CME

Effects of Core Stabilization Exercises on Pulmonary Function, Respiratory Muscle Strength, Peripheral Muscle Strength, Functional Capacity, and Perceived Appearance in Children With Adolescent Idiopathic Scoliosis

A Randomized Controlled Trial

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Objective: The aim of the study was to investigate the effects of core stabilization exercises on pulmonary function, respiratory muscle strength, peripheral muscle strength, walking capacity, and perceived appearance in children with adolescent idiopathic scoliosis.

Design: This is an evaluator-blinded, randomized controlled trial. A total of 30 patients were randomly allocated to either a training group (n = 15, age = 13.8 ± 2.8 yrs, Cobb angle = 19.3 ± 6 degrees, Risser sign: $n_{(1)}$ = 1; $n_{(2–4)}$ = 14) or a control group (n = 15, age = 15.8 ± 3.4 yrs, Cobb angle = 20.8 ± 7.9 degrees, Risser sign: $n_{(1)}$ = 1; $n_{(2–4)}$ = 14). The training group received core stabilization exercises in addition to the traditional scoliosis exercises for 8 wks. The control group only received the traditional scoliosis exercises for 8 wks. Spirometry, maximal inspiratory and expiratory pressures, 6-min walking test, peripheral muscle strength, and the Walter Reed Visual Assessment Scale were assessed at the beginning and end of the study.

Results: The training group showed statistically significant improvements in maximal inspiratory pressure, maximum expiratory pressure, and Walter Reed Visual Assessment Scale score (respectively, mean changes = 17.4 ± 5.2 cmH_2O; 10.6 ± 4.3 cmH_2O; 2.4 ± 1.6), which were significantly larger compared with the control group ($P < 0.05$).

Conclusions: Core stabilization exercises given in addition to the traditional scoliosis exercise can improve respiratory muscle strength and perceived appearance in patients with adolescent idiopathic scoliosis.

Key Words: Adolescent Idiopathic Scoliosis, Core Stabilization Exercises, Respiratory Muscle Strength, Perceived Appearance

What Is Known

- Core stabilization exercises increase the strength of spinal muscles, improve quality of life, and reduce the angle of trunk rotation and pain in adolescent idiopathic scoliosis.

What Is New

- Core stabilization exercises do not significantly improve spirometry test parameters and peripheral muscle strength (quadriceps and hand grip strength) but significantly improve inspiratory and expiratory muscle strength and perceived appearance in patients with adolescent idiopathic scoliosis.

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Scoliosis is defined as the three-dimensional structural change of vertebrae with lateral flexion in the frontal plane of greater than 10 degrees, rotation in the axial plane, and flattening components in the physiological curve in the sagittal plane. Adolescent idiopathic scoliosis (AIS) is a variant of idiopathic scoliosis occurring from the onset of puberty until the growth plates are closed.[1]

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CME Objectives: Upon completion of this article, the reader should be able to: (1) Determine the evaluation methods required for scoliosis patients; (2) Evaluate respiratory parameters in scoliosis patients; and (3) Plan and implement an exercise program for scoliosis patients.

Level: Advanced

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Adolescent idiopathic scoliosis can lead to ventilatory restriction, respiratory muscle weakness, and decreased functional capacity.[2] In addition, it has been shown that forced vital capacity, forced expiratory volume in 1 sec, maximal inspiratory pressure, maximal expiratory pressure, and quadriceps muscle strength values are lower in patients with AIS compared with healthy individuals.[3]

Conservative and surgical treatment options have been reported in the treatment of AIS. Conservative treatment includes exercise and orthotic options.[1] The purposes of therapeutic exercises in AIS are to stop curve progression at puberty, increase muscle strength and flexibility, improve aesthetics, physical endurance, cardiovascular, and respiratory function, and prevent or treat spinal pain syndromes.[1,4,5] In the literature, different exercise training can improve respiratory function and functional capacity in AIS.[3,6]

