Impact of a 12-Month Exercise Program on the Physical and Psychological Health of Osteopenic Women

Gina [redacted] PhD,[*] Pierre Gauthier, PhD,[†] Pierre-Michel Roy, MD,[‡] Hélène Payette, PhD,[§] Philippe Gaulin, MSc,[||] Monique Harvey, BSc,[||] Lucie Péloquin, MSc,[||] and Marie-France Dubois, MSc[||]

OBJECTIVE: To describe the effect of a supervised physical activity program on the physical and psychological health of osteopenic women.

DESIGN: A randomized controlled trial.

SETTING: Sherbrooke, Quebec, Canada.

PARTICIPANTS: A total of 124 community-living postmenopausal women, between 50 and 70 years of age, with low bone mass took part in the study.

INTERVENTION: Subjects allocated to the experimental group performed weight-bearing exercises (walking, stepping up and down from benches), aerobic dancing, and flexibility exercises for 60 minutes, three times a week, over a period of 12 months. All subjects were invited to attend bi-monthly educational seminars covering topics related to osteoporosis.

OUTCOME MEASURES: Spinal and femoral bone mineral density (BMD), functional fitness (flexibility, coordination, agility, strength/endurance, cardiorespiratory endurance), psychological well-being, back pain intensity, and self-perceived health.

RESULTS: Spinal BMD stabilized in the exercisers while decreasing significantly in the controls ($P = .031$). No change in femoral BMD was observed in either group ($P = .597$). Four of the five parameters chosen to evaluate functional fitness, namely flexibility, agility, strength, and endurance, were affected positively by the exercise program (all $P < .01$). Adjusting for prescores by means of an analysis of covariance revealed a significant difference between the groups in psychological well-being, which favored the exercisers ($P = .012$). After 12 months, back pain reported by exercisers was lower than that reported by controls ($P = .008$). Finally, self-perceived health increased in the exercise group, whereas no difference was observed in the control group ($P = .790$).

CONCLUSION: These results suggest that after 12 months, exercising can produce a significant increase above initial levels in the functional fitness, well-being, and self-perceived health of osteopenic women. Intensity of back pain can also be lowered by exercise. The exercise program succeeded in stabilizing spinal BMD but had no effect on femoral BMD. **J Am Geriatr Soc 44:756–762, 1996.**

The aging of the population has made osteoporosis a major public health problem with significant medical, social, and economic consequences.[1] Knowledge of these consequences has motivated the scientific community to search for interventions designed to prevent or slow down the progress of the disease.[2] In particular, the potential of physical activity as a strategy for counteracting bone loss has been the subject of many studies.[3–5] Some of these studies have identified regular physical exercise as one of the determinants of peak bone mass in adults.[6] Others have shown that prolonged immobilization is responsible for accelerated bone loss.[7] A number of cross-sectional studies have also reported a significant relationship between physical activity and bone mass. As pointed out by Dalsky,[4] these studies must be interpreted with caution since they do not isolate the effect of exercise from that of genetic, nutritional, and hormonal factors. Only longitudinal studies, preferably including a control group, can truly measure the impact of exercise on bone mass. Several such studies can be found in the literature.[8] These have been largely restricted to healthy postmenopausal women who present no risk factor for osteoporosis.[9] To our knowledge, no randomized controlled trial has ever been conducted to estimate the effectiveness of physical activity in women with bone mass below a preset threshold. Moreover, in most of the studies conducted to date, bone parameters were the primary, if not exclusive, outcome measures. Although it is recognized that the prevention of fractures is the endpoint of clinical relevance, the large sample size needed to demonstrate a reduction in fracture rate forces investigators to study a proxy for fracture risk, namely change in the amount of bone present.[10] Yet a significant effect on bone mass following an intervention does not imply an improvement in the quality of life of the participants. Because of the costs involved in treating osteoporosis and the potential benefits offered by exercise, several authors have emphasized the need to expand the evaluation of exercise programs to include other relevant endpoints, such as quality of life and general fitness, and well-being.[11,12]

From the [*]Department of Community Health Sciences, [†]Faculty of Physical Education, [‡]Department of Family Medicine, and [§]Department of Nursing, University of Sherbrooke; and [||]Geriatrics Research Centre, Youville Hospital, Sherbrooke, Canada.
This study was funded by Grant #6605–3507-OS from Health and Welfare Canada.
Address correspondence to Gina Bravo, PhD, Centre de Recherche en Gerontologie et Geriatrie, Hopital d'Youville, 1036 Rue Belvedere Sud, Sherbrooke, Quebec J1H 4C4, Canada.

