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Home-based trunk-strengthening exercise for osteoporotic and osteopenic postmenopausal women without fracture – a pilot study

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Objectives: To investigate whether a 12-week home-based programme of trunk-strengthening exercise could benefit spinal mobility, function and quality of life for osteoporotic and osteopenic postmenopausal women without fracture.
Designs: Randomized controlled clinical trial.
Setting: Department of Physical Therapy in National Taiwan University Hospital.
Subjects: Twenty-eight postmenopausal women (mean age 60.3 ± 9.3 years) diagnosed with osteoporosis or osteopenia without fracture history were recruited for this study. Subjects were randomly assigned into exercise or control groups, each consisting of 14 subjects.
Interventions: The 12-week exercise programme included strengthening routines for the trunk extensor and flexor muscles. The subjects performed three sets of 10 repetitions for each of the exercises, with programmes carried out three times per day at home.
Main outcome measurements: Muscular strength, spinal range of motion (ROM) and motion velocity, Oswestry Disability Questionnaire (ODQ) and quality of life (QOL) were measured before the start and after completion of the exercise programme.
Results: Statistically significant improvements were demonstrated in spinal ROM and motion velocity in the sagittal and frontal planes for the exercise group ($p<0.05$). Further, the strength of the trunk flexors and extensors increased after exercise training ($p<0.05$). ODQ measure was significantly reduced in the exercise group ($p<0.05$), while the controls showed no significant change. Subjects in the exercise group showed better satisfaction in some domains of the Short-Form-36 Health Survey quality of life questionnaire ($p<0.05$).
Conclusions: This 12-week home-based trunk-strengthening exercise programme could improve trunk mobility and strength, and enhance QOL in osteoporotic and osteopenic postmenopausal women without vertebral fracture. Future study should recruit more cases or more severe subjects to verify the results.

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Introduction

Osteoporosis is a major public health problem characterized by low bone mass and increased susceptibility to fracture.[1,2] It is demonstrated that nearly 20% of Taiwanese women over 65 years of age suffered from spinal fracture secondary to osteoporosis,[3] a risk comparable to that of their Western counterparts.[4] It is well known that both aerobic and resistance exercise training, providing mechanical stimuli, are important and effective for the maintenance or improvement of bone health.[2,5] Additional benefits from regular exercise included reducing risk of osteoporosis; improving stability thereby reducing risk of falling and associated injuries and fractures; and also providing a number of psychological benefits related to preserved cognitive function and self-efficacy.[6,7]

Previous investigations have suggested that a significant relationship exists between muscle strength and bone density,[8,9] and some longitudinal studies have also shown a positive effect of strengthening exercise on muscle strength.[10,11] However, the effects of strengthening exercise on bone mineral density (BMD) are controversial,[12,13] and little attention has been addressed to the influence of strength, spinal mobility and functional status. Moreover, a previous study has reported that these effects decayed rapidly after stopping exercise training.[14] Such training programmes should be easy to learn, easy to perform, and easy to review at regular intervals. A home programme which is well designed will be less costly and more enjoyable for osteoporotic postmenopausal women.

The impact of osteoporosis on individual function levels and quality of life (QOL) was of particular interest; however, to the best of our knowledge, no study has yet been done on the assessment of the efficacy of exercise programmes for osteoporotic postmenopausal women without fractures. Our previous investigation showed that, even in subjects without vertebral fractures, osteoporosis was associated with increased functional impairment level.[15] In addition, some workers have pointed out that progression of spinal osteoporosis results in a progressive decline in health-related QOL.[16–18] Thus, we considered it important to develop a programme for osteoporotic postmenopausal women without fracture to facilitate exercise habituation and prevent further functional and QOL decline.

The purpose of this pilot study was, therefore, to investigate the efficacy of a 12-week home-based trunk-strengthening exercise programme on spinal mobility, functional impairment level and QOL for osteoporotic and osteopenic postmenopausal women without fracture. The study hypothesis was that spinal mobility in subjects undergoing a 12-week home-based trunk-strengthening programme would be improved, as assessed by trunk muscle strength, spinal range of motion (ROM) and velocity, as well as decreased functional impairment and improved QOL.

Materials and methods

Study design

This was a single-blind, randomized controlled study. The tester was not aware of the grouping, with participants randomly assigned into exercise or control groups.