There are several scoliosis-specific exercise methods including Schroth, functional individual therapy of scoliosis, and scientific exercise approach to scoliosis (SEAS) commonly used in scoliosis treatment.[7] On the other hand, there are general exercise programs such as core stabilization exercises, Pilates, and yoga, which have been used in the conservative treatment of AIS.[7]

The primary role of core stabilization muscles is stabilizing the spine and body. Core stabilization exercises contribute to increasing stability, endurance, and strength with effective abdominal training.[8]

When we look at randomized controlled core stabilization exercise training studies, we see that core stabilization exercises help reduce the angle of rotation and pain and improve back muscle strength and quality of life in AIS.[7,9] However, there are no studies showing the effect of core stabilization exercises on respiratory function, respiratory muscle strength, functional capacity, and peripheral muscle strength with AIS.

Thus, the aim of this study was to investigate the effects of the 8-wk core stabilization exercise program (every day of week for half an hour) given in addition to the traditional scoliosis exercise on respiratory function, respiratory muscle strength, functional capacity, peripheral muscle strength, and perceived appearance of adolescents with mild to moderate idiopathic scoliosis.

MATERIALS AND METHODS

This prospective randomized controlled evaluator-blinded trial was approved by the clinical research ethics committee of Bezmialem Vakif University (050.05.04-13/149) and registered to ClinicalTrials.gov with ID number NCT03823053. This study was conducted in the Physiotherapy and Rehabilitation Department of Faculty of Health Sciences at Bezmialem Vakif University between February 2019 and June 2019 in accordance with the Declaration of Helsinki. This study conforms to all Consolidated Standards of Reporting Trials (CONSORT) guidelines and reports the required information accordingly (see Supplementary Checklist, Supplemental Digital Content 1, http://links.lww.com/PHM/B576).

The inclusion criteria were having a diagnosis AIS, the age range of 10–20 yrs, a Cobb angle between 15–40 degrees, and not receiving any treatment related to scoliosis.

The exclusion criteria were surgical operation in the last 3 mos, having an orthopedic, neurological, or mental disease that prevents from exercising; respiratory disease (bronchitis, pneumonia, etc.) in the last month; doing exercise (swimming, playing basketball, etc.) 3 or more days per week; and non-AIS. Patients and their families who met the criteria and gave informed consent were included in the study. They signed the consent form.

The volunteers among the patients who applied to the scoliosis outpatient clinic of Bezmialem Vakif University Hospital were evaluated by a medical doctor, and the patients who met the criteria of our study were referred to us by the medical doctor. The patients were randomly allocated to either the training group or the control group by using a computer-based randomized list of numbers (http://www.random.org). Patients were unaware of their group assignments. The numbers were enclosed in sequentially numbered, opaque, and sealed envelopes. The statistician of the study generated the random sequence and prepared the envelopes. After the initial evaluations of the patients were completed, each patient picked an envelope and was included in either the training or the control group according to their chosen number. In our study, we preferred to give our patients traditional scoliosis exercises and core stabilization exercises because not every physiotherapist could take courses with scoliosis-specific exercises, and these exercises were not easy to do by children alone. The training group received core stabilization exercises training as well as traditional scoliosis exercises for 8 wks. The control group received only traditional scoliosis exercises. All patients were evaluated for pulmonary function, respiratory muscle strength, walking capacity, peripheral muscle strength, and perceived appearance at the beginning and end of the study. The evaluations were made by the other physiotherapist who was blinded to the study.

The Cobb angle was recorded at the first visit of the patients. The Cobb angle is the angle between the lines drawn perpendicular to the endplates first and last vertebrae involved in the curvature.[10] The Cobb angle and Risser sign were measured by an orthopedist. The orthopedist was blinded to group allocation.

