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Effects of a 12-Week Global Corrective Exercise Intervention on Sway Back Posture in Young Adults: A Randomized Controlled Trial

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Abstract

Background: *Sway back posture (SBP) is a common postural deviation of sagittal alignment and is the most common postural deviation in 18 to 28-year-old individuals, but there is no standard exercise protocol for treating SBP. Our objective was to assess the effectiveness of the global corrective exercise intervention (GCEI) on spinal posture of healthy individuals 18-25 years of age with SBP.*
Methods: *This study was a randomized controlled design with a parallel group, two-arm trial with 1:1 allocation ratio. Seventy participants (mean age 20.9 ± 2.1 years) with SBP (⩾ 10°) were enrolled in the study for 12 weeks. The participants were randomly assigned to an exercise (n = 35) or control group (n = 35). The targeted global spine strengthening and stretching exercise intervention included core and postural training, delivered by a corrective exercise specialist in 2 groups of 20 and 15 participants 3 times a week for 12 weeks. Forward head angle and sway angle were measured using a digitized side-view photograph. Kyphosis index and llordosis index were measured using a flex curve ruler.*
Results: *The 12-week intervention program resulted in significant within group differences in forward head, kyphosis, lordosis and postural sway angle (P < 0.001). There was also a significant between group difference in the changes of all postural variables (P < 0.001).*
Conclusions: *The GCEI resulted in improved sway back posture in our sample of 18-25-year-old participants. This study supports the theoretical basis for clinical rehabilitation of postural deviations. Further studies are required to generalize these findings to other age and population groups.*

Keywords: Posture, Sway back, Corrective exercise, Spinal alignment.
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Introduction

Sway back posture (SBP) is a common deviation of sagittal alignment and is the most common postural deviation in individuals 18 to 28 years old.[1-3] The major clinical characteristics of this faulty posture include posterior displacement of the trunk relative to the pelvis, long thoracic kyphosis, reduced lumbar lordosis, posterior pelvic tilt, and extended hip and knee joints.[4,5] This is a slumped, fatigue posture, where the antigravity postural musculature expends a minimum of energy and the strain falls largely on the supporting ligaments of the trunk and pelvis.[1,6,7]

Although the precise etiology of SBP is unknown, there are many underlying musculoskeletal impairments associated with SBP.[1-4,8] Some studies have shown decreased activity of the lumbar stabilizer muscles, such as lumbar multifidus, internal abdominal oblique and transversus abdominis, when adopting SBP.[9,10] In addition, upper quarter muscle imbalance including tightness of the upper trapezius and levator scapula, pectoralis major and minor, and weakness of deep cervical flexors, as well as middle and lower trapezius are associated with hyper-kyphosis (KI) and forward head posture (FHP) which are part of SBP.[11,12] O'Sullivan et al. (2002)[9] reported a failure of the passive structures such as ligaments, capsule and bone in the maintenance of upright erect posture against gravity.

In SBP, there is trunk posterior sway and pelvic anterior sway, creating an angle between the upper and lower body described as Sway Angle (SA).[3,9] Smith, O'Sullivan and Straker[3] have identified a significant gender-based correlation between the increased SA and low back pain, such that male adolescents with increased SA are more prone to low back pain lasting three or more months than in those with a normal posture. This may be the result of postural malalignments associated with increased SA such as flattened lumbar angle, slumped posture, ligament and capsule strain, bone approximation, and muscular imbalances surrounding the lumbopelvic area.[3,9,10,13] In response to the high frequency of back pain in people with SBP, it is important to understand the factors that contribute to the development of SBP and to develop effective methods to prevent and correct the faulty posture.

Corrective exercise interventions are common methods to manage patients with postural deviations, such as hypo-lordosis,[14] scoliosis,[15] hyper-kyphosis,[16] FHP[17] and rounded shoulder posture.[18] We hypothesized that corrective exercises that target the multiple components of SBP[4,12] would improve SBP. The purpose of this study was to investigate the effects of 12 weeks of targeted exercise training on the outcomes of Sway Angle (SA), Forward Head Angle (FHA), Kyphosis Index (KI), and Lordosis Index (LI) among healthy young adults age 18-25 years old with sway back posture.