Subjects

Postmenopausal women who had been diagnosed with osteoporosis or osteopenia by dual-energy X-ray absorptiometry (DEXA, Norland XR-26 Mark II; Norland Corp., Wisconsin, USA) for measurement of lumbar spine (L2–4) BMD (g/cm^2) were recruited from an outpatient department of a medical centre. The long-term coefficient of variance calculated from daily measurements of areal BMD on a lumbar phantom was 0.7%.[19]

Medical charts of all subjects were reviewed to obtain information concerning past medical history and current medication. Of the 33 postmenopausal women who had an interest in participating initially, however, only 28 fulfilling the following inclusion criteria were recruited for the study: (1) menopause for at least one year[20]; (2) no fracture history; and (3) no medical conditions that would interfere with the test results, such as hyperparathyroidism, renal disease, poorly controlled hypertension and cardiopulmonary disease, or using medicine that could interfere with calcium absorption (Figure 1).

Written consents were obtained from all subjects. After the initial evaluation, the participants

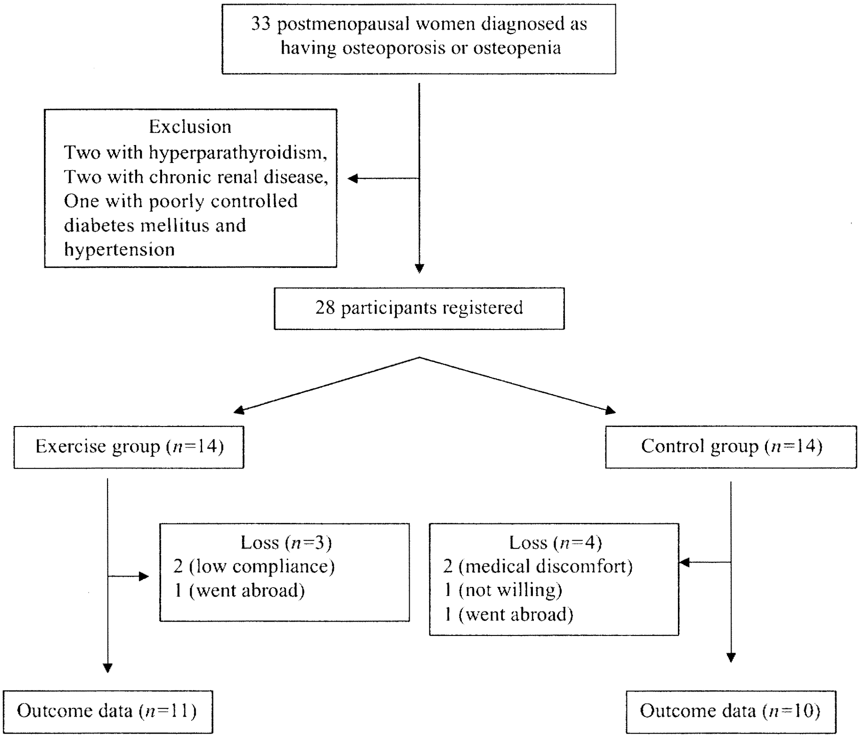

Figure 1 Recruitment of participants.

were randomly assigned to either the exercise group or the control group. A table of random numbers was used to assign the subjects into groups. To ensure equal group sizes, the assignment was by block, with block size being four, i.e., there were two subjects in each group for every four subjects recruited. Finally, each group consisted of 14 subjects. Subjects in the exercise group were instructed in the accurate performance of the strengthening exercises by a licensed physical therapist. The control subjects were told to maintian usual dietary habits and physical activities. All subjects were instructed not to change their physical activity habits, medication or diet until completion of the study.

Measurements

All subjects were assessed when recruited, with the assessments consisting of trunk flexion/extension isokinetic strength, and spinal ROM and motion velocity in three motion planes (sagittal, frontal and transverse). In addition, functional impairment was measured using the Oswestry Disability Questionnaire (ODQ),[21] and QOL assessment was conducted using the Short-Form-36 Health Survey (SF-36) before and after the 12-week exercise programme.[22,23]

Cybex 6000 (Cybex; Division of Lumex Inc., Ronkonkoma, NY, USA) was used to measure the peak torque of the trunk flexor and extensor muscles in newton-metres. Patients performed both flexion and extension for five repetitions at angular speeds of 60°/s and 120°/s, respectively. Mean of peak torques of each repetition of the trunk flexors and extensors was recorded for analysis. The isokinetic measurement reportedly has good reliability and validity.[24]

A Lumbar Motion Monitor (LMM; Chattanooga Group Ltd, Oxfordshire, England) was used to assess spinal ROM and motion velocity. The subjects were asked to perform movements within maximum range and using fastest speed within 8 s in each plane.[25] It was also reported to have good reliability and accuracy.[25]

The ODQ instrument consists of 10 items, pain intensity, personal hygiene, lifting, walking, sitting, standing, sleeping, sex life (if applicable), social activity and travel.[21] It was self-administered in a standard manner by subjects. The total sum of the subscales yields a maximum score of 50. The score was then doubled and interpreted as a percentage of patient-perceived disability. The higher score indicates the severer functional impairment level.