The angle of trunk rotation was measured with a Bunnell scoliometer. The maximum rotation angles in the spine were recorded when the patients were in the forward bending position (the maximum angle of trunk rotation was recorded).[11]

Pulmonary functions were measured with spirometry (Cosmed Pony FX, Italy) according to the criteria of the American Thoracic Society and European Respiratory Society.[12] The patient, whose nose was closed with a clip, was asked to breathe in and out of the spirometer mouth several times at a tidal volume. The patient was then asked to breathe deeply and then rapidly exhale deeply (it should continue for at least 6 secs). The best value from three acceptable tests was recorded. Forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV_1), forced vital capacity/forced expiratory volume in 1-sec ratio (FEV_1/FVC), and peak expiratory flow (PEF) were measured and expressed as the percentages of the predicted values.[13]

Maximal inspiratory pressure (MIP) and maximum expiratory pressure (MEP) were evaluated by respiratory pressure meter (MicroRPM; Micro Medical, United Kingdom) according to the criteria of the American Thoracic Society and European Respiratory Society.[14] All tests were repeated 3 times and the highest values were recorded.

Functional capacity was determined by the 6-min walking test (6 MWT) according to the criteria of the American Thoracic Society.[15] Patients were instructed to walk as fast as possible between two cones positioned 30 m apart and the distance

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walked in 6 mins was recorded. Oxygen saturation and heart rate were also measured before and after the test using a pulse oximeter. The distance that the patients walked was recorded in meters.

The strength of the quadriceps muscle was measured using an electronic hand dynamometer (Commander muscle testing), by applying maximum resistance 2–3 cm above the ankle malleoli of patients in sitting position. Quadriceps isometric maximum voluntary contraction was obtained through a brief (3-sec) effort performed with one leg and then the other, when the patients were seated with both their trunk and thigh fixed and their knees flexed 90 degrees.[2] At the position where the evaluator positioned the leg, the patient was asked not to let the leg moved while the evaluator applied resistance. The test was terminated as soon as the leg was moved by evaluator (break test). The measurement was repeated 3 times with each extremity (right and left) and the highest value was recorded.

The hand grip strength was performed on the dominant hand with a hydraulic dynamometer (Jamar). All patients were seated with their shoulder adducted and neutrally rotated, the elbow flexed at 90 degrees, and forearm and wrist in a neutral position.[2,16] The patients were required to squeeze the handle maximally and to sustain this for 3–5 secs. The measurement was repeated 3 times with each hand (dominant and nondominant), and the averages were recorded. One-minute rests were given between each attempt.

The Walter Reed Visual Assessment Scale consists of a visual test including seven items that deal with various aspects of the perceived appearance. Each question has a set of five figures that represent degrees of severity of the perceived appearance concerns: spinal appearance, rib prominence, lumbar prominence, thoracic appearance, trunk imbalance, shoulder asymmetry, and scapular asymmetry. Each question is shown with five levels of increasing severity of the perceived appearance concerns that are scored from minimum (1) to maximum (5). On this scale, the best score is 7 and the worst score is 35.[17] The scale was filled in by patients.

Traditional scoliosis exercises were explained to all patients in the training and control groups by the physiotherapist. The control group only received a half hour of traditional scoliosis exercises every day of the week for 8 wks. The traditional scoliosis exercises included posture, interscapular muscle strengthening, stretching, spine mobilization exercises, and breathing exercises (Appendix 1, Supplemental Digital Content 2, http://links.lww.com/PHM/B577). The exercises of the control group were performed once a week under the supervision of a physiotherapist (half hour), and for the rest of the week (6 days/half an hour a day), the patients continued their exercises as a home exercises program for 8 wks. In core stabilization training, exercises were given for local muscles (multifidus, transversus abdominis, diaphragm, and pelvic floor) and global muscles (erector spinae, internal and external obliques, quadratus lumborum, gluteus maximus, and latissimus dorsi) that contribute to spinal stability (Appendix 1, Supplemental Digital Content 2, http://links.lww.com/PHM/B577). The training group received a half-hour core stabilization exercises in addition to the half hour of traditional scoliosis exercises every day of the week for 8 wks.