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Recently, a randomized controlled trial was conducted to determine the effectiveness of a 1-year, supervised, physical activity program offered to osteopenic women. Several indicators of physical and psychological well-being were included along with bone density as outcome measures. The present report describes the impact of the program on these endpoints.

METHODS

Subjects

Women participating in the study met the following criteria: (1) aged between 50 and 70 years; (2) menopausal for at least 12 months; (3) not institutionalized, (4) not expecting to being absent from the city for more than 2 months, (5) no contraindication to undertaking physical exercises without close medical supervision, and (6) judged osteopenic after a dual-energy X-ray absorptiometric evaluation (DEXA, Lunar Radiation Corporation, Madison, WI). For the purposes of the present study, women were considered eligible if spinal bone mineral density (L2-L4) was less than 1 g/cm^2 or proximal femur bone mineral density was less than 0.9 g/cm.[2,13,14] This last threshold is slightly higher than that suggested by the WHO in 1994.[15]

Subjects were volunteers recruited through advertising in the media and personal contacts with physicians in the area. Publicity posters were also posted in a variety of strategic locations, such as day-care centers, drugstores, and physicians' offices. After signing an informed consent form agreeing to participate in the study, eligible subjects were assigned randomly by the research coordinator to the experimental or control group. Prepared from random number tables, randomization was blocked and stratified by age (5-year groups) and by whether the subject was on cyclical etidronate therapy and/or estrogen replacement therapy.

Exercise Program

Three times a week, women in the experimental group were asked to attend hour-long exercise classes held in a hospital and conducted by two experienced exercise leaders. The presence of two educators permitted the progress of the participants to be monitored on an individual basis and facilitated the adaptation of the program to the functional limitations of each participant. In order to increase accessibility to the program, exercisers were invited to choose between morning (11:00 to 12:00), afternoon (1:00 to 2:00), and evening (7:00 to 8:00) classes. Group varied in size from 13 to 22 participants.

Each exercise session was divided into four segments. The session began with a 10-minute warm-up period during which moderate exercises promoting flexibility involving the main joints and muscles were performed. The second segment consisted of about 25 minutes of rapid walking. Once a week, this activity was replaced by aerobic dancing. Fifteen minutes of stepping up and down from benches followed, interspersed with passive or active rest between each 2-minute period. Each subject had to progressively reach 60 to 70% of her heart rate reserve. Participants took their pulse immediately after the walking or dance period and again at the end of the last period of stepping up and down from benches. A period of localized exercises concentrating on the muscles made up the third part of each session. This period, which lasted 10 to 15 minutes, included a variety of anisometric exercises performed in a standing, sitting, or prone position and involved principally the muscular groups of the upper limbs, the scapular waist, the abdomen, and the back. The addition of wrist weights and elastic tubes was used to increase resistance, with the aim of reaching 12 to 15 maximum repetitions. The exercise session ended with a 5-minute cool-down period that varied in content but included relaxation movements, stretching, balancing, and coordination exercises with aids such as tennis balls, hoops, and sand bags. A complete description of the exercise program is available from the corresponding author upon request.

Educational Seminars

Subjects assigned to the control group were asked to continue their daily routine activities. As will become clear below, all outcome variables, except bone density, are either of a subjective nature or partially dependent on the subject's motivation. Recognizing the possible threat of the Hawthorne effect on the internal validity of the study and the important role played by education in any rehabilitation program, all subjects (experimentals and controls) were invited to attend bi-monthly seminars given by experts in the field. Topics included risk factors, nutrition, medical treatments, and fall prevention. Seminars were given separately to the experimental and control subjects in order to avoid contamination. For the same reason, the potential of physical activity was not addressed during any of the information sessions.

Outcome and Confounding Variables

As mentioned previously, bone density was measured before the study to determine the eligibility of a potential subject. Because of a known seasonal variation in bone measurements after menopause,[16] bone density was remeasured only at the end of the program, that is, 1 year later. The other outcome variables, functional fitness, psychological well-being, back pain intensity, and self-perceived health, were measured at 6-month intervals.

