



Effect of Six Weeks of Core Stability Exercises on Trunk and Hip Muscles' Strength in College Students

Sobhy M Aly ^{1*}, Azza M Abd El-Mohsen ¹, Salam M El Hafez ¹

¹Department of Biomechanics, Faculty of Physical Therapy, Cairo University, Egypt.

Abstract

Background: Health promotion activities in an academic setting have a significant impact on the prevention of illness. **Purpose:** To investigate the effect of six weeks of core stability exercises on trunk and hip muscles' strength in college students.

Methods: Thirty-two healthy college students, volunteered to participate in this study, were subdivided into the study (5 males and 12 females) and control (5 males and 10 females) groups. The study group received core stability training program for six weeks. Peak torque data were collected using the Biodex Isokinetic System 3 at angular velocity of 60°/sec and concentric contraction mode. The participants were tested twice; before and after the training program.

Results: Results of this study showed a significant improvement in peak torque of trunk flexors, extensors, hip flexors, extensors, and adductors post testing in the study group with no significant change in hip abductors' peak torque. There were no significant differences between the pre and post testing mean values of all measured variables in the control group. There was a significant increase in the post testing peak torque of hip extensors and adductors in the study group compared with that of the control group. However, there were no significant differences in the post testing peak torque of trunk flexors, extensors, hip flexors, and abductors between groups.

Conclusion: Six weeks of core stability exercises have significant effects on trunk and hip muscles strength, especially hip extensors and adductors. They can be included in the exercise programs to improve trunk and hip muscles performance.

Keywords: Core stability, Isokinetic, Trunk muscles, Hip muscles.

***Corresponding Author:** Sobhy M Aly. Department of Biomechanics, Faculty of Physical Therapy, Cairo University, Egypt. email: drsobhyahmoud@gmail.com. Tel: 00201005771081.

Introduction

Promotion and maintenance of healthy life styles for young adults are essential to guard against the development of chronic diseases as they progress through life. Health promotion activities in an academic setting have a significant impact on the prevention of illness [1]. Grimmer et al. [2] has indicated that 10% to 30% of teenagers experience back pain, especially low back pain. Hicks et al. [3] and Akuthota et al. [4] advised core stability exercises to younger age population as subjects with weak core are more susceptible to back disorders, anterior cruciate ligament injury and other lower limb injuries, thus incorporation of core strengthening program in their life style is important to provide protection against injuries [5, 6]. The well-trained core is essential for optimal performance and injury prevention [7].

The human core has been described as a box with the abdominals in the front, paraspinals and gluteals in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom [8]. The core serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement. Within this box are 29 pairs of muscles that help to stabilize the spine, pelvis, and kinetic chain during functional movements. Without these muscles, the spine would become mechanically unstable with compressive forces as little as 90 N, a load much less than the weight of the upper body [9].

The core serves as the center of the functional kinetic chain. In the alternative medicine world, the core has been

referred to as the "powerhouse" the foundation or engine of all limb movement. Popular fitness programs, such as Pilates, yoga, and Tai Chi, follow core strengthening principles. Broad benefits of core stabilization have been touted, from improving athletic performance and preventing injuries, to alleviating low back pain [4].

When the core musculature works as it should, the result is proper force distribution and maximum force generation with minimal compressive, translational, or shearing forces at the joints of the kinetic chain [10]. The hip musculature plays a significant role in the kinetic chain by transferring forces from the lower extremities to the pelvis and spine. The hip and trunk musculature has been shown to contribute about 50% of the kinetic energy and force of throwing motion [11]. Several studies have reported that hip muscle dysfunction is related to distal movement patterns and is a possible cause of injuries. Therefore, it is possible that increased hip muscle strength may affect lower extremity biomechanics and therefore reduce the risk of lower extremity overuse injury [12].

Recent biomechanical studies indicate that hip muscle activation significantly affects the ability of the quadriceps and hamstrings to generate force or resist forces experienced by the entire leg during jumping [13]. Hip abductors and external rotators also play an important role in lower extremity alignment. They assist in the maintenance of a level pelvis and in the prevention of movement into hip adduction and internal rotation during single limb support [14]. These findings have led some authors to suggest that the knee may be a "victim of core instability" with respect to

lower extremity stability and alignment during athletic movements [13, 15]. The current study intended to investigate the effect of six weeks of core stability exercises on trunk and hip muscles strength in college students.