Materials and Methods

This was a randomized controlled, parallel group, two-arm design trial (figure 1). The participants were randomized using block randomization (blocks 4, 6, and 8) with 1: 1 allocation ratio, stratified by sex, using a computer-generated sequence (random allocation software 2.0). Group allocation was concealed in sequentially numbered, opaque, sealed envelopes, and corresponding envelopes were opened once the enrolled participants completed all baseline assessments. Neither the participants nor the instructor were blinded to allocation, but the laboratory specialist assessing the postural variables and the data analyst were blinded to the allocation.

The population consisted of university students aged 18-25 years with SBP recruited from Bu Ali Sina university through flyers, posters and mass email to university colleagues. Ninety-six volunteers with suspected SBP were invited to the initial postural screening exam, and screened for participation based upon criteria for SBP (≥ 10) as assessed by computerized photographic analysis.[8,19,20] Participants were excluded for history of fracture, surgery and / or arthritic diseases in the spinal column, shoulder girdle, and pelvis, medical prescription specifically dictating therapeutic exercises for posture, scoliosis (> 5 degrees peak axial rotation on forward bending test), structural hyper-kyphosis as confirmed by radiographs, or regular weekly physical activity program.[16,21] Before the initial testing, the eligible participants signed an informed consent form approved by the physical education and sport science board of Bu Ali Sina university (clinical trial registration code: IRCT2017011431942N1).

SA and FHA were measured using the lateral photographic method,[3,5,22] and KI and LI were measured using the flexicurve method.[23,24] Based upon SBP > 10 and after meeting all other inclusion criteria, 70 participants (40 males and 30 female) were enrolled in the study.

Lateral photographic techniques were used to measure SA. Three anatomical landmarks of the acromion lateral tip, the midpoint of the femoral greater trochanter, and the lateral malleolus tip were identified and marked by removable red adhesive dots.[8-10] A digital camera (Sony DSC-W35) placed on a tripod 80 cm high and 250 cm on the left side of each individual was used to obtain photographic images in front of a non-reflective background. The participants were asked to adopt their habitual standing position and avoid conscious postural corrections. Digital photographs were stored on a PC and later processed using Adobe AutoCAD 2010 to calculate the angle (SA). The average SA from three photographs was recorded.

FHP was assessed using a digitized, side-view photograph taken in a relaxed-standing posture. First, the tragus of the subject's ear was marked with a removable red adhesive dot, and a white plastic pointer was taped to the skin overlying the C7 vertebra. Next, the photograph was obtained and Adobe AutoCAD 2010 was used to calculate the angle between the vertical line passing through C7 and a line extending from the tragus of the ear to C7. Higher FHA indicates greater FHP.[22,25]

Thoracic kyphosis and lumbar lordosis were measured using a flexicurve ruler (Jakarflex 600 cm, Crystal edge). The validity of flexicurve postural measures has been previously established.[26-29] We palpated the bony landmarks of the spinous processes of the seventh cervical (C7) and first sacral vertebra (S1) and marked them with removable red adhesive dots according to Hoppenfeld, et al. (1976)[30] and Youdas JW, Suman VJ, (1995)[31] methods. After marking these landmarks, the participants were instructed to stand in their usual posture whilst the assessor placed the flexicurve ruler over the spinous processes of the thoracic and lumbar spine[24,27] at the C7 mark superiorly and S1 mark inferiorly, where the shape of the flexicurve ruler was conformed to the curvature of the spine. The flexicurve ruler was removed from the participant's spine and the side of the ruler contacting the participant's skin was traced onto a paper. A vertical line was drawn to connect the C7 (most superior point) and S1 (most inferior point) landmarks and a perpendicular line was drawn at the thoracolumbar level marking the transition between the thoracic and lumbar curves. The maximum width and the total length of each curve were measured in centimeters. A KI and LI were calculated from the width and length measures of the thoracic and lumbar portions of the spine using the following formula.

KI = thoracic width / thoracic length ×100

KI = lumbar width / lumbar length ×100

Higher indices indicated greater degrees of kyphosis / lordosis.

The flexicurve was molded to the spine 3 times, being flattened between each measurement. The average of the 3 measurements was used for analysis.