Bone measurements were taken by one of three technicians, blinded to group assignment. Measurements were made with a DEXA model DPX-αlpha and analyzed with Lunar Software Version 3.6z. Consistent subject positioning at posttest was checked by examining the pretest hard copy report of each subject. Scanning speed was chosen in light of the subject's weight (750 μA for those weighing 125 pounds or less, 3000 μA for the others). Short-term precision of BMD measurements is known to be high (about 0.01 g/cm^2 at the lumbar spine and femoral neck).[17]

Functional fitness was determined through the five components of the American Alliance of Health, Physical Education, Recreation, and Dance (AAHPERD) battery of tests.[18] Designed to measure flexibility, coordination, body agility, strength/endurance, and cardiorespiratory endurance in older adults, this battery has recently been the subject of two validation studies.[19,20] All five tests were administered by research personal who had no previous contact with the subjects. Flexibility was measured by the modified "sit-and-reach" test. The subject, seated on the floor with legs extended, slowly reaches forward with her hands placed one on top of the other and holds the final position for at least 2 seconds. Two trials were performed and the highest number of inches reached was the score recorded. The "soda pop" test was used to evaluate coordination. Seated at a table on which six circles had been drawn along a straight line with cans of soda pop placed in three of the circles, the subject was instructed to successively turn the cans upside down onto the adjacent circle and then return them to their original position. Two trials were performed and the time required to complete each trial was recorded. The score assigned to the subject was the best time. Agility was assessed by asking the subject seated in a chair to rise and walk around a cone placed to the right of the chair, return to a full seated position, and repeat the walking portion around a second cone placed at the same distance to the left of the chair. One trial consisted of two complete circuits of the agility course. Two trials were performed with a 30-second rest period between trials. The shortest time required to execute the test was recorded as the score. Strength/endurance was measured by asking the subject seated in a chair to lift a 4-lb. weight, starting with the dominant arm extended toward the floor and contracting the biceps through the full range of motion until the lower arm touched the hand of the evaluator on the biceps. The number of complete repetitions in a 30-second interval was the score assigned to the subject. Finally, cardiorespiratory endurance was assessed by the time required to walk half a mile. Subjects were instructed to walk as fast as they could walk comfortably without running.

Dupuy's General Well-Being Schedule,[21] which has been validated extensively,[22] was used to evaluate psychological states. Total scores range from 0 (extreme distress) to 110 (optimal well-being). Using the previous 4 weeks as a reference period, the intensity of back pain was evaluated with a 10-point numerical scale ranging from 0 (no pain) to 10 (extreme pain). The metrological qualities of this instrument are well established.[22] Subjective health was measured by a single question taken from the Canadian Health Promotion Survey, which asks the respondent to qualify her state of health from excellent (1 point) to poor (5 points). In spite of its simplicity, this question has proved to be strongly correlated with more sophisticated indices of overall health.[23]

In addition, several potentially confounding variables were measured: age, years postmenopause, body mass index, medication/supplements (estrogen, progesterone, calcium, phosphorus, vitamin D, fluoride, calcitonin, bisphosphonates, and anabolic steroids), and smoking, drinking, and caffeine habits. Because the control subjects were not asked to refrain from regular exercise, it was essential to monitor their physical activity closely throughout the study. This was done using the *Seven-Day Recall*, developed and validated for the Five-City project.[24,25] This measure, which was administered every 4 months, generates an estimate of energy expenditure expressed in kcal per week. The instrument was also administered to the experimental subjects in order to document their physical activity between exercise classes.

Sample Size Estimate

For many of the outcomes chosen for the present study, the parameters needed to determine sample size were not available because they had never been used on the targeted population. Accordingly, sample size was determined using the standardized approach proposed by Cohen.[26] Setting α at 5% (one-tailed) and β at 20%, a minimum of 50 subjects per group had to be available at the end of the study in order to detect a medium effect size of 0.5. Anticipating a 20% attrition rate, the aim was to enrol at least 60 subjects in each group.