Core stabilization exercises were selected specifically for the patient, and the exercise program was advanced according to the patient. The training group was performed once a week under the supervision of a physiotherapist (half-hour traditional exercises + half-hour core stabilization exercises); other days of the week, the patients continued their exercises as a home exercises program for 8 wks. All exercises were done as 1 set of 10 repetitions and once a day. All patients kept a diary to document attendance at the treatment session and compliance with home exercises. Diaries were checked every week when patients came to the session. All patients in the control and training groups attended all supervised sessions for 8 wks. All patients in the control and the training groups completed home exercises with 100% compliance. At the end of 8 wks, all evaluations were repeated for the control and training groups.

Statistical Analysis

Statistical analyses were performed using SPSS 21.0 statistical program (SPSS, Inc).

All data were analyzed by the Shapiro-Wilk test to determine distribution characteristics. The descriptive statistics for the normally distributed data are described as mean ± SD and nonnormally distributed data are described as median (min–max). Descriptive statistics of categorical data are given as frequency (percentage).

A mixed analysis of variance (repeated-measures analysis of variance with between-subjects factor) was used to analyze whether the effects of the interventions differ between groups. A P value less than 0.05 was considered to be statistically significant for all analyses.

In the literature, there are no studies investigating the effect of core stabilization training on 6 MWT in children with AIS. The normative value of the 6-min walking distance (6 MWD) in AIS children is 400 ± 49 m.[6] The minimum clinically significant change amount defined in this test was determined as 54 m.[18] Therefore, 30 patients were included in the study so that the sample size would be sufficient to achieve 80% power to detect a 54-m difference between group using an α level of 0.05 (n = 15 for each group).

RESULTS

A total of 45 patients with AIS applied to the department. Fourteen patients did not meet inclusion criteria. Eight of these patients were outside the age range, and six were non-AIS scoliosis. One patient refused to participate in the study. All of the 30 patients who enrolled in the study and were randomized into two groups completed the study (Fig. 1). We have no patients who have undergone any previous surgical operation or used a brace. No adverse events or significant harm were recorded throughout the intervention period.

The comparison of the demographic and clinical characteristics of the groups is shown in Table 1. The demographic characteristics were not significantly different between groups despite the following observed mean differences for the control compared with the training group: 2 yrs older for mean age, 7 cm taller for height, and 4 kg heavier. There was also five more patients at Risser sign 1 or 2 in the training group than in the controls. There was four more patients at Risser sign 4 in the control group. Five patients were older than 18 yrs in the control group compared with only two patients over this age in the training group (Appendix 2, Supplemental Digital Content 3, http://links.lww.com/PHM/B578).