MATERIALS AND METHODS:

Participants:

Thirty-two healthy college students, from the Faculty of Physical Therapy, Cairo University, Egypt, volunteered to participate in this study. They were divided into two groups; study and control. Study group involved 17 participants (5 males and 12 females) and control group involved 15 participants (5 males and 10 females). The age, body mass, and height ranges were 18 - 25 years, 55 - 80 kg, and 155 - 170 cm respectively. Only the dominant lower extremity was examined for measuring the peak torques of hip muscles. The dominant side for all participants was the right side. Leg dominance was identified by subjects as the one that would be used to kick a ball [16]. Participants were included in the study if they were healthy (free from musculoskeletal injuries, deformities and not taking medications for pain at the time of testing). In addition, trunk and hip muscles strength was at least grade four as assessed by manual muscle test. On the other hand, participants were excluded if there were any previous musculoskeletal or neurological deficits or previous experience with stabilization exercises.

Instrumentation:

Isokinetic dynamometer Biodex System 3 multi-joint testing and rehabilitation (Biodex Medical System, Shirley, NY, USA) was used to measure peak torques of trunk flexors, extensors, hip flexors, extensors, abductors, and adductors. Isokinetic dynamometer maintains a constant velocity while giving an accommodating resistance throughout a joint's range of motion. the Biodex System 3 isokinetic dynamometer provided mechanically reliable measures of torque, position and velocity [17].

Procedures:

Each participant of both groups was tested for the isokinetic parameters twice with a six week period in between. Participants in the study group performed the beginners' core stability program for six weeks, while the others in the control group didn't. Subjects gave written consents upon agreement to participate in the study. The participant's personal data were collected. The data included the participant's name, age, address, body mass, height, dominant side, and phone number. The nature of the study, aims, equipment, and procedures were explained to the participants before starting measurement to be familiar with the study.

The isokinetic strength of trunk and hip muscles was evaluated in a concentric mode of muscle contraction at an angular velocity 60°/sec. This velocity is the most representative of muscle strength according to force velocity relationship [18, 19].

Trunk flexion and extension testing:

Trunk seated compressed protocol was used, isolating trunk movement with no pelvic and hip muscles sharing. The pelvis and thighs were stabilized by straps. Two curved anterior leg pads were secured to adjust the knee block position. In addition, a lumbar support pad was located against the lower lumbar spine [20]. The two anterior force application straps were aligned vertically and then connected to another horizontal strap, which was aligned with the second inter-costal cartilage on the anterior chest wall when measuring the flexion torque. The posterior force application padded roller bar was placed on the posterior trunk just distal to the spine of the scapula when measuring the extension torque. The axis of the dynamometer arm was aligned at the intersection point of the mid-axillary line and the disc space between the 5th lumbar and 1st sacral vertebrae [21]. The tested trunk range of motion for each participant were set at

50° flexion and 20° extension through a total range of 70° (figure 1A).

Hip flexion and extension testing:

Concerning hip flexion and extension, appropriate right hip attachment, which is suitable for the participants' dominant side, was affixed to the dynamometer shaft. The participant was instructed to lie supine on positioning chair with hip to be tested closest to the dynamometer. Chair and dynamometer were adjusted so that shaft was aligned at the level of the greater trochanter; the axis of rotation of the hip [22]. Range of motion limits were set at 50° flexion and 0° extension by moving participant through range of motion to check for proper alignment and participant comfort and to be sure that straps did not impede range of motion. The participant was instructed to push and pull the tested hip up and down as hard and as fast as possible for five successive repetitions while the knee joint was flexed (figure 1B).

Hip abduction and adduction testing:

For testing hip abduction and adduction, participant was instructed to assume side lying position on positioning chair with the limb to be tested on the top and the opposite limb flexed at the knee [22]. Dynamometer shaft was aligned with the axis of rotation of the upper hip at the level of anterior superior iliac spine and the hip attachment length was adjusted, so that the pad was positioned just superior to the popliteal fossa [23]. Range of motion limits were set at 45° abduction and 0° adduction by moving the limb through the desired range to check for proper positioning and comfort [22]. The participant was instructed to push and pull the upper hip up and down as hard and as fast as possible for five successive repetitions while the knee joint was extended (figure 1C).

Core stability training program:

The study group performed the beginners' core stability program suggested by McGill (2007) [24]. It was conducted three times per week for six weeks. The program consisted of three phases, with each phase lasting for two consecutive weeks. The program was performed once, twice, and thrice per day in the first, second, and third two weeks respectively. The participant was asked to perform 15 repetitions for each exercise at each session. McGill (2007) [24] recommended that the isometric holds be held no longer than 7-8 sec because there is a rapid loss of the available oxygen in the torso muscles contracting after these limits. Short relaxation of the muscles restores oxygen. The participant was instructed not to do the core stability exercises in the first hour of awakening because of the increased hydrostatic pressure in the intervertebral discs during this time.

