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Stability of Kyphosis, Strength, and Physical Performance Gains 1 Year After a Group Exercise Program in Community-Dwelling Hyperkyphotic Older Women

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Abstract

Objective—To determine if subjects maintained improvements in kyphosis, spinal extensor strength, and physical performance 1 year after a 12-week multidimensional group exercise program.

Design—Follow-up data compared with posttest outcome measures.

Setting—Outpatient academic medical center.

Participants—Nineteen of the initial 21 women, ages 65 to 80, with thoracic kyphosis of 50° or greater at the onset of the study completed follow-up testing.

Interventions—Initial intervention included multidimensional group exercise performed 2 times a week for 12 weeks, consisting of spinal extensor strengthening, flexibility exercises, and integrated spinal proprioception training. Subjects exercised independently during the following year.

Main Outcome Measures—Primary measures at the 1-year follow-up were usual and best kyphosis. Secondary measures included spinal extensor strength, modified Physical Performance Test (PPT), and the Jug Test.

Results—Subjects maintained gains at the 1-year follow-up ($P > .05$). Best kyphosis improved by 3° during the follow-up year ($P = .022$). There were no significant declines in usual kyphosis ($P = .302$), spinal extensor strength ($P = .999$), PPT ($P = .087$), and the Jug Test ($P = .999$) at follow-up.

Conclusions—Hyperkyphotic women maintained gains in usual kyphosis, spinal extensor strength, and physical performance 1 year after a group exercise program. Improvement in best kyphosis in the year after the intervention was also observed. Detraining effects may be minimized by multidimensional exercises.

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Keywords

Aging; Exercise; Kyphosis; Posture; Rehabilitation

Increased thoracic kyphosis among older community-dwelling women has been associated with a decline in physical performance, impaired balance, slower walking and stair climbing speeds, shorter functional reach, and decreased household activity performance.^{1,2} The kyphosis angle has been correlated with back extension strength, which is an important predictor of quality of life among postmenopausal women with osteoporosis.^{3,4}

Previous studies have shown promising short-term improvements in kyphosis among older women with a 12-week yoga intervention⁵; 6-month spinal bracing intervention⁶; and 4-week treatment with spinal weighted orthosis, trunk extension exercises, and balance exercises.⁷ One study provided long-term follow-up of a 2-year spinal-strengthening exercise program that reduced kyphosis and improved strength among hyperkyphotic subjects.⁸ However, strength and kyphosis gains were not maintained at the 8-year follow-up.⁸

Our previous study⁹ showed improved kyphosis, strength, and physical performance after a 12-week multidimensional exercise program. Given this short-term success, we sought to investigate whether subjects were able to maintain improvements over time. The primary purpose of this study was to determine if subjects maintained improvements in thoracic kyphosis, spinal extensor strength, and physical performance 1 year after a 12-week multidimensional group exercise program.

METHODS

Study Design

In our previous cohort study,⁹ 21 women were tested before and after a 3-month group exercise intervention. Nineteen (91%) of the 21 women in the previous study agreed to retesting 1 year later. The Institutional Review Board at the University of California, San Francisco approved this study, and all participants gave informed consent.

Subjects

Subjects were initially recruited from the University of California, San Francisco Medical Center and San Francisco senior programs through mailings, flyers, and public talks. At baseline, the mean age of the subjects was 72.0 ± 4.2 years, the mean bone mineral density T score was 1.5 ± 1.3 , and the median number of vertebral compression fractures was 2. Subjects were not excluded for antiresorptive medications. All of the subjects were white with the exception of 1 Hispanic woman. Two women did not participate in follow-up testing. One declined to participate, and 1 was excluded because of recent surgery.

Compliance With Exercise Program During Year Break

According to verbal self-report, only 1 subject continued the exercises. Another reported that she had begun swimming daily. None of the other women (17 out of 19) had altered their usual activities. However, all participants reported the incorporation of postural correction into ADLs.

Intervention

In the previous study, participants engaged in group exercises led by a physical therapist twice a week for 12 weeks and performed daily postural corrections at home.⁹ The exercises

included spinal extension; scapular and transversus abdominis strengthening; postural alignment training; and stretching to increase thoracic rotation and extension, shoulder flexion, and hip extension.⁹ Equipment included foam rollers, gym balls, stretch straps, handheld dumbbells, and resistance bands.⁹ No structured intervention occurred between the completion of the 3-month exercise program and the 1-year follow-up.

