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The effect of core strength training on flexibility and balance in sedentary healthy young individuals

Hatice Yakut
Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, Süleyman Demirel University, Isparta, Turkey, haticeyakut@sdu.edu.tr

Burcu Talu
Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, İnönü University, Malatya, Turkey, burcu.talu@inonu.edu.tr

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Abstract

Background: The aim of this study is to examine the effect of core strength training on the static and dynamic balance and flexibility of the sedentary young individuals. Material and methods: 41 healthy sedentary students participated in the study (age=21.56±1.05; height=171.90±8.18 cm; body weight=66.63±11.99 kg). Training was applied for 20–30 minutes a day, 2 days a week for 6 weeks. The sit-and-reach test, lateral bending test, hip flexion flexibility test, and the static and dynamic balance scores were used for outcome measures, which were calculated using the Balance System SD (Korebalance Premier-19 Systems Inc. USA). Results: Statistically significant increases were observed in the flexibility tests and dynamic balance parameters between before and after training ($p<0.05$). In static balance, there was no significant difference between the preliminary and final values. Conclusions: 6-week training was effective in increasing dynamic balance and flexibility, but had no effect on static balance. In the light of this information, we think that training should be a part of life, especially when considering functions that require dynamic balance such as walking in sedentary young individuals. We think that this study is important in terms of preventing injuries of young individuals who do/will do sports recreationally.

Keywords

core strength training; students; dynamic balance; static balance; flexibility

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Hatice Yakut[1 EF], Burcu Talu[2 ABCD]

[1] Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, Süleyman Demirel University, Isparta, Turkey

[2] Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences, İnönü University, Malatya, Turkey

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Corresponding author: HATİCE YAKUT, Süleyman Demirel University, Faculty of Health Sciences, Department of Physical Therapy and Rehabilitation; Isparta –TURKEY; Phone: +90 5434490625; E-mail: haticeyakut@sdu.edu.tr

INTRODUCTION

The core allows maintaining postural alignment and dynamic postural balance during functional activities, helping to avoid a series of distortion patterns. CST (Core Strength Training) emphasizes the strength and conditioning of local and global trunk muscles that work together by stabilizing the spine. Basically, CST includes the training of deep trunk muscles. Bergmark [1] made a local and global muscle classification in the lumbosacral spina. Accordingly, he stated that the global muscles cause the movement of the spine, while the local muscles work within the segmental stabilization system [1]. Many authors have proposed progressive training from local muscle groups to global muscle groups in stability training and the integration of the muscles in this group. It has been reported that balance and mobility will improve in addition to trunk functions in CST [2–4].

Core stability is a general definition describing the training of the abdominal and lumbopelvic muscles. According to Kibler [5], core stability and strength are important for maximizing athletic function and effective balance in lower and upper extremity movements. And again, according to the author, the core forms the basis of movement or proximal stability for distal mobility [5]. Although there are contradictions on this subject, the literature emphasizes that CST is an important component for almost every gross motor activity. CST, which is carried out with the stable state of the spine, has positive effects on postural control systems, and postural stability can be completely changed with this training [6]. Recently, a lot of exercising methods have been developed for the stabilization of the core region. The core stabilizing exercises are known as a very effective exercise method for strengthening muscles and improving balance ability and flexibility [7].

There has been an increase in the frequency of injuries in the youth over the past few decades [8]. Neck, shoulder, and back pain are common among college students [9, 10]. A study whose participants were students, reported that the strengthening training applied to the abdominal muscles caused an increase in the stability of the lumbar spine [11]. The effects of spinal stability exercises have been demonstrated in individuals working in sedentary professions [12]. A systematic review concluded that Pilates exercises, known to improve core stability, can also improve dynamic balance in healthy populations [13]. Balance measurement programs, development, and maintenance methods should be included in rehabilitation and injury prevention programs. Clinical methods evaluating balance ability include the berg balance scale, functional reach test, and Tinetti performance scales. However, these methods may be insufficient to monitor various aspects of balance [14]. Therefore, this research aims to examine the effects of CST on static and dynamic balance scores by using the Balance System SD (Korebalance Premier-19 Systems Inc. USA).