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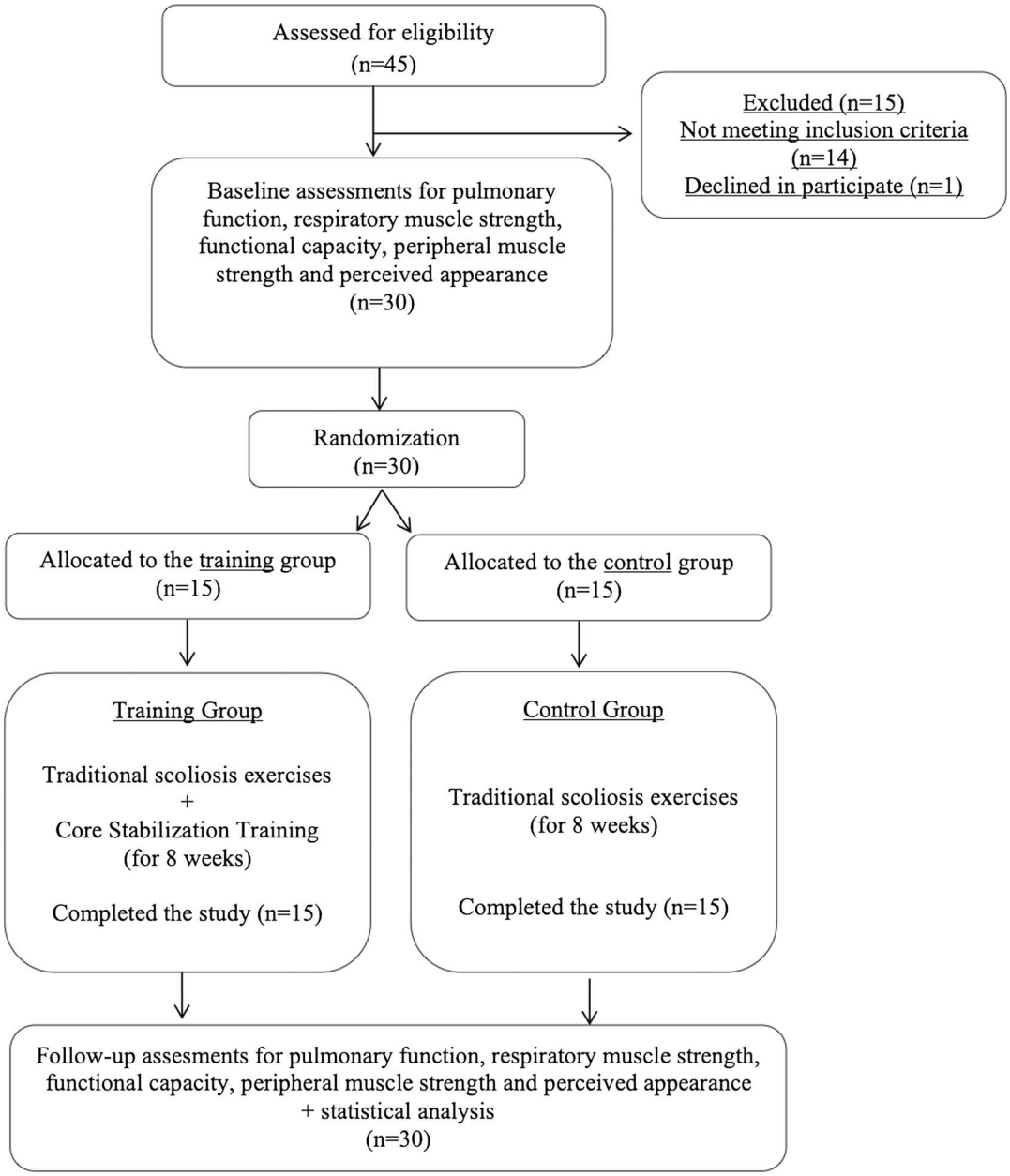

FIGURE 1. The flowchart of participant recruitment in this study.

Baseline values of the outcome measures did not differ significantly between group except the 6 MWD for which the control group walked significantly longer (24 m) than the training group ($P = 0.037$).

The group effects (none reached significance) and the time effect values (both groups improved for FVC%, FEV_1%, 6 MWD, and both quadriceps strength) were shown in Table 2.

There was a significant interaction between time and group for MIP, $F(1,28) = 6.878$, indicating that MIP increased significantly more in the training group compared with the control group ($P = 0.014$; Table 2).

There was a significant interaction between time and group for MEP, $F(1,28) = 8.045$, indicating that MEP also increased significantly more in the training group compared with the control group ($P = 0.008$; Table 2).

In addition, there was a significant interaction between time and group for the Walter Reed Visual Assessment Scale score, $F(1,28) = 7.309$, indicating that this score improved significantly more (reduced score) in the training group compared with the control group ($P = 0.012$; Table 2).

DISCUSSION

In this prospective randomized controlled and evaluator-blinded trial in which we examined the effect of core stabilization exercises on respiratory parameters, peripheral muscle strength, functional capacity (6 MWD), and perceived appearance in patients with AIS, core stabilization exercises given in addition to traditional scoliosis exercises, we found core stabilization exercises to be more effective than traditional scoliosis

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TABLE 1. Demographic and clinical characteristics of the training and control groups