Statistical Analyses

Baseline data were first examined to verify if the two groups were comparable on all variables. Student's *t* test was used for normally distributed variables. Continuous variables failing the normality test were analyzed using Mann-Whitney's test. Fisher's exact test was used to study categorical variables. For normally-distributed outcome variables, the effect of the program was studied through a mixed, two-factor analysis of variance incorporating the group, time, and group-by-time interaction effect. The positive effect of the program was judged on the basis of a significant group-by-time interaction. All confounding variables unequally distributed between the groups were included in the analyses as co-variates. Analyses were done, first considering all experimental subjects (intent-to-treat analysis), then restricting the experimental group to those subjects who completed the program (as-treated analysis). To study the effect of the program on pain intensity, the Wilcoxon rank sum test was used given the typically skewed distribution of this variable. Friedman's test was used to investigate self-perceived health in view of the ordinal nature of this outcome. All analyses were performed using SAS statistical software (SAS Institute Inc., Cary, NC).

RESULTS

During the 6-month recruitment period, 213 women contacted the research coordinator to express their interest in the study. Of these, 52 did not satisfy all six eligibility criteria, 18 because of high BMD. Thus, 161 women were eligible for the study. Nineteen of the 161 women eligible chose not to enter the study for various reasons such as lack of interest, major impediments, or lack of encouragement from their physician. Comparison of these 19 women with those who agreed to enter the study revealed no statistically significant difference with regard to age, bone mass, and use of estrogen or bisphosphonates. Of the 142 women who agreed to enter the study, 18 (13%) were lost to follow-up. Losses were equally divided between the exercise and control groups. In general, these women were in worse physical and psychological health than those who were remeasured at the end of the study (data not shown). Analyses presented in this report are thus based on 124 subjects, 61 exercisers and 63 controls.

Baseline data on exercisers and controls are presented in Table 1. It may be noted that the time since menopause was longer among the women in the control group. On the other hand, the proportion of women who took progesterone was higher in the experimental group. In addition, 30 women in the experimental group and 20 in the control group were on a combination of two or three drugs. Although not significant, the proportion of women in the experimental group receiving estrogen and calcium simultaneously was slightly higher than in the control group. As these three differences favor the experimental group, the corresponding variables were controlled for when analyzing the effectiveness of the program. No other variable approached the significance level. One fact worth noting is that the initial degree of sedentariness was comparable in the two groups.

Table 2 presents the mean values obtained by the two study groups on the eight normally-distributed outcome variables. After 12 months, we see a slight increase in spinal bone density among the experimental subjects, whereas a significant decrease was observed among the controls ($P = .035$). The effectiveness of the program on this variable is revealed

Table 1. Baseline Characteristics of the Study Groups

	Exercisers n = 61	Controls n = 63	*P* Value
Continuous variables*			
Age (years)	59.6 ± 5.82	59.9 ± 6.36	0.789
Years postmenopause	12.4 ± 8.91	18.6 ± 13.20	0.008
Body mass index (kg/m²)	24.3 ± 4.05	24.3 ± 3.71	0.980
Alcohol consumption (Number of drinks/month)	6.05 ± 13.20	4.39 ± 10.70	0.527
Energy expenditure (kcal/wk)	12,130.8 ± 2,821	12,033.1 ± 2,516	0.844
Categorical variables†			
Smoking status (%)			
Non smoker	32 (54.2)	36 (57.1)	
Ex-smoker	17 (28.8)	17 (27.0)	
Smoker	10 (17.0)	10 (15.9)	0.969
Caffeine consumption (%)			
Light	9 (15.3)	7 (11.1)	
Moderate	32 (54.2)	43 (68.3)	
Heavy	18 (30.5)	13 (20.6)	0.294
Subjects taking (%)			
Estrogen	22 (36.7)	16 (25.4)	0.241
Progesterone	9 (15.3)	1 (1.6)	0.008
Calcium	46 (78.0)	48 (77.4)	1.000
Phosphorus	2 (3.4)	4 (6.5)	0.680
Vitamin D	20 (33.9)	18 (29)	0.695
Bisphosphonates	4 (6.7)	5 (7.9)	1.000
Estrogen + calcium	12 (20.3)	5 (8.1)	0.068
Calcium + vitamin D	13 (22.0)	7 (11.3)	0.144
Estrogen + calcium + vit. D	5 (8.5)	8 (12.9)	0.560
Activity level (%)			
rather sedentary	20 (36.4)	23 (37.7)	
moderately active	30 (54.6)	36 (59.0)	
rather active	5 (9.1)	2 (3.3)	0.471

* Data expressed as mean ± standard deviation.
† Data expressed as number of subjects with percentage in parentheses.

by the significant group-by-time interaction ($P = .031$). The effect of the program on femoral bone density shows a similar trend to that for the spine, namely an increase in the experimental group (0.002 ± 0.043 g/cm²) and a decrease in the control group (-0.003 ± 0.055 g/cm²). However, the differences are too small for the group-by-time interaction effect to be statistically significant ($P = .597$).