Although a lack of evidence exists for CST in sedentary young individuals, research has shown that CST improves flexibility, body alignment, and muscular strength in athletes, dancers, and women [15–17]. To the best of our knowledge, no studies investigated the effectiveness of CST in terms of static and dynamic balance depending on the direction in sedentary students. Therefore, this study aimed to investigate the effect of CST exercises on the static and dynamic balance and flexibility of university sedentary students.

MATERIAL AND METHODS

SUBJECTS

Forty-one healthy sedentary young individuals, 15 men and 26 women from the İnönü university volunteered to participate in this study. None was excluded. The means and standard deviations for their age, height, and weight were 21±1.05 years, 171±8.18 cm, and 66±11.9 kg, respectively (Table 1). In this study, “sedentary” was defined as not regularly exercising for the subjects. All participants had previous experience in CST since they studied in the department of physical therapy and rehabilitation. All subjects completed a demographic and health history questionnaire, and they would be excluded from the study if they reported acute or chronic low back pain or a history of lower back surgery, musculoskeletal pain, joint or bone disease, neuromuscular disorders, previous ankle sprains and tendon, fascia or ligament inflammation. The participants were asked not to make any changes to their daily activities throughout the study. All participants were interviewed and measured by the same examiner using the same Balance System SD (Korebalance Premier-19 Systems Inc. USA). The assessments were performed before joining the training program, and after finishing the program in the 6th week. All subjects read and provided an approved consent form. Approval for this study was granted by the institutional review board in Human Subjects Ethics Committee of İnönü University (approval number=2016/16, approval date=27.02.2016).

Table 1. Participant's characteristics at baseline testing

Physical characteristics	Mean± SD	Max–Min	Range
Age (years)	21.56±1.05	24.00–19.00	5.00
Weight (kg)	66.63±11.99	87.00–36.00	51.00
Height (cm)	171.90±8.18	190.00–158.00	32.00
Body mass index (kg/m^2)	22.41±3.14	27.80–13.10	14.70

OUTCOME MEASURES

Trunk extensor (lower back), lateral flexion, hip flexion, and hamstrings flexibilities were measured by the sit-and-reach test, the lateral bending test, and the hip flexion flexibility test, respectively.

The Sit-and-Reach Test. Trunk extensor (lower back) and hamstring flexibility were measured by the sit-and-reach test. A box was vertically marked in centimeters on top and had a movable yardstick at the 0-cm edge. The participants sat on the floor keeping their legs straight with the soles of their feet touching the box. They put their fingertips on the 0-cm edge of the box and pushed the yardstick as far as they could while maintaining the position of their legs. The best score of 3 trials was recorded in centimeters [18]

The lateral side bending test (LBT). Subjects stood upright against a wall on two parallel lines at right angles to the wall. Arms were held straight at the sides of the body. On each side, the middle finger level was marked with a horizontal line on the side of the thigh. The patient was then asked to bend sideways slowly and maintain contact. Two attempts were performed for each side. The distance between the first and final positions of the middle finger was recorded [19].

Hip flexor flexibility. The subject was positioned supine on a plinth. The examiner used one hand to elevate the limb meanwhile the other hand was placed on the contralateral anterior superior iliac spine to prevent posterior rotation. The subject's leg was moved passively into hip flexion until firm resistance was felt and the pelvis tilted posteriorly. This was defined as the end of the range of motion and a goniometric measurement of hip flexion was measured [20]. The examiner closely monitored the knee to ensure that full knee extension was maintained during the test. The test was measured on a stretched limb.

Static and Dynamic balance. The Balance System SD (Korebalance Premier-19 Systems Inc. USA) was used to measure standing balance ability by assessing posture imbalance, which was recorded as the anterior-to-posterior and the medial-to-lateral postural sway for 30 s. The Balance System SD facilitates the performance of a 4-way evaluation of the balance of front/

left, front/right, behind/left, and behind/right and calculates the total score. The total score, including deviations caused by impairment of postural balance, is calculated by the device. The software of the system issues a score following static and dynamic balance assessments (Figure 1).