The SF-36 questionnaire was used to evaluate the QOL. It was self-administered in a standard manner, with no interpretation of the questions by the interviewer, requiring approximately 5–15 min to complete. The SF-36 consists of 36 items, with between two and six response options for each item, assessing eight distinct health concepts or domains: physical function, physical role (role limitations due to physical health problems), bodily pain, general health perceptions, vitality (energy or fatigue), social functioning, emotional role (role limitations due to emotional problems), and general mental health (psychological distress and well-being).[22] Item scores were coded, summed and transformed along a scale from 0 (worst possible health) to 100 (best possible health) for each domain. Higher score indicates greater satisfaction with quality of life. Good reliability and validity have been demonstrated for the SF-36.[23]

Exercise programme

The strengthening programme included three sessions every day (seven days a week) at home for 12 weeks. The subjects in the exercise group all had an instructional booklet in which detailed descriptions of the exercises with figures were shown. An introductory session was given to familiarize them with all the exercises in the booklet. A log book and phone contact every two weeks were provided to record and foster compliance, respectively. At the final assessment, each subject submitted the written record of daily exercise, which was then assessed for overall compliance (total exercise sessions [$3 \times 7 \times 12 = 252$]). If subjects failed to achieve a minimum 70% completion rate,[26] they were classified as dropouts.

The aim of the exercise programme was to promote trunk stabilization and increase the ROM of trunk extension. As exercises were selected by a physical therapist based on an individual's abilities, for some individuals only a subset of routines was used for each position initially, with items added as performance improved. The detailed exercise programmes were as follows:[27]

In supine position: (a) isometric abdominal contraction to strengthen abdominal muscles; (b) gluteal setting and bridging (pelvis raising) to strengthen hip extensors; (c) pelvis raising with legs crossed; (d) pelvis raising with single-leg raise. In prone position: (a) head and thorax extension with chin retraction with progression to arms at sides, behind head, and overhead; (b) leg raise to extend the spine, alternate legs initially, and then both; (c) combination arm–leg raise with initially of one arm and opposite leg, and then all four limbs simultaneously. On hands and knees position: (a) alternate arm raises; (b) alternate leg raises; (c) opposing arm and leg.

Subjects were asked to maintain pelvis posterior tilt during exercise sessions. Each exercise session began with a warm-up and ended with stretching of the target muscles. Each movement was held for 3 s initially, with the exercise interval lengthened to a maximum of 10 s as endurance increased. Subjects were asked to perform three sets of 10 repetitions for each exercise initially; with repetitions and interval increased according to each subject's capability. Subjects exercised at their own pace.

Statistical analysis

Results are presented as mean with standard deviation, as analysed using the Statistical Package for Social Sciences (SPSS for Windows Release 10.0; SPSS Inc. Chicago, IL, USA). The Mann–Whitney *U*-test was used for between-group comparison of all the baseline measurements, with the Wilcoxon signed ranks test used to compare baseline and post-training data. The alpha level was set at 0.05.

Results

Eleven subjects (78.6%) completed the exercise programme, with exercise compliance over 90% throughout the exercise period (range 86.9–98.5%).

Two subjects were excluded due to low compliance (below 70%) because of personal circumstances, with the third individual failing to attend our final measurement session due to travel abroad. Two subjects in the control group experienced medical discomfort, and one was not willing to do the final test. The other one was also travelling abroad. None of the exercise group complained of discomfort during the strengthening period. Because of the small sample size and relatively high dropout rate, data for all the 28 subjects were included for analysis.

All participants in this study received calcium supplementation (600–900 mg/day) but none were under other bone-specific medication therapy. There were only two subjects (one in the exercise group and the other in the control group) who had been under hormonal therapy for two and three years, respectively.

There were no statistically significant differences in the between-group comparison in the basic physical characteristics (Table 1). The L2–4 BMD for the exercise and control groups was 0.741 ± 0.121 g/cm^2 (*T*-score −2.41) and 0.785 ± 0.148 g/cm^2 (*T*-score −2.06), respectively. During the 12-week study period, no significant height loss was determined for any subject. Between-group comparison of baseline measurements also revealed no significant difference.