A- Warm-up exercise:

The program began with flexion-extension cycle (cat-camel) motion from quadruped position to reduce spine viscosity and neural tension followed by core stability exercises. The cat-camel was intended as a motion exercise, not a stretch, so the emphasis was on motion rather than pushing at the end ranges of flexion and extension. It was recommended that 5-8 cycles were often sufficient to reduce most viscous stresses (figure 2A).

B- The beginners' program for stabilization:

1- Anterior abdominal exercises (curl-up): curl-up exercises were done with hands under the lumbar spine to preserve a neutral spine posture, preventing flattening the back. Flattening the back flexes the lumbar spine, violates the neutral spine principle, and increases the loads on the disc and ligaments. One knee was flexed but the other knee was straight to lock the pelvis-lumbar spine and help preserve a loss in the neutral lumbar posture. The participant was asked to alternate the bent leg (right to left) midway through the repetitions. With isometric contraction of the abdominals, the head and shoulders were raised off the mat, so the motion took place in the thoracic region only. The exercise was made more challenging by raising the elbows

off the mat. The participant was asked to hold this position for 7-8 sec while breathing deeply and avoid holding the breath. Increasing the intensity of the abdominal brace was avoided [24] (figure 2B).

2- Isometric side-bridge: The beginners' level of exercise involved bridging the torso between the elbows and knees. Once this was mastered and tolerated, the challenge was increased by bridging using the elbows and feet. The participant assumed side lying position on the right side with the right shoulder abducted, such that the upper arm was aligned vertical on the ground and the forearm rested on the floor. The participant was asked to raise the pelvis from the floor and hold it in a straight line "plank" position. The participant was asked to hold this position on one side for 7-8 sec. Attention was directed towards locking the pelvis to the rib cage via an abdominal brace while breathing deeply and not holding the breath [24] (figure 2C).

3- Bird-dog exercise: The participant began on the hands and knees with spine and neck in a neutral position and held this position for 7-8 sec. The participant was asked to extend the left leg behind and raise right arm forward in line with the trunk, and finally, alternate sides. The abdominal bracing was maintained throughout the exercise [24] (figure 2D).

Data analysis:

2x2 mixed design multivariate analysis of variance (MANOVA) was conducted to compare between the “pre” and “post” tests of the isokinetic trunk flexors’, extensors’, hip flexors’, extensors’, abductors’, and adductors’ peak torques in each group. Also, it was intended to compare between these variables in both study and control groups. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS), version 20 for Windows.

Results:

Subject characteristics:

Table 1, showed the mean \pm SD age, body mass, height, and BMI of study and control groups. There was no significant difference in the subject characteristics between both groups ($p > 0.05$).

Within group comparison:

Study group

The results of mixed design MANOVA revealed that there was a significant increase in the post testing mean values of trunk flexors', extensors', hip flexors', extensors', and adductors' peak torques compared with the pre testing values in the study group ($p < 0.05$). Meanwhile there was no significant difference in the post testing peak torque value of hip abductors ($p > 0.05$).

Control group:

Concerning the control group, there was no significant difference in the post testing peak torque values of trunk flexors, extensors, hip flexors, extensors, abductors, and adductors compared with the pre testing ($p > 0.05$).

Between group comparison:

There was no significant difference in the pre testing mean values of trunk flexors', extensors', hip flexors', extensors', abductors', and adductors' peak torques between the study and control groups ($p > 0.05$). There was a significant increase in the post testing mean values of hip extensors' and adductors' peak torques in the study group compared with that in the control group ($p < 0.05$). On the other hand, there was no significant difference in the post testing mean values of trunk flexors', extensors', hip flexors', and abductors' peak torques in the study group compared with that in the control group ($p > 0.05$).

Table 1. Mean age, body mass, and height of the study and control groups:

	$\bar{x} \pm SD$			
	Study	control	t- value	p-value
Age (years)	20.94 \pm 2.22	19.93 \pm 1.79	1.4	0.17
Body mass (kg)	65.58 \pm 8.55	70.27 \pm 14.34	-1.13	0.26
Height (cm)	165.47 \pm 9.34	167.53 \pm 8.73	-0.64	0.52
BMI (kg/m ²)	23.89 \pm 1.75	24.88 \pm 3.87	-0.94	0.35
\bar{x} , mean; SD, standard deviation; p-value, level of significance				

Table (2): Mean trunk flexors', extensors', hip flexors', extensors', abductors', and adductors' peak torques pre and post testing of study and control groups:

Study group				Control group			Between groups	
	Pre test	Post test		Pre test	Post test		Pre test	Post test
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	p value	$\bar{x} \pm SD$	$\bar{x} \pm SD$	p value	p value	p value
Trunk peak torque (Nm)								
Flexors	99.14±20.04	118.29±26.75	0.001*	102.74±11.02	108.52±19.32	0.31	0.54	0.25
Extensors	144.05±35.32	166.29±43.08	0.04*	147.86±23.81	151.33±42.43	0.75*	0.54	0.34
Hip peak torque (Nm)								
Flexors	101.20±32.01	123.14±24.95	0.005*	102.17±23.31	104.39±16.01	0.77	0.92	0.11
Extensors	52.86±1.80	72.94±20.68	0.0001*	48.07±11.01	51.90±6.68	0.47*	0.26	0.001*
Abductors	84.02±20.28	84.07±1.72	0.99*	86.25±19.74	87.59±21.24	0.78	0.76	0.56
Adductors	59.86±18.65	90.28±17.34	0.0001*	62.93±19.49	67.67±17.99	0.46	0.65	0.001*
\bar{x} , mean; SD, standard deviation; p-value, level of significance; * significant								



Figure (1). Isokinetic testing. A. Trunk flexors and extensors. B. Hip flexors and extensors. C. Hip abductors and adductors.

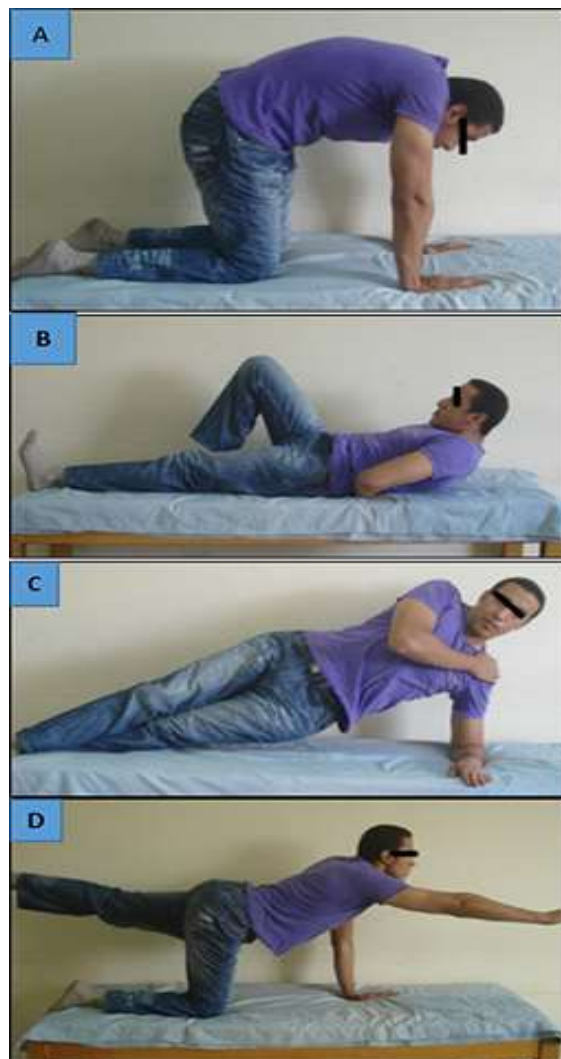


Figure (2). Core stability program. A. Warm up exercise (cat-camel) motion. B. Curl-up exercise. C. Side bridge on elbows and feet. D. Bird dog exercise.

Discussion:

Exercises performed for maintenance of health need not emphasize strength with high-load low repetition tasks, rather more repetitions of less demanding exercises will assist in the enhancement of endurance and strength [24]. The musculature of the lumbar spine is interdependent with the musculature of the pelvic area and hence, are described together as lumbo pelvic-hip complex [25]. The purpose of the current study was to investigate the effect of six weeks of core stability exercises on trunk and hip muscles' strength in college students.

Results of this study showed a significant improvement in peak torque of trunk flexors, extensors, hip flexors, extensors, and adductors post testing in the study group with no significant change in hip abductors peak torque. On the other hand, there were no significant differences between the pre and post testing of all measured variables in the control group. There was a significant increase in the post testing peak torque of hip extensors and adductors in the study group compared with control group, however, there were no significant differences in the post testing peak torque of trunk flexors, extensors, hip flexors, and abductors between groups.