A significant difference with regard to flexibility was observed between the groups at 12 months ($P = .036$). This difference is attributable primarily to a deterioration in the performance of the controls. The performance of the experimental subjects on the coordination test improved substantially after 6 months. However, the interaction effect is not significant because of a slight improvement in the performance of the controls. A similar scenario was observed on the agility test. However, in this case, the average performance of the two groups is clearly different at 12 months ($P = .025$), and the interaction effect is significant. After 12 months, a significant difference was found between the groups on the strength test ($P < .001$). The increase in the experimental subjects is substantial enough compared with the relative stability in the controls to conclude that a significant interaction effect exists. Finally, the effect of the program on cardiorespiratory endurance is apparent after only 6 months of treatment ($P = .008$). In spite of a slight improvement in the control subjects, the interaction effect is very significant. The improvements observed in physical capacity cannot be attributed to a change in weight, which was found to be not significant ($P = .605$). Nor can it be attributed to an increase in the time devoted to physical activity outside the program. Indeed, no time effect could be detected in average caloric expenditure as measured by the 7-day recall although a slight decrease in activity was noted in the winter months ($P = .070$). Furthermore, at each time point, the groups were comparable with respect to this potentially confounding variable ($P > 0.05$).

The average psychological well-being of the control group was significantly lower than that of the experimental group in pretreatment ($P = .027$). Therefore, caution must be used when interpreting the difference between the groups at 12 months. When the initial level of psychological well-being is controlled for using an analysis of covariance for repeated measures, the P value associated with the interaction effect is .012, thus confirming the positive effect of the program on the psychological well-being of the participants.

As indicated previously, nonparametric analyses were performed on the last two outcome variables, namely back pain intensity and self-perceived health. The results show that after 12 months of treatment, the pain reported by the experimental subjects was lower in intensity than that felt by the

Table 2. Outcome Values for the Study Groups at Baseline (T_0), Six Months (T_1), and Twelve Months (T_2)*

	Exercisers			Controls			*P* Value for the Group-by-Time Interaction Effect‡
	T_0	T_1	T_2	T_0	T_1	T_2	
BMD (g/cm²)							
Spine	0.911 (0.158)		0.916 (0.154)	0.932 (0.181)		0.920† (0.180)	0.031
Femur	0.745 (0.106)		0.747 (0.100)	0.749 (0.108)		0.745 (0.112)	0.597
Functional tests							
Flexibility (inches)	23.02 (3.54)	23.98 (2.97)	23.27† (3.04)	23.27 (3.78)	23.72 (3.58)	21.85† (4.09)	<0.001
Coordination (seconds)	13.06 (2.42)	11.75 (2.03)	11.41† (2.49)	12.83 (2.53)	12.27 (1.60)	12.51† (1.95)	0.123
Agility (seconds)	30.35 (5.29)	26.94 (4.01)	26.51† (4.53)	29.80 (4.49)	28.19 (3.44)	28.39† (4.36)	<0.001
Strength (# of repetitions)	18.86 (4.11)	20.85 (5.44)	20.87† (4.97)	18.25 (3.55)	19.91 (3.61)	17.77† (4.17)	0.002
Endurance (minutes)	9.27 (1.14)	8.30 (1.00)	8.23† (1.16)	9.14 (0.88)	8.87 (1.12)	8.93† (0.87)	<0.001
Psychological well-being (/110)	73.38 (14.74)	74.55 (15.16)	80.98† (16.13)	67.15 (15.15)	71.83 (17.68)	69.84 (16.95)	0.028

* Data reported as mean values with standard deviation in parentheses.
† Indicates a significant within-group time effect following an analysis of variance for repeated measures; $P < .05$.
‡ Based on a mixed, two-factor analysis of variance.

controls (2.65 vs 3.93, $P = .008$). Furthermore, Friedman's nonparametric test showed an increase over time in the proportion of experimental subjects who had a positive perception of their state of health ($P = .002$). Over the same period, the distribution of the variable remained relatively stable among the controls ($P = .790$).