	Control Group (n = 15)	Training Group (n = 15)	P
Age, yr	15.87 ± 3.46	13.80 ± 2.85	0.085
Sex, female/male	13/2	13/2	1.000
Height, m	1.64 ± 0.10	1.57 ± 0.12	0.128
Weight, kg	53.62 ± 11.55	49.41 ± 13.87	0.375
Body mass index, kg/m^2	19.82 ± 3.33	19.66 ± 3.88	0.903
Curve type			
Thoracic	12 (80%)	11 (73.3%)	
Lumbar	1 (6.6%)	4 (26.6%)	0.146
Thoracic–lumbar (double major)	2 (13.3%)	0 (0%)	
Risser sign			
1	1 (6.7%)	1 (6.7%)	
2	1 (6.7%)	6 (40%)	0.088
3	5 (33.3%)	4 (26.7%)	
4	8 (53.3%)	4 (26.7%)	
Cobb angle, degree			
Thoracic	19.6 ± 4.51	19.86 ± 9.35	0.925
Lumbar	22.0 ± 7.58	18.8 ± 6.53	0.495
Angle of trunk rotation, degree			
Thoracic	6.0 (4–11)	6.0 (3–11)	0.550
Lumbar	7.0 (4–11)	6.0 (2–14)	0.968
Dominant hand, right/left	14/1	14/1	1.000

Data are reported as mean ± SD, median (min–max), and n (%).

exercises on respiratory muscle strength and perceived appearance. In addition, both treatments groups achieved significant improvements FVC%, FEV_1%, 6 MWD, and both quadriceps strength measurements.

In the literature, it has been stated that there is a restrictive respiratory disorder in the respiratory system in scoliosis and the severity of the disorder changes depending on the severity of thoracic curvature and the degree of thoracic cage deformity.[19,20] Szapo and Domagalska-Szopa[21] showed that in 75% of 68 patients with mild idiopathic scoliosis, the VC% value was within the normal range. On the other hand, Amaricai et al.[3] found that the FVC value was significantly lower in children with mild to

TABLE 2. Effects of core stabilization training on pulmonary function, respiratory muscle strength, functional capacity, peripheral muscle strength, and perceived appearance

	Control Group (n = 15)		Training Group (n = 15)		P		
	Initial Assessment	Final Assessment	Initial Assessment	Final Assessment	Time	Group	Time × Group
Pulmonary function							
FVC, % predicted	99.00 ± 11.55	100.53 ± 10.03	96.93 ± 16.63	103.26 ± 12.79	0.008	0.942	0.091
FEV_1, % predicted	95.86 ± 9.43	96.14 ± 8.06	94.40 ± 9.48	98.93 ± 11.44	0.030	0.846	0.052
FEV_1/FVC, % predicted	85.56 ± 4.95	86.46 ± 8.46	89.64 ± 11.30	91.41 ± 11.31	0.297	0.239	0.240
PEF, % predicted	96.06 ± 18.19	99.80 ± 22.12	103.26 ± 21.30	105.46 ± 18.30	0.255	0.357	0.766
Respiratory muscle strength							
MIP, cmH_2O	66.53 ± 23.99	70.93 ± 24.05	61.26 ± 17.64	78.73 ± 29.46	<0.001	0.882	0.014
MEP, cmH_2O	64.13 ± 16.96	66.80 ± 15.85	65.13 ± 18.51	75.80 ± 17.31	<0.001	0.421	0.008
Functional capacity							
6 MWD, m	628.66 ± 50.54	658.13 ± 65.13	604.33 ± 34.99	631.67 ± 34.46	<0.001	0.127	0.876
Peripheral muscle strength							
Dominant hand, kg	18.40 ± 8.21	17.93 ± 7.60	13.56 ± 8.11	14.81 ± 8.30	0.433	0.182	0.092
Nondominant hand, kg	16.00 ± 7.01	16.0 ± 5.64	12.70 ± 7.73	12.81 ± 7.94	0.914	0.216	0.914
Right M. quadriceps, N	104.75 ± 23.48	119.96 ± 23.68	96.64 ± 23.76	117.82 ± 23.76	<0.001	0.536	0.443
Left M. quadriceps, N	96.72 ± 22.43	100.06 ± 19.92	86.10 ± 28.04	99.87 ± 23.81	0.047	0.482	0.217
WRVAS	11.06 ± 2.43	11.33 ± 2.66	12.53 ± 4.35	10.07 ± 3.34	0.038	0.927	0.012

Data are reported as mean (SD); significance at $P < 0.05$.