The intervention was a global, sway back-specific exercise program which was developed based on postural malalignments associated with sway back based on previous studies (table 1).[16,18,21,31] Intervention included strengthening exercise that targeted the periscapular, thoracic spine extensor, neck flexor and lumbopelvic muscles and stretching exercise that targeted the flexibility of the pectoral, suboccipital, and hamstring muscles. On the other hand, the stretching portion of the intervention aimed at increasing the flexibility of the pectoral, suboccipital, and hamstring muscles. The exercises were selected based on literature which suggested that selective activation of the lower and middle trapezius/middle trapezius,[32] lumbar erector spine,[33] gluteal,[33] internal oblique and rectus abdominal muscles,[33] lengthening the pectoralis minor[34,35] and improving deep cervical flexor function[36] improve the posture.[16,18,21,37] The participants in the intervention group were initially trained using an instructional video of the exercises and illustrated handouts of the postural exercises each week. Each subject first warmed up with a light aerobic activity and general stretching exercises for five minutes and then performed exercises 1 to 7 sequentially. After that, the participants cooled down with general stretching exercises and slow walking for five minutes. The intervention participants performed the exercises of the program for 45 - 90-min, 3 sessions per week for 12-weeks. The exercises progressed in frequency, hold time, and intensity during the study as long as the participants were able to demonstrate good-quality movements. The intensity of the exercise was prescribed on an individual basis, using the rate of perceived exertion (RPE) of the Borg scale,[38] where for all strengthening exercises it gradually progressed from moderate-intensity (40% – 59% HRR) to high-intensity (60% – 84% HRR) with a gradual increased frequency (from 6 to 12 repetitions) and hold times (15 to 30 s active holds). Intervention sessions were conducted by a corrective exercise specialist in two groups according to gender (male group (n = 20) and female group (n = 15)) at the corrective exercise laboratory of (blind) the university from 1

October to 30 December 2015. At the end of week 12, all measurements were repeated and the SA, FHA, KI, LI were recorded. The control group participants were tested at baseline and 12-weeks and did not receive any intervention.

The baseline characteristics of the treatment and control groups were compared using independent t-tests. Two sample t-tests were used to assess the effects of the intervention on changes in SA, FHA, KI, LI, between the two groups. Paired t-tests were used to compare the baseline and post intervention SA, FHA, KI, LI data for each study group. Given the number of outcome measures, we divided the alpha of .05 by 4 and established statistical significance at P less than .0125. SPSS statistical software (version 18.0, SPSS Inc., Chicago, IL, USA) was used to analyze all data.

Based upon an expected difference between groups as 40% to 60% of the standard deviation for all postural variables,[39] we determined that a sample size of 70 participants would have 80% power in two-sided tests with a type-I error rate of 5%, and dropout rate of 10% to detect a change of 50% of the standard deviation for all postural variables.[39] We used the software package NCSS-PASS 1.0 to calculate the sample size.

Results

We screened 96 volunteers suspected of SBP and 70 participants were enrolled in the study (figure 1). The randomization assigned 35 participants to the corrective exercise group and 35 to the control group. Three participants did not complete the study; 2 for illness and 1 for excessive absence from visits. The 67 participants (38 males and 29 female) were included in the study with a mean age of 20.79 ± 2.09 years old, weight of 69.54 ± 12.01 kg, and height of 174.21 ± 7.21 cm (table 2). Subject characteristics did not differ between the groups at baseline.

There was a statistically significant between-group difference in changes of all postural variables, SA, FHA, KI and LI, with P < 0.001 (table 3).

There was a significant difference in changes of SA between the two groups of 3.7° (95% CI: -4.8, -2.8) (P < 0.001). SA decreased significantly within the exercise group -4.8 ± 1.8 (P < 0.001) but not within the control group -1.1 ± 1.2 (P > 0.0125).

There was a significant difference in the changes of FHA between the two groups of-4.7° (95% CI: -6.4 to-2.9), (P < 0.001). FHA diminished significantly within the exercise group -7.2 ± 2.9 (P < 0.001) and within the control group -1.3 ± 2.6 (P < 0.01).

There was a significant difference in the changes of KI between the two groups of -2.5 (95% CI: -3.3 to -1.6) (P < 0.001). KI dropped significantly within the exercise group -3.06 ± 1.3 (P < 0.001) but not within the control group -0.13 ± 0.9 (P > 0.0125).

There was a significant difference in in the variations of LI between the two groups of 1.5 (95% CI: 0.9 to 2.0), (P < 0.001). LI improved significantly within the exercise group 1.7 ± 1.12 (P < 0.001) but not within the control group 0.3 ± 1.13 (P > 0.0125).

