravity exercise consisted of one minute of one-leg stance, 20 repetitions of sumo-style leg stamping, and 20 repetitions of lifting with ball. In the intensified intervention period, a number of participants succeeded in performing the antigravity exercise as it was designed, while a smaller number succeeded in performing 2 sets of the antigravity exercise in the general intervention period. As for walking, the target was 8,000 or more steps. However, few participants successfully completed the one-year walking program as instructed. Only one participant of the Intervention Groups completed the entire program exactly as instructed. There were some participants who successfully underwent the program during the intensified intervention period but not during the general intervention period. This indicates the necessary of re-establishing an appropriate amount of exercise from the viewpoint of participants’ capacity for continuation. It is also speculated that the once-per-month general intervention may insufficient in facilitating continuation of the program. The method of follow-up also needs to be reviewed.

Judging from the results of the assessment of physical fitness, the Intervention Groups showed a tendency for improvement. The ACSM (1995) has reported that exercise is necessary for the normal development and maintenance of bone health, and that the effect of exercise on bone mineral content of middle-aged and elderly women is not as significant as improvement of changes in BMD based on aging but is as significant as a reduction of changes based on a lack of exercise or inactivity, though to a minor extent. An appropriate amount of exercise can improve the muscle strength, muscle tenderness, and cooperativeness in elderly women, can prevent falls and can reduce osteoporosis-based fractures without fail, though indirectly (Iwamoto & Takeda, 1997). When examined not from the viewpoint of bone strength increase but from the viewpoint of the prevention of falls or/and fractures, participants in this study showed improvement in balance, lower leg muscle strength, and walking capacity. This suggests the effectiveness of this one-year exercise program.

Regarding rate of change of physical performance after one year from the beginning of the program, both the Exercise & Nutrition Group and the Exercise Group showed improvement, though the former exhibited a greater tendency for improvement than the latter. For the one-leg stance, the Exercise Group increased by 15.7% and the Exercise & Nutrition Group increased by 58.0%. For whole body reaction time, the Exercise Group decreased by 6.5%, and the Exercise & Nutrition Group decreased by 9.5%. For 10-meter obstacle walk, the Exercise Group decreased by 12.9% and the Exercise & Nutrition Group decreased by 13.9%. In the CS-30 test, the Exercise Group increased by 29.7% and the Exercise & Nutrition Group increased by 46.7%. For Effect Size, the Exercise & Nutrition Group had a higher value than that of the Exercise Group. These results indicate intervention including not only exercise but also nutrition is more effective.

It is generally considered difficult to strictly specify control groups in human-based studies. While it is possible to maintain control groups, which are set for the purpose of the verification of
effects on model groups, away from any organized interventions, it is not always possible to isolate them from all intervention factors, such as a visit to a health promotion center and the use of health information. Ethically, it is often difficult to exercise full control in a human-based study. The mean age of the Control Group in this study was higher than those of the Intervention Groups. The subjects of the analysis in the Control Group were to be those who underwent all measurements, which were conducted twice, and showed no increase in exercise amount based on questionnaire responses. The analysis subjects of the Control Group chosen through this process were older than those of the Intervention Groups. This can be explained as follows: the results of the first measurements were returned to the subjects with a notice that they were to undergo all measurements again after one year, which may have lead younger members of the subjects to engage in exercise voluntarily. It is also speculated that many of those who participated in this study as members of the Control Group tended to be highly conscious of their health and physical fitness, have positive ideas about health promotion, and that they in fact acted upon those ideas.

In order to clarify effective ways of establishing healthy living habits with appropriate exercise and diet, individual lifestyles should be examined and assessed comprehensively in consideration of rest-based health habits including sleep in the future. Based on the results of such examinations and assessments, ideal methods of improving diet and physical fitness of local elderly individuals should continue to be pursued.

5. Summary

With the aim of improving living habits and preventing fractures in elderly women, a program of one-year exercise intervention and guidance for nutrition was designed and executed on both group and individual bases. The effects of the program on fracture risk factors were examined and analyzed. The subjects of this study consisted of an Exercise & Nutrition Group (n=40), an Exercise Group (n=48), and an Control Group (n=38), whose mean ages were 63.5±4.4, 63.9±5.0, and 68.0±4.6, respectively. After the 3-month intensified intervention and the 9-month general intervention, physical fitness and body composition, which are associated with fracture risk factors, were measured and living habits were surveyed. The results indicated that both the Exercise & Nutrition Intervention Group and the Exercise Group improved in the one-leg stance with eyes open and in lower leg muscle strength. In 10-meter obstacle walk and in whole body reaction time, both the Exercise & Nutrition Group and the Exercise Group showed significant improvement, while the Control Group showed no significant change. Of the Intervention Groups, only the Exercise & Nutrition Group showed a significant increase in bone stiffness at the end of the one-year program. Due to nutritional guidance, the calcium intake of the Exercise & Nutrition Group increased significantly (10.5%) on measurement at one-year. These results proved the improvement of fracture risk factors such as bone stiffness, balance capacity, reaction time, lower leg muscle strength, and walking capacity. These results provide evidence of significant improvements in physical factors associated with fracture with a 1-year combined intervention of exercise and nutritional guidance.

References


