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The effect of a core exercise program on Cobb angle and back muscle activity in male students with functional scoliosis: a prospective, randomized, parallel-group, comparative study

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Abstract

Objective: To assess the effect of core strengthening exercises on Cobb angle and muscle activity in male college students with functional scoliosis.

Methods: Static and dynamic back muscle activity were evaluated via surface electromyography (sEMG). A core exercise protocol comprising 18 exercises was performed three times/week for 10 weeks. Patients were randomly allocated to either a home- or community-based exercise programme. Cervical thoracolumbar scans and sEMG were performed after 10 weeks.

Results: A total of 87 students underwent cervical thoracolumbar scans. Of these, 53 were abnormal and were randomised between the home-based ($n = 25$) or community-based ($n = 28$) groups. After the 10-week exercise programme, Cobb angles were significantly lower and back muscle strength was significantly improved than baseline in both groups, but there were no statistically significant between group differences.

Conclusions: A 10-week core strengthening exercise programme decreases Cobb angle and improves back muscle strength in patients with functional scoliosis.

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Scoliosis, core exercise, Cobb angle, college students, cervical thoracolumbar scans, surface electromyography

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Introduction

Gravitational forces move along the spine and may cause changes in posture that can lead to postural deformity including scoliosis, lordosis and kyphosis.[1,2] Scoliosis is the most common type of spinal curvature disorder, and is classified as structural or functional depending upon whether or not the change is fixed.[3] The key factor in functional scoliosis is the reversibility of abnormal curvature by various positions and movements.[4] Scoliosis is diagnosed via cervical thoracolumbar X-ray scanography, viewed while the patient is standing.[5] The effects of exercise in patients with structural scoliosis have been well documented,[6–12] but there are limited data available regarding the effects of exercise in the treatment of functional scoliosis.[3] Clinical evidence supports the use of core strengthening exercises in the treatment and prevention of lower back pain and other musculoskeletal disorders.[13]

The present study evaluated the effect of a 10-week core strengthening exercise programme on Cobb angle and back muscle strength in male college students with functional scoliosis. Patients were randomized to perform the exercise programme in either a home-based or community group-based setting.

Patients and methods

Study population

The study recruited male college students who applied to undertake a core exercise programme at the Department of Physical Medicine and Rehabilitation, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, Changwon, Republic of Korea between 2 June 2014 and 29 August 2014. Students with evidence of dorsolumbar scoliosis as indicated by the Adam's forward bend test were eligible for inclusion in the study.[14] Exclusion criteria were: previous spinal surgery; neurological or rheumatic disease; contraindication to exercise/physical activity.

The study was approved by the ethics committee of Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, and all participants provided written informed consent.

Patient assessments

Degree of scoliosis was evaluated via the Cobb method,[15] and a medical technician blinded to study conditions performed cervical thoracolumbar X-ray scanography on all patients. Static and dynamic back muscle activity was evaluated by surface electromyography (sEMG; MyoVision, Seattle, WA, USA) in all patients with abnormal scan results. Data are reported in microvolts (0.08 – 200 μV) and represent the amplitude of muscle activity over time. Static scanning was performed using three pairs of sEMG electrodes applied bilaterally to the skin overlying the paraspinal muscle region at level T7, T12 and L3 with the patient in a relaxed standing position. Symmetricity was determined by the ratio of right to left static activity. Dynamic sEMG (muscle strength) was recorded from L1 and L5 paraspinal muscles with the patient bending at 90° from the vertical.

Core exercise programme

Patients were randomized via computer-based programme to either a home-based

Table 1. Core strengthening exercise programme for male patients with functional scoliosis.

Section	Exercise type	Duration
Warm up	Stretching	10 min
Main exercise	1. Basic crunch	30 min
	2. Knees up crunch	
	3. Compound crunch	
	4. Crossed leg crunch	
	5. Sky reachers	
	6. Bicycles	
	7. Crossed leg raisers	
	8. Hip raisers	
	9. Rowers	
	10. Single/double leg V ups	
	11. Oblique crunches	
	12. Cross limb superman	
	13. Superman	
	14. Cat back raises	
	15. Knees to elbows	
	16. Stable arm reachers	
	17. Sideways crawl	
	18. Hand walkouts	
Cool down	Stretching	10 min

exercise programme or a community group-based exercise programme. The 50-min exercise programme was identical in both groups, and was to be performed three times/week for 10 weeks. Details of the exercise programme are shown in Table 1. In brief, the programme comprised warm-up stretching exercises (10 min), 18 main exercises (30 min), and cool-down stretching exercises (10 min). All participants were trained initially in the gymnasium. Patients in the home-based programme received an exercise video and were periodically telephoned by an instructor. Patients in the community group-based programme completed all exercises together in the gymnasium under direct supervision of an instructor.