WRVAS, Walter Reed Visual Assessment Scale.

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moderate idiopathic scoliosis than healthy children. They even reported that after 12 wks of exercise training (stretching, strengthening, breathing, core exercises), although there was a significant increase in respiratory function parameters, they did not reach the values of the healthy control group. In the present study, pulmonary function test parameters in the first evaluation (FVC%, FEV_1%, FEV_1/FVC, PEF%) were within normal limits. Only 2 of 30 patients (6.6%; 1 patient training, 1 patient control) in this study were found to have low FVC% parameters. The fact that the FVC% values of our other patients were within normal values was compatible with the previously mentioned studies. After 8 wks of exercise training, it was observed that these values of two people with low FVC% reached normal limits and they increased even more in the patients who were given core exercises (but this increase was not statistically significant). The fact that our FVC% value is within normal limits unlike that in the study by Amaricai et al.[3] may be because we have more patients with mild scoliosis (Cobb angle < 20 degrees). Similar to the previously mentioned study, after 8 wks of exercise training, increases in pulmonary function test parameters were detected in this study. The reason why we did not observe a statistically significant difference between groups although both groups improved FVC% significantly can be explained by the fact that the 8-wk period was not sufficient for core exercises to achieve a clinically larger effect. The training program of both groups had breathing exercises.

The cause of muscle dysfunction in AIS is not fully known, and several factors are thought to affect muscle function (nutritional status, physical activity, systemic inflammation, etc.).[2] The inspiratory muscles are subjected to increased mechanical loads due to problems with spinal deformity and ventilation, and the length-tension relationship may change because of chest deformity. Expiratory muscles are affected less by geometric distortion, but the distortion of the thoracic cage makes the chest wall much less compliant; thus, they are subjected to increased mechanical loads as well.[22] Therefore, the muscles may not work effectively and may not produce maximal pressures.[22] Martínez-Llorens et al.[2] found that MIP and MEP values are lower in patients with AIS compared with healthy controls. The MIP and MEP values of our cases in this study were lower than the reference values generated by Hulzebos et al.[23] According to the American Thoracic Society/European Respiratory Society, maximum inspiratory pressure values less than 80 cmH_2O are indicative of inspiratory muscle weakness.[14] Based on the information in the literature, we can say that our cases had inspiratory muscle weakness (MIP training/control, 61.26 cmH_2O [17.64]; 66.53 cmH_2O [23.99], respectively). In the literature, the number of studies investigating the effect of exercise training on respiratory muscle strength in these patients is limited. Alves et al.[4] stated that there was an increase in MIP (48.7%) and MEP (44.6%) after stretching and aerobic exercise administered for 4 mos. Although our working time was shorter and our exercise method was different from the previously mentioned study, we found significant improvement in MIP and MEP values. This improvement was higher in our core group (training/control, MIP 28%; 6.6%; MEP 16%; 4%, respectively). The inspiratory muscles are morphologically and functionally skeletal muscles. When the appropriate physiological load is applied, it responds similarly to any skeletal muscle. Considering that the diaphragm and external intercostal muscles, which are among the primary inspiratory muscles, are also core region muscles, the improvement we achieved is not surprising. The MEP measurement shows the combined effect of abdominal and internal intercostal muscles, as well as the elastic recoil of lungs and chest wall.[14] The abdominal muscles constitute a large part of this measurement. We may have increased MEP values because core exercises improve the balance between the abdominal and erector muscles and increase the strength of the muscles in the lumbopelvic area. In addition, because daily exercise duration of the patients in the training group was longer than the control group, the breathing exercises they did during the exercises were more. Repeated inspiratory and expiratory maneuvers performed during exercises may have induced the neural conditioning effect for both MIP and MEP values in our study. Neural conditioning improves the neuromuscular recruitment pattern and consequently provides improvements in muscle strength.