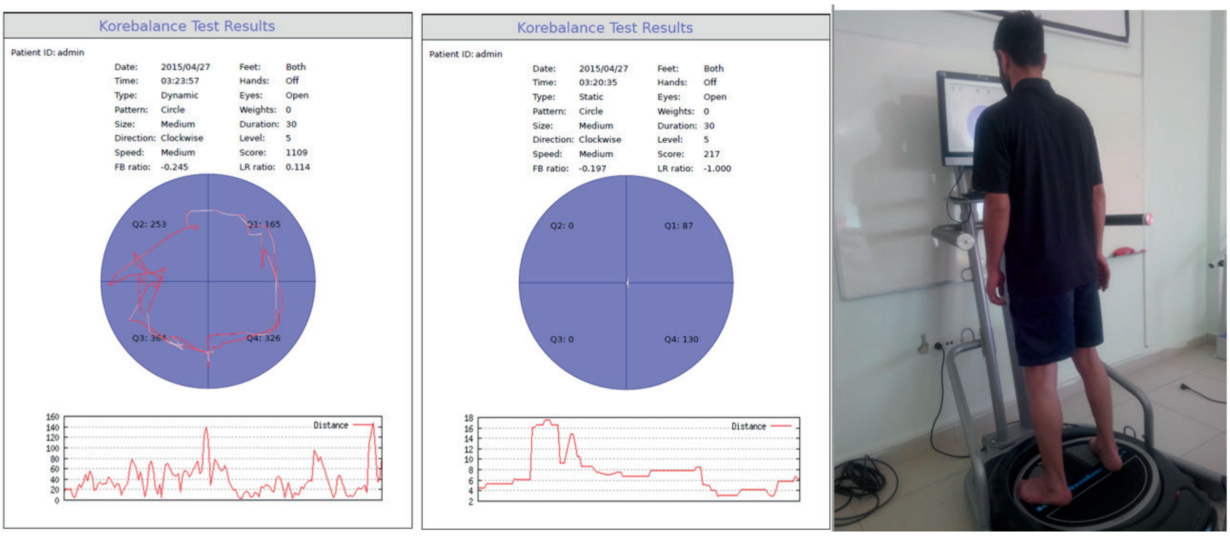

Fig. 1. The software of the system issues a score following static and dynamic balance assessments

An increase in the total score indicates worse balance; that is, higher total scores indicate poorer balance, and lower total scores – better balance [21]. The intermediate stable level (level 5) was used for the examination of balance in all subjects. In this study, the balance score in 4 directions included forward-right (FW-RT), forward-left (FW-LT), backward-right (BW-RT), and backward-left (BW-LT). All the subjects were instructed to maintain the center of mass in the middle of the platform through visual feedback. The instrument calculates the variance from the center and expresses it as a balanced index. Sway that is more postural is reflected as a large variance which is quantified as a higher score of the balance index. Moreover, this system was used for both assessment and rehabilitation in different groups in previous studies [22, 23]. As a balance assessment tool, it has been shown to have a moderate level of reliability with an excellent intraclass correlation value [24].

INTERVENTION

Core strength training (CST)

The "abdominal corset" technique is used for the activation of the lumbar region multifidus and transversus abdominus muscle. Stabilization exercises were applied to provide biomechanical neutral spine stabilization at every stage of neurodevelopmental steps (supine, prone, side lying, bipedal, quadripedal). Stabilization exercises consisting of straight arm crunch, alternate arm and leg extension, wall squat, shoulder bridge, back extension, hamstring curl, leg raise were performed in different positions. The exercise program shown to the individuals was applied by the physiotherapist according to the muscle strength, clinical condition and pain intensity of the patient based on the evaluations. Stabilization exercises were applied as group training under the control of a physiotherapist for 3 sets of 10 repetitions two days a week for 6 weeks. On the remaining days, the individuals were asked to do these exercises at home. Before starting the study and at the end of the 6th week, certain evaluations were made on the individuals, and the effectiveness of the exercises was determined according to the differences between the evaluations made before and after.

An additional 2–3 min rest was provided between exercises [7]. To minimize the risk of injury, 10-minute warm-up and cool-down protocols were followed before and after exercises. The warm-up and cool-down protocols consisted of 2 sets of 15-second light static stretches for each major muscle followed by 5 minutes of walking at a moderate pace.

The training programs are aimed at creating a neutral spine (avoiding anterior or posterior tilt of the pelvis) and activation of deep muscles of the spine.