Cobb angle and sEMG were assessed at baseline and after 10 weeks. Due to the nature of the intervention, research staff and participants could not be blinded to the type of exercise programme, but the physician who assessed outcome measures was blinded to the exercise regimen.

Statistical analyses

Sample size was determined via a pilot study with a maximum of five patients per group. The mean $\pm$ SD difference in Cobb angle was 2.0 ± 2.8 and 4.5 ± 3.4 in the home-based and community-based groups, respectively. A total sample size of 52 (26 per group) was therefore required ($\alpha = 0.05$, power 80%). Assuming a dropout rate of 10%, the final sample size was increased to 58 (29 in each group).

Data were presented as mean $\pm$ SD. Between group differences in Cobb angle and muscle activity were analysed using mixed two-way repeated measures analysis of variance (ANOVA). Statistical analyses were performed using SPSS® version 18 (SPSS Inc., Chicago, IL, USA) for Windows®. P-values <0.05 were considered statistically significant.

Results

The study screened 276 male college students, 189 of whom did not meet the inclusion criteria. Cervical thoracolumbar scanography was performed on the remaining 87 patients. A total of 53 patients had abnormal scans and were eligible for randomization ($n = 25$ home-based programme; $n = 28$ community-based programme). A total of two patients were lost to follow-up, and the final analysis included 51 patients ($n = 23$ home-based programme; $n = 28$ community-based programme). A chart indicating the flow of patients through the study is shown in Figure 1. Baseline demographic data are shown in Table 2. There were no significant between-group differences in age, height, weight or body mass index.

Data regarding Cobb angle and sEMG parameters are shown in Table 3. After 10

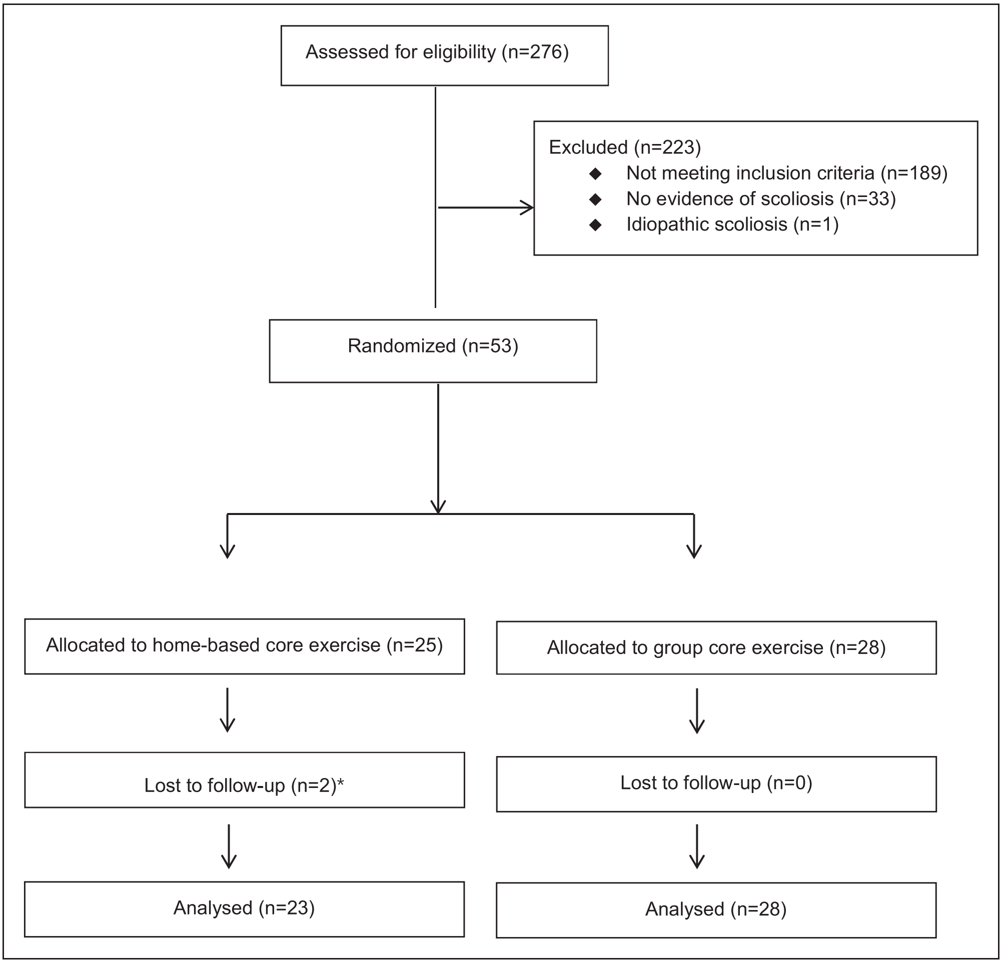

Figure 1. Flow chart indicating recruitment, randomization, and follow-up of patients with functional scoliosis included in a study to compare the effects of a home-based or community group-based 10-week core strengthening exercise programme on Cobb angle and back muscle strength.

weeks of exercise, Cobb angle was significantly lower than baseline in both groups ($P < 0.001$), but there was no significant between-group difference. Muscle strength (dynamic sEMG) was significantly improved at 10 weeks compared with baseline ($P = 0.029$), but there was no significant difference between the groups. The exercise programme had no significant effect on static sEMG (back muscle symmetry at T7, T12, and L3; Table 3).