Disorders in the respiratory system and skeletal muscle dysfunction are the most important factors limiting functional capacity in patients with AIS.[24] Kuo et al.[25] stated that these patients have abnormal muscle activation that adversely affects postural control and functional capacity. Martínez-Llorens et al.[2] reported that skeletal muscle dysfunction has been observed since the early stages of the disease even if young patients with AIS have no serious ventilatory disorder, and this has led to a decrease in functional capacity. In accordance with the literature, we found that peripheral muscle strengths were low in our cases (n = 30; 106 N) compared with their healthy peers (325 N).[26,27] Despite the loss of strength in the peripheral muscles, 6 MWD of our cases were within normal limits. The fact that the control group had higher 6 MWD at the first evaluation may be due to the fact that these patients had slightly higher age, height, and weight values (no statistical difference) compared with the other group. At the end of the 8 wks, despite the minimal difference in baseline demographic characteristics, there was 6 MWD increase in both the training group and the control group (although the difference between groups was not statistically significant).

The reason for the lack of limitation in the functional capacities of our patients may be because the curve degree was low, and there was no ventilatory disorder. Amaricai et al.[3] reported that the increase in 6 MWD as a result of core exercise training was not sufficient to reach the values of healthy subjects. Ko et al.[5] showed that the range of motion and muscle strength of the lumbar region increased as a result of 12-wk core exercises. We thought that increases in the strength of the hip muscles, which are also involved in core integrity and which are the most important ring of the kinetic chain in the transfer of power from the lower limbs to the pelvis and vertebrae in standing activities (such as walking, running), would increase 6 MWD. Increases in the strength of the hip muscles may be due to the clinically positive effect of core exercises or because daily exercise duration of the training group was longer. In this study, we found significant increases in peripheral muscle strength and functional capacity (6 MWD) in both groups but differences between groups did not provide statistical significance. We could not clearly demonstrate the additional effect of core exercises on these parameters. Although our study was similar to the previously mentioned studies in terms of age, Cobb angle, and exercises given, the short duration of our study may have led to different results. In the literature, 10–12 wks of

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exercise is recommended for strength training to have a positive effect on aerobic capacity.[28]

In the consensus formed by the International Scientific Society on Scoliosis Orthopedic and Rehabilitation Treatment, correction of trunk balance and improvement in cosmetic appearance are stated as the primary targets of scoliosis treatment.[1] In a systematic review, it was stated that stabilization exercises in the group that was given Pilates-based spinal stabilization exercises helped reactivation of the spinal muscles and strengthened the spine and corrected body asymmetry by providing postural facilitation.[29] Shin et al.[30] reported that core stabilization exercises increase the strength of trunk muscles, correct trunk symmetry, and improve sitting balance in patients with AIS. The results of this study are compatible with the results of the previously mentioned studies. We found more improvement in the perceived appearance with core stabilization exercises given in addition to traditional exercises compared with traditional exercises.

STUDY LIMITATIONS

This study has some limitations. One of the limitations of this study is that our control group was older, taller, and heavier, even if these differences did not reach statistical significance. Another limitation is that the duration of treatment was short. The training group had a higher duration of daily exercise session than the control group. In both groups, the patients could perform supervised exercises only once a week. The fact that our cases were school-aged children caused us to carry out our study without long-term follow-up and with a relatively small number of patients. Another limitation was that we could not show the effect of core exercises on the Cobb angle because long-term follow-up of our patients was not possible. Another limitation is that we do not have objective measurements of posture and core muscle function at baseline. Our final limitation is that we did not have a group that did not receive placebo and treatment.

CONCLUSIONS

Core stabilization exercises significantly improve respiratory muscle strength and perceived appearance in AIS. In the future, we recommend carrying out studies that equal exercise session durations showing the short- and long-term effect of core stabilization exercises in a larger number of patients in the different severity of scoliosis (mild and moderate AIS).

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