STATISTICAL ANALYSIS

For statistical analysis, "SPSS 16 for Windows" was used. The variables were investigated by using visual (histograms, probability plots) and analytical methods (Shapiro-Wilk) to determine whether they were normally distributed. Continuous variables were defined by the mean±SD. To analyze the difference in the dynamic and static balance, flexibility before and after training, paired sample t-tests were used. The level of significance for the statistics of the differences was set at $p < 0.05$. Spearman correlation test was used to compare the associations between all directions in static and dynamic balance.

RESULTS

Statistical significance was observed in the flexibility tests between pre-and post-training ($p<0.05$). For all directions, while there were significant differences between pre-training and post-training in dynamic balance ($p<0.05$), no difference in static balance was observed in the sedentary students before and after training ($p>0.05$) (Table 2). Indeed, in dynamic balance a linear relationship between left-forward and right-backward has been documented in post-training ($p=0.000$, $r=0.534$), and in static balance, a linear relationship between right-forward and left-backward in both pre and post-training, respectively ($p=0.030$, $r=0.339$; $p=0.029$, $r=0.342$) (Table 3).

Table 2. Differences in flexibility and balance pre and post training

		Pre-training N=41 X±SD	Post-training N=41 X±SD	p	t
Flexibility	Sit and reach (cm)	24.74±8.91	26.54±8.95	.000*	-3.882
	Lateral bending-R (cm)	22.34±4.22	23.75±4.10	.000*	-5.674
	Lateral bending-L (cm)	22.70±4.11	24.24±3.97	.000*	-5.982
	Hip flexor (°)	62.51±15.71	64.29±14.58	.032*	-2.226
Static Balance	FW-LT	50.85±70.47	30.58±48.55	.076	1.825
	BW-LT	31.00±44.34	31.29±42.18	.959	-.051
	FW-RT	134.19±151.38	84.58±67.36	.076	1.823
	BW-RT	74.14±94.11	67.04±64.84	.708	.377
Dynamic Balance	FW-LT	682.00±322.37	513.90±244.26	.003*	3.118
	BW-LT	679.90±345.10	570.21±287.02	.030*	2.253
	FW-RT	531.02±251.82	405.02±177.00	.003*	3.141
	BW-RT	652.24±300.81	482.21±228.91	.000*	3.994

*p<0.05 FW-LT: Forward left, BW-LT: Backward left, FW-RT: Forward right, BW-RT: Backward right

Table 3. Relationship between directions in static and dynamic balance

			Pre-training (N=41)	Post-training (N=41)
Static balance	FW-LT/ BW-RT	r	-.292	-.292
		p	.064	.064
	FW-RT/BW-LT	r	-.339*	-.342*
		p	.030	.029
Dynamic balance	FW-LT/ BW-RT	r	.018	.534**
		p	.910	.000
	FW-RT/BW-LT	r	.065	.033
		p	.684	.839

*p<0.05 FW-LT: Forward left, BW-LT: Backward left, FW-RT: Forward right, BW-RT: Backward right

DISCUSSION

It was hypothesized that CST would positively influence the balance and flexibility of sedentary young individuals. In this paper, in which balance was evaluated with the core balance system, the main findings were that the CST improved dynamic balance and flexibility in all directions in healthy young individuals, after a 6-week program. Additionally, it was observed that it did not affect the static balance.

The present results are in line with the literature regarding the effects of CST on balance and flexibility in youth. Clinically, trunk stability or core training is used in patients of all ages, as an adjunct to traditional therapies, to prevent muscle and joint injury formation or repetition, to improve functional movement, proprioception, coordination, and balance [25]. Granacher et al. reported that CST is a feasible and safe training modality that produces marked increases in strength, flexibility, balance, coordination, and speed components of physical fitness in healthy youths [7]. This finding is in agreement with Sekendiz et al. [16], who reported improved strength, balance, and flexibility in sedentary housewives. In a systematic review with meta-analysis, it has been stated that Pilates, another method targeting the core region in healthy individuals, has strong evidence for improving flexibility and dynamic balance, and moderate evidence for improving muscle endurance [26].