Figure 1 gives a visual presentation of the impact of the exercise program. Results are presented in terms of the percentage improvement observed in each group between the beginning and the end of the program. The conclusions that may be drawn are similar to those mentioned above. However, it should be noted that these analyses ignore the existence of the measures taken at 6 months, which explains the slight variations in P values.

As mentioned earlier, these analyses were redone, limiting the experimental group to the subjects who maintained their participation right to the end of the exercise program. A total of 133 exercise sessions were held. Of the 61 women in

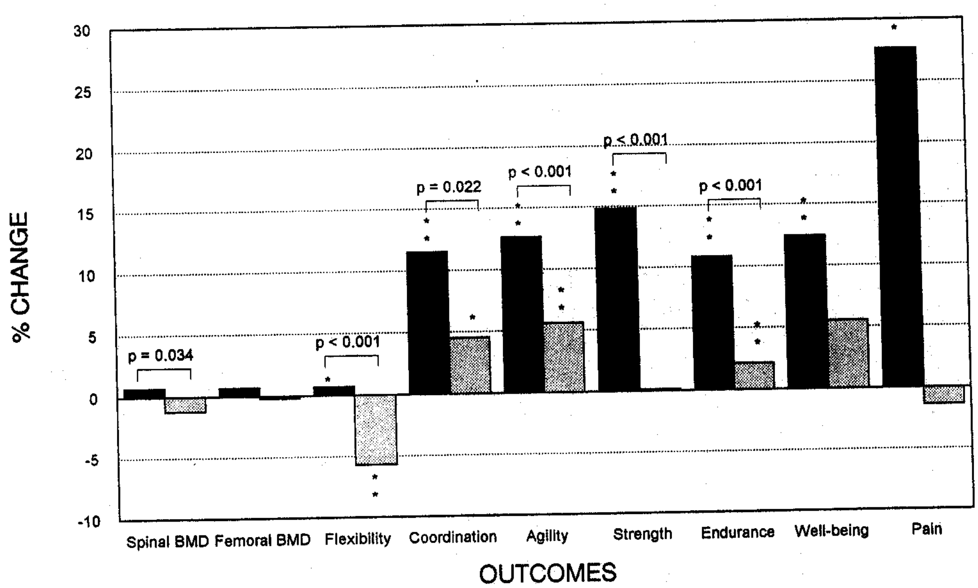

Figure 1. Percentage change in outcome measures for the exercisers ■ and controls ▩ over a 12-month period. Between group comparison of percent change based on a two-sample *t* test; except for pain, Wilcoxon rank sum text. Within-group test of a nul percent change based on a one-sample t test; except for pain, Wilcoxon signed rank test. *$P < .05$, **$P < .01$.

the experimental group included in the preceding analyses, 17 had dropped out during the course of the exercise program, and 14 of these dropped out during the first 3 months of the program. The average assiduity of the 44 women who continued to participate in the program was 73% (SD = 14.6%). The only significant difference between the women who continued to participate and those who dropped out was in body mass index, which was slightly higher in the latter group (23.42 ± 3.43 vs 26.67 ± 4.74; $P = .020$).

The analyses conducted on the limited experimental group produced the same results as those described above, except in the case of two variables. The first difference concerns the coordination test where there was a significant difference between the groups after 12 months ($P = .011$). The P value associated with the interaction effect barely exceeds the significance threshold ($P = .065$). On the other hand, excluding drop-outs from the experimental group shows the impact of the exercise program on agility 6 months earlier ($P = .044$).

DISCUSSION

To our knowledge, the present study is one of the first to rely on a randomized design for evaluating the effectiveness of exercise in women with bone density below a preset threshold. Nelson et al.[27] recently published the results of a study similar to ours in design but different with respect to the definition of the targeted population. Indeed, bone density was not a criteria for inclusion in that study, resulting in baseline BMD values for their subjects slightly higher than those of ours.