None of the individuals reported adverse effects from the intervention.

Table 1. Global Corrective Exercises Intervention Framework

Exercise	Description	Target	Repetitions	Equipment
Chin tuck exercise 17,18	Subjects lengthened the neck by lifting the crown of the head to the ceiling and pushing the chin and head straight back, simultaneously. The chin should be parallel to the floor and the ear in line with the tip of the shoulder	Improving the posture of the head and neck region	Active from 15 to 30 s holds / from 10 to 15 repetitions	Physioball
L to Y exercises 16, 18, 37	Subjects begin with arms abducted to 90° and elbows flexed to 90° hanging toward floor. They then retract their scapula and externally rotate their arms to 90° of shoulder abduction (L position). Maintaining retraction of the scapula, they raise their arms above the head and fully extend the elbows so that their arm would form the letter 'Y with 120° with their torso.	Improving the strength and endurance of scapular retractor muscles (lower and middle trapezius and rhomboid muscles) and spinal extensor muscles	Active from 15 to 30 s holds / from 6 to 12 repetitions	Physioball
Pectoralis muscle stretching exercise 16,37,44	Subjects stand erect in a doorway or the corner of a room with arms raised shoulder height, elbows bent, and hands grasping doorjambs, feet in a front-stride position. Lean forward on door frame, with your hands on the wall, until you feel significant stretching across the front of your chest.	Lengthening the pectoralis major muscle, expanding rib cage and anterior chest wall	Active from 15 to 30 s holds / from 6 to 12 repetitions	Doorway or room corner
Spinal mobilization 16,37,44	Subjects lie supine on the roll foam with knee up, so it is under the back of the neck. Push with the feet to roll slowly and gently the back over the roll foam from the neck to the buttocks	Improving the spinal mobilization and sub back muscle stiffness		Roller foam
Quadruped arm and lower extremity lift 33,42,44	From a quadruped position, subjects lift 1 arm forward (shoulder flexion) and lift the opposite leg backward (hip and knee extension); they then repeat with the opposite limbs.	Improving the strength and endurance of gluteal, lower trapezius, spinal extensor, and multifidus muscles	Active from 15 to 30 s holds / from 6 to 12 repetitions	Body weight
Side-bridge exercise 33,46	In a side lying position, with elbow supporting shoulder, hips in neutral position, and knees fully extended. The subject would lift hips off the ground until the body is in a straight line, hold, and return; repeat with the opposite side.	Improving the strength and endurance of spinal extensor, multifidus, and abdominal muscles especially external oblique muscle	Active from 15 to 30 s holds / from 6 to 12 repetitions	Body weight
Unilateral bridge exercise 33,46	Subjects lie supine on the floor with knees flexed (90 degree) so that the foot is on the floor. Then, they lift 1 leg from floor across the spine (hip and knee extension) so that the trunk is in neutral spine alignment; then repeat with the opposite leg.	Improving the strength and endurance of gluteal, spinal extensor, multifidus, and abdominal muscles especially lower rectus abdominis	Active from 15 to 30 s holds / from 6 to 12 repetitions	Body weight

Table 2. Baseline characteristics of study participants

Characteristics	Exercise group (n = 32) Mean ± SD	Control group (n = 35) Mean ± SD	Between group difference Mean (95%CI)	Pvalue
Age(y)	21.11 ± 2.16	20.51 ± 2.15	0.6(-0.4 - 1.6)	0.25
Height(cm)	175.66 ± 8.69	172.89 ± 7.70	2.77 (-1.1 - 6.7)	0.91
Weight (Kg)	70.28 ± 13.21	68.87 ± 12.30	1.41 (-4.7 - 7.5)	0.67
SA (°)	11.94 ± 1.41	12.22 ± 1.37	-0.28(-0.9 - 0.4)	0.39
FHA (°)	46.59 ± 3.93	45.52 ± 3.55	1.06(-0.7 - 2.8)	0.25
KI (%)	11.94 ± 1.92	11.48 ± 1.82	0.46 (-0.4 - 1.3)	0.31
LI (%)	4.06 ± 0.93	4.17 ± 1.09	-0.11 (-0.6 - 0.4)	0.64

Y = years, cm = centimeters, kg = kilograms, ° = degrees, % = percent, SA = Sway Angle; FHA = Forward Head Angle; KI = Kyphosis Index; LI = Lordosis Index; SD = Standard Deviation