The ROM, motion velocity and trunk strength values for the three planes before and after 12 weeks of exercise are compared in Table 2. For the exercise group, the ROM was significantly increased in the sagittal and frontal planes ($p<0.05$). Increases of motion velocity were demonstrated for all three planes in the exercise group, and the significance was also shown in the sagittal and frontal plane ($p<0.05$). All strength tests after resistance training in the exercise group showed significant increase except for the trunk flexor at an angular velocity of 60°/s ($p<0.05$). No statistically significant change of all variables measured was shown in the control group.

Table 1 Between-group comparison of baseline physical characteristics

	Exercise (*n*=14)	Control (*n*=14)
Age (years)	61.7±9.0	58.6±9.3
Body height (cm)	154.8±5.6	154.8±5.8
Body weight (kg)	53.0±4.2	52.5±8.3
Body mass index (kg/m^2)	22.09±2.56	22.56±2.09
Bone mineral density (g/cm^2)	0.741±0.121	0.785±0.148
T-score	−2.41±0.93	−2.06±1.10

No significant differences noted for any of the above comparisons.

The results of the ODQ and QOL assessment are presented in Table 3. Significant between-group differences were not demonstrated for any of the baseline measurements. In the exercise group, however, ODQ measure was significantly decreased after exercise training ($p<0.05$), while there was no change in the control group. Significant improvement in SF-36 QOL scores was demonstrated for physical role, bodily pain and mental health in the exercise group ($p<0.05$), while no significant changes were noted in the control group.

Discussion

This study has shown that a daily home-based trunk-strengthening exercise programme over 12 weeks results in some improvements in spinal muscular strength, ROM and motion velocity, reduced functional impairment, and enhanced QOL for postmenopausal women with osteoporosis and osteopenia without fractures.

Sinaki *et al*. have reported that a back strengthening programme significantly increased the strength of the trunk extensors within three months.[28] The present study also demonstrated significant improvements in trunk strength in the exercise group, in agreement with the previous studies.[8,9,28] Although a significant relationship exists between muscle strength and bone density, the results of strengthening exercise on BMD for osteoporosis women are controversial. Some of them could not show positive effects of strengthening exercise on the lumbar spine (L2–4) BMD.[10,11] It might be due to insufficient training intensity on target bone, and insufficient training duration.

However, the aim of this study was not to show how to improve BMD in osteoporotic postmenopausal women but how to improve functional level and QOL, therefore, BMD was not reassessed after training. Besides, bone remodelling takes at least 100 days[29] and our exercise programme lasted for only 12 weeks. A longer training period and

Table 2 Spinal range of motion, velocity and strength in the sagittal, frontal and transverse planes for the two groups before and after training

	Exercise group (n=14)		Control group (n=14)	
	Pre-test	Post-training	Pre-test	Post-training
Range of motion (°)				
Sagittal	49.9±17.2	59.3±10.3*	54.9±14.9	49.1±15.8
Frontal	40.6±9.4	45.0±9.9*	58.8±14.6	57.8±12.2
Transverse	52.9±16.9	56.9±13.5	43.8±15.2	42.0±6.7
Velocity (°/s)				
Sagittal	65.3±21.9	89.1±22.8*	77.6±27.3	58.8±15.0
Extension	69.0±23.3	95.3±22.0*	80.9±26.2	68.3±13.7
Bend-down	77.5±24.3	86.8±22.5*	77.8±16.3	72.8±15.5
Bend-up	76.9±22.6	87.9±29.1*	79.1±18.8	70.8±14.9
Rotation-f	107.6±38.5	136.1±39.3	135.3±42.4	116.9±33.3
Rotation-e	111.3±35.0	139.8±33.1	139.3±49.4	120.8±36.2
Strength (N-m)				
Flexion at 120°/s	59.9±18.2	68.9±23.7*	67.4±31.1	57.8±14.3
Flexion at 60°/s	87.8±26.0	96.6±14.4	87.8±18.3	85.9±17.8
Extension at 120°/s	41.4±19.1	48.7±19.5*	49.6±15.9	42.7±18.1
Extension at 60°/s	60.5±21.2	76.6±17.9*	66.9±24.7	66.5±20.5

* Wilcoxon signed ranks test, $p<0.05$.

assessment of the effect on BMD will be used in a future study.