A second feature of the present study is that variables related directly to quality of life were included in the evaluation of the exercise program. Although the pertinence of having a positive effect on bone mass is undeniable, it is unlikely that this effect is perceived by the participant. Yet the importance of feeling a short-term effect of well-being on maintaining a new life habit is well known.[28] The positive effect observed on psychological well-being, back pain intensity, and self-perceived health suggests that the quality of life of the participants in the program improved significantly.

By noting that the exercise program had a positive effect on back pain intensity, we are not implying that women with osteopenia report more pain than other women of the same age. Experience of back pain is prevalent in the older population and was present, to varying degrees, in 70% of our sample.[29] Low bone density without vertebral compression fractures does not cause pain per se. Moreover, minor vertebral deformities caused by vertebral compression fractures are usually not associated with pain.[30,31] For the present study, intensity of back pain was chosen as an outcome measure not because of its association with low bone mass, but rather as a marker of quality of life.[31] The same rationale motivated the decision to use measures of psychological states and self-perceived health as outcomes.

The on-going rehabilitation program offered at the Queen Elizabeth Hospital in Toronto is one of only a few that has been evaluated in terms of its effects on the general well-being of patients with low bone mass. After a description of the educational, social, and exercise components of the program, Chow et al.[32] present data on 90 patients followed for 2 years. Although all 90 were enrolled in the program, 53 of these patients, who exercised at least three times a week and showed significant improvement in VO_2 max, were designated as the exercise group. The remaining 37 patients were classified as the nonexercise group. Using a 0 to 10 visual analog pain scale, the investigators observed a two- to threefold improvement in pain tolerance in the exercise group. On the other hand, the severity of back pain increased in two-thirds of the patients designated as nonexercisers. It is also mentioned that those who exercised reported an improvement in well-being, stamina, strength, and self-confidence. However, no data are supplied to support these conclusions.

Most longitudinal studies designed to evaluate the effects of exercise training are concerned with maintaining or increasing bone mass. However, some investigators have included measures of fitness in their evaluation of exercise. Results of these studies, though not always consistent, generally support the hypothesis of an increase in physical fitness following exercise training.[5] The results of our own study lead to the same conclusion. Its interest lies in the measure of physical fitness that appears more representative of the daily life activities of older people. Given that lack of coordination, endurance, agility, and strength have been identified as risk factors for falling,[33,34] improved performance in the five items measured by the AAHPERD battery may prevent an osteopenic women from falling, thereby reducing her risk of fracture.

Bone mass maintenance was observed in the lumbar spine with no effect in the femoral neck. The different effects observed at the two sites studied could be attributed to two factors. First, the exercise program developed for the present study was designed mainly to stimulate the axial skeleton. Consequently, more effect was expected at the lumbar spine than at the femoral neck. The type of bone found primarily at the two sites could also explain the results. The lumbar vertebrae are 65% trabecular bone, one characterization of which is greater metabolic activity. The femoral neck, on the other hand, is 75% cortical bone, which is more compact and less quickly reactive to treatment.[35,36] Improvements in spinal BMD following an exercise program, with no change in femoral BMD, have also been observed in two recent clinical trials.[37,38] However, both spinal and femoral BMD were affected positively by the exercise program evaluated by Nelson et al.,[27] perhaps because of the high level of intensity that characterizes their training program.

In spite of this limitation, the positive effect of the program on spinal bone mass, and the general well-being of the participants, is sufficient to consider the intervention effective. It is worth noting that, in general, this effectiveness is apparent even when the women who dropped out of the exercise program are included in the analyses. Studies published to date generally exclude drop-outs. Recognizing the bias that characterizes the interpretation of results generated by an analysis that is limited to subjects who adhered to the treatment being studied,[39] efforts were made to encourage all subjects to return for the final measure. An attrition rate of 13% between the beginning and end of the study attest to the success of these efforts. This decision to remeasure drop-outs increases the validity of our study.

CONCLUSION

This study demonstrates the physical and psychological benefits from physical activity available to women between the ages of 50 and 70 with low bone mass. The results lead us to recommend that similar programs be offered to women interested by this type of intervention. In addition to increasing the well-being of millions of women currently suffering from this disease, the possible resulting reduction in treatment costs could lighten the considerable financial burden placed on society.

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