Discussion

The use of core strengthening exercises to sustain the functional stability of the spine by strengthening the abdominal and lumbar muscles was first proposed in the 1970s.[13,16] This type of exercise contributes greatly to the rehabilitation of injured sportsmen and women.[17] Although opinions differ about the most effective exercises to use,[18] the common objective of core stability training

Table 2. Baseline demographic characteristics of male patients with functional scoliosis included in a study evaluating the effect of a home- or community-based core strengthening exercise programme on Cobb angle and back muscle strength.

Characteristic	Home-based programme $n = 23$	Community-based programme $n = 28$
Age, years	20.0 ± 2.0	20.6 ± 1.8
Height, cm	174.4 ± 6.0	173.7 ± 6.3
Weight, kg	70.2 ± 9.3	70.4 ± 7.3
Body mass index, kg/m^2	22.9 ± 2.5	23.4 ± 2.8

Data presented as mean ± SD.
No statistically significant between-group differences ($P \geq 0.05$; mixed two-way repeated measures analysis of variance).

is to recondition the muscles that stabilize the spine by improving lumbar muscle endurance.[19] Exercise such as yoga and Tai Chi have been shown to reduce the severity of functional scoliosis, correct posture, and improve balance.[3,20] Core exercise can correct misalignment of the spine via improvement of neuromuscular control and the strength and endurance of a number of muscles in the trunk and pelvic floor that are believed to play important roles in spinal stability and arrangement.[21]

The present study investigated the impact of core strengthening exercise on functional scoliosis by examining changes in Cobb angle and paraspinal muscle activity using scanography and sEMG. We found that both home-based and community group-based exercise reduced Cobb angle and

Table 3. Effect of a 10-week home- or community-based core strengthening exercise programme on Cobb angle and back muscle strength in male patients with functional scoliosis.

Parameter	Home-based programme $n = 23$	Community-based programme $n = 28$	Statistical significance[a] Time effect	Group effect	Time/Group Interaction
Cobb angle, °			$P < 0.001$	NS	$P < 0.001$
Baseline	9.12 ± 2.26	9.58 ± 2.66			
10 weeks	7.07 ± 3.01	4.33 ± 2.45			
T7 symmetry			NS	NS	NS
Baseline	1.70 ± 1.37	2.26 ± 3.18			
10 weeks	2.69 ± 4.79	5.17 ± 11.39			
T12 symmetry			NS	NS	NS
Baseline	1.32 ± 0.79	1.58 ± 1.15			
10 weeks	1.54 ± 1.30	1.76 ± 2.49			
L3 symmetry			NS	NS	NS
Baseline	1.37 ± 0.78	1.79 ± 2.59			
10 weeks	1.92 ± 3.39	2.71 ± 4.84			
Muscle strength, μV			$P = 0.029$	NS	NS
Baseline	153.56 ± 35.93	144.21 ± 28.03			
10 weeks	157.28 ± 33.19	160.94 ± 29.30			

Data presented as mean ± SD.
[a]Mixed two-way repeated measures analysis of variance.

improved muscle strength, with no significant between group differences observed. This finding was surprising since we expected that the home-based exercise programme would be less effective than the community group-based programme because of problems with compliance. The outcome may have been affected by the small study population, which did not reach our calculated minimum sample size. Further large scale and long term studies are required to confirm our findings. In addition, sEMG did not provide any meaningful results regarding symmetry of the spinal muscles, possibly due to a poor relationship between static sEMG and symmetry of the back muscles and/or limitations in detecting muscle fibre currents. It is possible that needle electrodes may be more effective than surface electrodes at detecting deep muscle activity. Since abdominal muscle strength is also important for spinal arrangement during the core exercise, moitoring of these muscles would have provided additional valuable data. A further limitation of our study was the lack of a control group. It was assumed that patients who did not exercise would not improve, leading to concerns for the ethics committee. The study was therefore comparative, investigating the effects of two settings for the exercise programme.

In conclusion, both a home-based and a community group-based 10-week core strengthening exercise programme decreased Cobb angle and improved back muscle activity in male patients with functional scoliosis. This core strengthening exercise protocol may be used to minimise the degree of scoliosis and improve back muscle strength in patients with functional scoliosis.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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