Spinal mobility is important for assessment of the functional performance of patients with spinal disorders,[30] however, there has been no previous study investigating this parameter and exercise training in this population. Our results show that subjects who were exercising achieved better spinal ROMs and motion velocities after training. By contrast, subjects in the control group showed mild deterioration after 12 weeks. Given the limited sample size, the exact clinical significance

Table 3 Oswestry Disability Questionnaire and quality of life measurement for the two groups before and after exercise training

	Exercise group (n=14)		Control group (n=14)	
	Pre-test	Post-training	Pre-test	Post-training
Oswestry mesaure	11.88±14.63	1.4±3.3*	10.7±12.0	10.8±15.4
25th percentile	0	0	1.5	0
50th percentile	7	0	8	0
75th percentile	22	0.5	13	23
Quality of life[a]				
Physical examination	67.5±18.6	71.8±13.0	70.4±13.4	72.7±17.2
Role physical	45.3±11.0	75.9±22.3*	46.4±18.9	66.4±.24.0
Bodily	67.9±20.4	78.1±12.8*	80.3±20.5	84.1±20.3
General health	57.2±15.7	57.8±7.4	67.7±13.2	62.7±17.4
Vitality	59.7±19.8	65.8±11.3	64.3±17.9	60.7±10.5
Social emotion	82.1±23.9	91.4±12.4	83.0±15.2	81.3±12.8
Role emotional	83.2±29.1	90.9±12.4	81.7±20.9	81.7±27.2
Mental health	63.3±10.2	69.4±10.0*	72.9±16.4	66.7±9.5

* Wilcoxon signed ranks test, $p<0.05$.
Role physical: limitations due to physical problems; role emotional: limitations due to emotional problems.
[a] Quality of life was evaluated with the Short-Form-36 Health Survey questionnaire.

of the improvements on ROM and motion velocity of spine could not be established conclusively. Future study should recruit more subjects and follow them for a longer period to observe the impact of trunk mobility on functional status and QOL.

Our results revealed significant improvement in the physical role, bodily pain and mental health domains of the SF-36 QOL questionnaire for the exercise group, but not the controls. This finding was in agreement with previous studies. Kemmler *et al*. reported that an intense exercise training programme was effective in improving strength, QOL parameters and even BMD in early postmenopausal women.[20] The SF-36 questionnaire used in the present study has gained widespread acceptance for general population studies, clinical trials and methodological investigations.[31,32] It is a generic instrument providing a broad range of data employed in previous studies to compare subjects both within and across diseases. Recently, some researchers have suggested that generic questionnaires have limited ability to cover all aspects of a given disease as compared with a disease-specific questionnaire;[16] these measures were considered to contribute little to the understanding of the total impact of osteoporosis. However, targeted questionnaires do not always provide an advantage over generic instruments.[33] Future study may use a disease-specific questionnaire like the Quality of Life Questionnaire of the European Foundation for Osteoporosis[16] or the Quality of Life Questionnaire for Osteoporosis[34] to provide more comprehensive information.

Exercise was recommended as the treatment for postmenopausal osteoporosis,[35] but the optimal exercise parameters and how to facilitate and encourage exercise motivation become important issues to be solved. In this 12-week pilot design, the home programme seemed to be a less costly and more enjoyable method for osteoporotic postmenopausal women, but compliance and long-term effects were concern. Kerschan *et al.* conducted a study to follow up the long-term effects on an unvarying exercise programme carried out at home.[36] After 7.7 years, the compliance of the training group was about 36%, and the results suggested that an unvarying home-based exercise programme might support general agility but did not yield enough force to improve muscle strength and postural stability in healthy postmenopausal women. What is needed is a more appropriate, enjoyable and interesting exercise programme for comprehensive improvement of functional outcome and QOL in postmenopausal women.

There were limitations to this study. First, there was the small sample size, although the single-blind and well-randomized design together with the standard procedure helped to maximize its heuristic value. The surprisingly good results may be due to the ethnic background of our participants as, traditionally, Taiwanese women seldom perform strengthening exercises, especially of the muscles around the trunk. So the exercise effect was promising. They typically choose calisthenics and exercises such as yoga and tai-chi chung, which did not focus on strength. Our previous study[2] and that of Lau *et al.*[37] also showed greater response, in terms of femoral neck BMD in Chinese postmenopausal women, to high-impact aerobic training. Future studies should utilize a larger sample size to establish this efficacy.

Secondly, there was a marked difference between the exercise and control groups in terms of contact with the care team. This may have had beneficial anxiety-reduction or attitudinal/motivational effects biasing the study results, especially in the mental health domain.

In summary, a 12-week home-based trunk-strengthening exercise programme is somewhat effective for improving spinal ROM and motion velocity, decreasing ODQ measure and enhancing QOL in osteoporotic and osteopenic postmenopausal women without fractures. Future studies should utilize more samples, longer training

Clinical messages

- Simple home-based trunk exercises seem acceptable to postmenopausal women at risk of osteoporosis.
- Such exercises may lead to reduced back disability and increased trunk mobility.
- Larger trials are warranted in the light of these findings.

periods and contact equivalence to establish the long-term effects of home-based strengthening programmes for postmenopausal women.

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