Improvement in muscle strength reported in this study may be attributed to the therapeutic effects of exercise. McGill protocol [24] has a high established reliability concerning improving the muscle performance [26, 27]. The "Big 3" stabilization exercises (modified curl up, side bridge, and quadruped bird dog) have been selected for their ability to ensure sufficient spine stability and optimal motor patterns; they spare the spine of many injury mechanisms and pain exacerbators and are designed to build muscle endurance [28]. Core stability exercises provide muscle activation without external loading for training endurance and stabilization of the trunk and hips [29]. Variations in the pelvic and trunk positions change the activation pattern of trunk and hip muscles, especially the multifidus, gluteus maximus, rectus abdominis, and oblique muscles [30].

As there is no single abdominal exercise challenges all abdominal muscles, the prescription of more than one exercise is required if the goal is to increase the force or endurance capacity of these muscles [31]. The core stability program utilized in this study composed of three big exercises that incorporated all trunk muscles. The curl-up challenges the anterior abdominal muscles with activating deep muscles and minimal activity of superficial muscles [32]. The side bridge is one exercise that appears to challenge the lateral oblique muscles without high lumbar compressive loading [31]. In addition, this exercise produces high levels of activity in the quadratus lumborum muscle, which have been shown to be one of the most important stabilizer of the spine [33]. The bird-dog exercise appears to create minimal external loads on the spine but produces high extensor moment, and small isometric twisting moments, that results in extensor muscle activity, suggesting that this position could be an appropriate choice for persons starting a rehabilitation program for lumbo-pelvic pain. Activity appears to be sufficiently high on one side of the extensors to facilitate training, but the total load on the spine is reduced because the contralateral extensors are producing lower forces. Switching legs results in training both right and left extensors [34].

Results of this study come in agreement with that of Abdallah and Beltagi [35] who investigated the effect of core stability exercises on trunk flexors' and extensors' peak torque in healthy individuals. They reported a significant increase in peak torque of flexors and extensors in study group with no changes in control group. They also reported no significant difference between groups in peak torque of trunk flexors. Also, improvement in study group trunk muscle strength agreed with the results of Kumar et al. [36] who investigated the effect of 12 weeks core stability exercise

program, they reported that core stability exercise program had a significant effect on abdominal and back strength among school age participants. However, they reported significant difference between exercise and control groups. In same context, Shankar et al. [37] studied the effect of five weeks of swiss ball core stability exercises in normal male participants. They reported significant increase in endurance of trunk extensors.

On the other hand, the insignificant improvement in hip abductors in study group in the current study is opposed by Ekstrom et al. [29], who studied electromyography (EMG) activity in side bridge exercise. EMG showed higher activity for gluteus medius and external oblique during side-bridge exercise. This means that side-bridge challenges the strength of gluteus medius muscle however, the current study showed insignificant difference of hip abductors post testing in the study group. The explanation to these contradicting results is that the EMG may yield results that may differ from isokinetic due to difference in the way of measurement.

The significant difference between groups post training in hip extensors and adductors may be explained as these muscles may be overloaded through exercises; gluteus maximus was overloaded in bird dog and adductors were overloaded in side bridge. The insignificant difference in the peak torque values of trunk flexors, extensors, hip flexors, and abductors between groups post testing may be attributed to conducting the study on healthy individuals. The rate of gain from exercises may not be obvious in case of healthy individuals compared to that of unhealthy individuals. Longer duration of exercise program may yield significant difference with control group. In addition, the big three exercises may be not specific for hip flexors. For example, curl-up exercise is done with one knee flexed to lock the pelvis-lumbar spine and ensure that motion only originates from the trunk [24].

The insignificant difference between groups reported in this study comes in agreement with the results of Lust et al. [38] who investigated the effect of six weeks core stability exercises on core strength and other performance measures. The results revealed a significant increase in all the tested measures post testing compared with pre testing, but there was no significant difference between groups. Also, Childs et al. [39] compared the effect of traditional exercise program versus core stabilization exercises on sit-up performance. The results revealed that there was a significant increase in overall fitness scores and sit-up performance post testing compared with those pre testing following core training program, but there was no significant difference between groups. In same context Steffen et al. [40] investigated the effect of 10 weeks of core stability training on isokinetic hip and knee strength and functional performance: vertical jump tests, sprint running, and soccer skill tests. The results revealed that there was no difference between the experimental and control groups in hip and knee strength and performance from the pre to post test for any of the tests used.

CONCLUSION

The presented findings strongly suggest that the core stability program improves trunk and hip muscles' strength except that of hip abductors. Meanwhile improving the hip extensors' and adductors' strength was more pronounced. Thus, it can be concluded that six weeks of core stability exercises have significant effects on trunk and hip muscles strength, especially hip extensors and adductors. They can be included in the exercise programs to improve trunk and hip muscles performance.

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COMPETING INTEREST

The authors have no conflicts of interest.

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