Table 3. Change in postural variables after the intervention

Postural measures	Within group changes (95%CI)		Between group differences (95%CI)	Pvalue
	Exercise	Control		
SA (°)	-4.8 (-5-4 - (-4.12))	-1.1 (-1.4 - (-0.6))	-3.7(-4.8 - (-2.8))	<0.001*
FHA (°)	-7.2 (-8.2 - (-6.2))	-1.3 (-2.2 - (-0.3))	-4.7 (-6.4 - (-2.9))	<0.001*
KI (%)	-3.06 (-3.5 - (-2.5))	-0.13 (-0.5 - 0.2)	-2.5 (-3.3 - (-1.6))	<0.001*
LI (%)	1.7 (1.3 - 2.1)	0.3(-0.5 - 0.4)	1.5 (0.9 - 2.0)	<0.001*

° = degrees, % = percent
*Pvalue for significance ≤ 0.0125

Discussion

We found that a 12-week GCEI targeting multiple components of SBP was safe (no adverse effects were reported) and effective in improving the SBP in individuals 18-25 years old with SBP. Theoretically, there is a close relationship between the postural deviations in SBP including FHP, hyper-kyphosis, and hypo-lordosis,[4,16,40] and our designed GCEI considered all postural deviations associated with SBP. We found a 4.8° change in SA after 12-week GCEI representing a 39% improvement in SBP from the baseline. Also, FHP and thoracic hyper-kyphosis decreased and lumbar hypo-lordosis increased, suggesting that the GCEI targeted multiple muscles that improved the spinal posture. The 7.34° change in FHP represented a 16% improvement from baseline and hyper-kyphosis and hypo-lordosis improved by 26% and 42%, respectively.

Our results in FHP are consistent with previous results of diminished FHP through strengthening and stretching corrective exercises.[17,18,36] A study by Harman et al. (2005)[17] found mitigated FHP following a 10-week intervention including stretching of the anterior shoulder muscles and strengthening of the posterior shoulder muscles. In addition, Lynch et al. (2010)[18] successfully improved FHP following a 8-week pectoralis and cervical neck extensors stretching and periscapular muscle strengthening exercises program. In their study, Falla et al. (2007)[36] used similar exercises to those of the current study and found that greater strength, endurance and postural self-awareness improved the postural head alignment of the research participants. Pearson and Valmsly (1995)[11] reported that the continuous chin tuck exercise improved the head and neck posture through deep neck flexor muscle strengthening and neck extensor muscle stretching; similarly, we used the chin tuck exercise as a low-load exercise targeting these muscles in FHP.[4,35,36]

In addition, we reported reduced hyper-kyphosis posture in our sample. This finding is in agreement with Vaughn and Brown (2007),[21] who demonstrated the efficiency of a 13-week home-based exercise program in decreasing the kyphosis angle of patients aged 39.8 ± 13.2 years with 23 – 80° of thoracic kyphosis. In addition, Seidi et al. (2014)[16] observed improved hyper-kyphosis in 20.84-year-old participants following a 12-week corrective exercise program. Ball et al. (2009)[41] observed that back extensor strengthening exercises can delay the progression of kyphosis in women 50 – 59 years of age. Similarly, several other studies have demonstrated that stretching and corrective exercise can improve age-related hyper-kyphosis.[37,42,43] Recently, Katzman et al. (2016) noted that multimodal spine strengthening exercise can significantly reduce hyper-kyphosis in older adults.[44] Many of these studies included the "L to Y" exercises that we used to target the thoracic spinal extensor and scapular retractor muscle strengthening.[18,35,37,45] Electromyography studies have shown that L to Y exercises strengthen the lower and middle trapezius muscles.[32,33] Ekstrom et al. (2007)[33] reported that prone position shoulder flexion (Y drill) and horizontal abduction with external rotation (L drill) cause the maximum activity of the lower part of trapezius. Moseley et al. (1999)[32] reported the maximum electromyographic muscle activity of the middle trapezius during prone arm abduction and abduction with external rotation (L drill) which we used in our study.