Measures

In our previous study, data were collected at 3 time points: time 1, time 2 (1 week later), and time 3 (after the 3-month exercise program). Data from time 1 and time 2 were used to test reliability and measurement variability (table 1). In this study, we collected data at time 4, 1 year after intervention completion.

The following measures in the previous study⁹ that showed statistically significant improvements between time 2 and time 3 were selected as outcome measures for time 4: usual and best kyphosis, spinal extensor strength, modified PPT, and Jug Test. The protocols for testing all measures were identical to those used in the previous study.⁹ Kyphosis was measured by using a Debrunner kyphometer^a to determine the Cobb angle between the T2 and T3 vertebrae and the T11 and T12 vertebrae. Usual kyphosis was standardized at full exhalation, whereas best posture measurements were measured at full inhalation and participants were cued to “stand as upright and tall as you can.”⁹(p193) Trunk extension muscle strength was measured on the Biodex 3^b by using a trunk extension protocol with the spine attachment; participants were positioned in 55° hip flexion and 35° to 40° knee flexion with feet supported.⁹ The Modified PPT involved 7 standardized timed tasks and 2 untimed tasks of physical performance to reach a maximum score of 36 points.¹⁰ The Jug Test measured the time in seconds to transfer five 3.8L (1gal) water-filled jugs (3.8kg [8.5lb]) from a shelf at patella height to a shelf at acromion height, 1 jug at a time.⁹

Statistical Analysis

Data analysis was completed by using Minitab statistical software.^c A 2-factor mixed-model General Linear Model analysis of variance was used to determine if there were significant differences across time in each dependent variable. If a significant difference was found, Tukey pair-wise comparisons were used to examine the differences between time 3 and time 4 for each of the following dependent measures: kyphosis usual, kyphosis best, spinal extensor strength, PPT, and Jug Test. We established statistical significance at *P* less than .05. Of the 21 subjects in the original study, 17 completed the Jug Test, 18 completed the PPT, and 19 subjects completed the kyphosis measurements and Biodex testing. Two women did not perform the Jug Test because of wrist dysfunction; another did not perform the PPT because of Achilles' tendonitis. Statistical tests were run by using a complete case analysis (only the 17 subjects who completed all measures at all time points), a last value forward method (missing values at time 4 were replaced with values at time 3), and an available case analysis (19 out of 21 subjects for the kyphosis and strength measures, 17 out of 21 for the Jug Test, and 18 out of 21 for the PPT). There was no significant difference between the methods, so we have chosen to present the available case analysis results.

Data Collection

Subjects were contacted by telephone at 11 months after time 3 and completed follow-up testing at 12 or 13 months after time 3. To maintain the consistency of measurements with the initial study, the same researcher directed Biodex testing, PPT, Jug Test, and kyphometer

^aTechmedica Inc, 487A Calle San Pablo, Camarillo, CA 93010.

^bBiodex Medical Systems Inc, 20 Ramsay Rd, Shirley, NY 11967.

^cMinitab Inc, Quality Plaza, 1829 Pine Hall Rd, State College, PA 16801-3008.

placement on subjects. A second investigator read and recorded the kyphometer measurements.

RESULTS

Changes in Outcome Measures Between Time 3 and Time 4

Change in kyphosis—There were no significant differences in usual kyphosis ($P>.05$). Best kyphosis improved by 3° ($P=.022$) (table 2).

Change in physical performance—No significant differences were found in PPT or Jug Test scores ($P=.087$; $P=.999$, respectively).

Change in strength—There was no significant difference in spinal extensor strength ($P=.999$).

DISCUSSION

On 1-year follow-up testing, subjects not only maintained improvements in usual kyphosis but also improved best kyphosis measurements by 3° . In the only other long-term follow-up study⁸ of interventions measuring kyphosis, both exercise and control subjects developed greater thoracic kyphosis at the 8-year follow-up. We were surprised that kyphosis reduced given that only 1 woman continued to perform the exercises. One explanation for this result may be the intervention helped subjects gain postural awareness that they incorporated into ADLs. This improved awareness may have been caused by the inclusion of integrated postural training in the exercise program, which provided sensory cues about alignment and position from the feet to the occiput to teach participants to correct posture. This improvement is consistent with research⁷ suggesting that women with greater kyphosis have impaired perception and integration of correct postural alignment, affecting the ability to maintain normal upright posture. Given that kyphosis progresses approximately 1% each year in women 65 years and older, slowing the progression of kyphosis and reducing kyphosis is likely a clinically important difference.^{11,12} Other studies^{13,14} have shown that greater kyphosis corresponds with a decrease in function including reduced walking speed, impaired balance, and increased odds of experiencing an injurious fall, with a graded increase in difficulty in physical function as kyphosis worsens. Reducing kyphosis progression has the potential to improve function. Unfortunately there are no thresholds for kyphosis and physical function and it is difficult to compare studies because there is no consistent method for measuring kyphosis.