We observed that the dynamic balance scores between pre-test and post-test in healthy students significantly improved in all directions. This improvement in balance scores confirms that CST affects balance. Kibler et al. concluded that the muscles of the core region allow a stable base for mobility while protecting the body against perturbations by creating a rigid cylinder and a state of immobility in the muscles [5]. Also, as Anderson and Behm [27] suggest, the proprioceptive system takes on information from the joints and muscles to coordinate deep unconscious reflexes to maintain balance. So, we can conclude that the core muscle system and balance are very closely related. In this line, the significant improvement in dynamic balance in our study provides very important evidence that the CST protocol in this study can not only facilitate the global muscles but can also facilitate the local deep muscle groups of the core. Therefore, similarly to Willson's study [28], the CST protocol can be implemented as preventative training against falls and subsequent injuries in sedentary students that is related to poor balance, lower limb, and core strength.

We observed that the balance scores in the anterior right and left, posterior right and left directions improved with CST. In addition, there was a relationship between the front-right and back-left values before and after the treatment in static balance scores, and between the front-right and posterior-left balance scores at the post-treatment in dynamic balance.

As opposed to our study, Junker et al. [29] found no effect of the interventions either of foam roller training or CST on dynamic balance. As regards the effects of CST on dynamic balance, our results are similar to the existing literature. There is evidence, that CST improves the dynamic balance of healthy participants [7, 30]. Unlike in our study, the SEBT, and Y-Balance tests were used to assess dynamic balance in those studies. In a meta-analysis by Behm et al. [31], strength training was shown to be effective in improving parameters of muscle strength, as well as power and balance. Furthermore, large effects were found for static and dynamic balance in older adults, but only a small effect was found for dynamic balance in younger adults. Dynamic balance tests, which are also used in these studies, include SEBT, walking test, FRT, and TUG tests. To the best of our knowledge, the present study is the first to examine the training effects of core training on dynamic balance with balance systems in all directions. In patients with balance problems, directional problems are very common, especially in the backward direction. In rehabilitation planning, there is a requirement for analyses based on this aspect [32]. Van Nes et al. [33] showed that improving lateral trunk control in stroke patients should be the main goal because medio-lateral balance is more affected by antero-posterior balance and has a strong relationship with balance scales. Therefore, they state that direction-specific balance assessment and treatment is an important issue in strength training [33]. Kim et al. [34] have shown that trunk stability at the end of unilateral CST develops symmetrically bilaterally without any particular direction preference. This was thought to be via a bilaterally connected neural network [34]. In addition, it has been reported that classical strength training, such as the squat, deadlift, snatch, clean, and jerk can cause an imbalance between the muscles of the trunk by affecting only the global muscles [35]. But, in our study, we observed that the effect of CST appeared symmetrically bilaterally or in all directions.

However, the latest research showed that static stretching before and after exercise does not improve flexibility [36]. Thus, the improvements in flexibility can be related to dynamic exercises [37]. Another study showed that sedentary women can benefit from the Swiss-ball CST protocol used through improved core muscular strength, endurance, flexibility, and balance as an enjoyable and cost-effective training for the prevention of low back pain, falls, and recovery from lower back injuries in sedentary adults that can help increase their quality of life in return [16]. In this study with the CST protocol in addition to balance improving, lumbar, hip flexibility and lateral bending flexibility increased. Unfortunately, for many patients, a static, isolated contraction of the transversus abdominis and lumbar multifidus is difficult to achieve. Since this study consisted of physiotherapy students, we observed that CST was done effectively. Further research is required to identify the effect of CST on muscle EMG analysis. In addition, future research should also include the analysis of the internal structure of the these movements.

To the best of our knowledge, this was the first study evaluating the effect of CST on flexibility and dynamic balance in sedentary young individuals.

CONCLUSIONS

We think that the six-week CST produced positive effects on dynamic postural control and that the duration of the program for a longer period would provide further benefits. The results supported our hypothesis that CST can improve flexibility and dynamic balance in healthy sedentary students. The results of the 6-week CST exercise protocol showed significant improvements in both the flexibility of the lower back and lateral flexion and dynamic balance in all directions. Researchers and clinicians must be concerned with improving a patient’s balance through rehabilitation after an injury, but also with strengthening their balance to prevent an injury. Our results suggest that CST could be beneficial for improving dynamic balance by strengthening those muscles.

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