In addition to strengthening the thoracic extensor and scapular retractor muscles, we used antagonist stretching and flexibility exercises (pectoralis muscle) to improve hyper-kyphosis deviations and SBP. Chest muscle stretching (especially pectoralis minor) and spinal mobilization using a foam roller are used in many kyphosis corrective exercise programs to improve the thoracic spine posture.[16,18,37] Borstad and Ludewig (2006)[34] reported doorway pectoralis muscle stretching as the most effective method to improve flexibility of these muscles. Seidi et al. (2014), Lynch et al. (2010), and Katzman et al. (2007) used pectoralis stretching and thoracic spine mobilization on a foam roller to stretch the pectoralis muscles, improve the thoracic extension, and reduce hyper-kyphosis. Ball et al (2009)[41] reported that pectoralis muscle stretching along with strengthening scapular retractor and thoracic extensor muscles can prevent progression of thoracic spine curve in elderly participants.

Another finding rarely examined in previous studies is the improvement in lumbar lordosis we observed after 12 weeks GCEI[13]. As electromyography studies suggest that lumbar erector spinae, lumbar multifidus, transverse abdominus, abdominal external oblique, upper rectus abdominis, iliopsoas and gluteus maximus muscles are weaker in people with SBP,[9,10] the increase in lumbar lordosis and improvement of SBP we observed might suggest the correction of muscle imbalance in the gluteal, lumbar and abdominal muscles. We used quadruped arm and lower extremity lift, one of the best exercises proposed by Ekstrom et al. (2007) to correct these imbalances and to improve the strength and endurance of lumbar multifidus, erector spinae, and gluteal muscles.[33] This exercise was used by Sinaki & Huntoon (2011) and Ball et al. (2009) to improve the spinal posture of the elderly population in their programs.[41,42] We also used the side bridge and unilateral bridge exercises, known to facilitate gluteal, abdominal external oblique and lumbar spine extensor muscle activity on EMG[33] and improve hypo-lordosis in elderly populations.[33,46] Note that the hamstring releasing exercises may also increase the anterior pelvic tilt and in turn increase lumbar lordosis while reducing the thoracic hyper-kyphosis by postural chain reactions.[4,40] Unilateral bridge exercise whereby the trunk is in neutral spine alignment was also used in this study, as a previous study indicated development of only a slight activity in the upper rectus abdominis, though the lower rectus abdominis claims a greater proportion of the total abdominal work than with the sit-up.[47] In addition, this exercise would improve the strength and endurance of gluteal muscles, lumbar multifidus, and erector spinae, which based on previous studies was weak in the people with sway back.

Our study had several strengths. This is the first study demonstrating the effects of GCEI on multiple components of postural alignment in young adults 18-25 years old with SBP. One of the strengths and possible explanation of the positive results of the GCEI is that we designed a program based upon the multiple muscle imbalances associated with SBP. We found that a combination of chin tuck exercise, L to Y exercise, pectoralis muscle stretching exercise and spinal mobilization, targeting the upper quarter muscle imbalances associated with FHP and hyper-kyphosis, and quadruped arm and lower extremity lift, side-bridge and unilateral bridge exercises, targeting the muscle imbalances associated with lumbo-pelvic imbalance and hypo-lordosis, constitute an effective treatment for our sample with SBP. We used standardized measurements of posture that were performed by a corrective exercise specialist.

We acknowledge that our study has several limitations. As previous studies reported most prevalent SBP cases for 18-25-year-old individuals, only this age group was chosen which limits the generalizability of the results to other age groups with SBP. In the present study, the corrective exercise program targeted postural alignment and muscle imbalance reported by previous studies, but did not address muscle activation and movement patterns that may affect SBP. Future study that includes assessment and training of muscle activation during functional movement in a dynamic corrective exercise program is warranted. Lack of participant blinding regarding group allocation may have influenced the results, however the laboratory specialist assessing the postural variables and data analyst were blinded to the allocation. In addition, we did not control for other exercise programs and leisure activity. Furthermore, the long-term effect of this exercise program was not investigated, and requires further study to determine whether the effects observed over 12 weeks can be sustained and whether participants with sway back can be motivated to continue a program over a number of years.

A 12-week targeted global spine strengthening and stretching exercise intervention improved the postural alignment in 18-25 years' persons with SBP. To better understand the mechanisms, further studies are required to evaluate the changes in muscle and inter-joint coordination using electromyography and motion analysis systems. Nonetheless, this study provides preliminary evidence to support the use of GCEI to promote better postural alignment in young adults 18-25 years old with SBP.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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