Back muscle strength has been shown to decrease by approximately 2.5% per year in women 50 to 80 years old.¹⁵ Sinaki et al⁸ showed an average loss of back muscle strength of 1.65% per year in the exercise group over the 8-year follow-up period. As a group, our subjects were able to maintain their original gains in spinal extensor strength over the 1-year follow-up. Among our 19 subjects, 9 increased, 5 decreased, and 5 maintained the strength of their back extensors during the year. By improving posture and incorporating it throughout ADLs, some of our subjects may have been able to prevent the strength loss that has previously been reported from detraining.

Even though there was no significant difference in physical performance test scores between time 3 and time 4, a trend toward a loss of improvement existed ($P=.09$). This was not unexpected because physical performance measures are more multifactorial than strength and posture. Brown et al¹⁰ defined the Modified PPT scores in terms of not frail (32–36 points), mildly frail (25–31 points), or moderately frail (17–24 points).¹⁰ Clinically, our subjects moved from the “mildly frail” category at time 2 (mean, 30 points) to the “not frail”

category at time 3 (mean, 32 points) and then back to the “mildly frail” category at time 4 (mean, 31 points).

Our previous study¹² suggests that a 12-week multidimensional exercise intervention improves kyphosis, spinal strength, and physical performance. This follow-up study suggests that older women maintain, or even improve, 1 year after 12 weeks of multidimensional exercise.

Study Limitations

One limitation of our study is that we did not include measures of spinal proprioception. Two studies^{16,17} have reported reliable methods for measuring proprioception in the lumbar spine. However, it has not been established whether these methods are directly applicable to the thoracic spine. Another limitation of our study is that it is not a randomized controlled trial.

Future studies may explore objective measures of proprioception to correlate with the change in posture. Furthermore, a randomized controlled trial with a larger sample size and longer follow-up would allow optimal analysis of the change in kyphosis, strength, and physical performance.

CONCLUSIONS

Hyperkyphotic women maintained improvements in usual kyphosis, spinal extensor strength, and physical performance 1 year after completing a multidimensional group exercise program. Improvements in best kyphosis were also observed. Detraining effects may be minimized by multidimensional exercises.

Acknowledgments

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List of Abbreviations

ADLs	activities of daily living
PPT	Physical Performance Test

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Table 1

Reliability Data

Measure	Mean Change T2–T1 (95% CI)	ICC _{3,1}
Kyphosis: usual (deg)	1 (–1 to 2)	.93 (.87 to .99)
Kyphosis: best (deg)	0 (–2 to 2)	.94 (.88 to .99)
Biodex extensor strength (% body weight)	–4 (–11 to 4)	.84 (.71 to .96)
PPT (points)	1 (0 to 2)	.73 (.53 to .93)
Jug Test (s)	–0.5 (–1.3 to 0.2)	.92 (.85 to .98)

Abbreviations: CI, confidence interval; deg, degrees; ICC, intraclass correlation coefficient; T1, time 1; T2, time 2 (1 week later).

Table 2

Measures of Kyphosis, Strength, and Physical Performance Pre- and Postintervention and 1 Year After Intervention

Dependent Measures	T2	T3	T4
Kyphosis: usual (deg)	57 ± 5	51 ± 5	49 ± 6
Kyphosis: best (deg)	50 ± 6	45 ± 6	42 ± 6*
Biodex extensor strength (% body weight)	35 ± 15	56 ± 17	56 ± 25
PPT (points, 36 possible)	30 ± 3	32 ± 2	31 ± 2
Jug Test (s)	13.5 ± 3.3	12.1 ± 2.6	12.8 ± 2.3

Abbreviations: T1, time 1; T2, time 2 (1 week later); T3, time 3 (after the 3-month exercise program); T4, time 4 (1 year after intervention completion).

* *t* test T3 versus T4 ($P < .05$).