Effects of Core Strength Training Using Stable Versus Unstable Surfaces on Lower Body Quality in 8th Grade Male and Female Students in a Junior High School in Bandung

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Abstract

Objective: To investigate the effects of core strength training performed on stable (CSTS) compared to unstable surfaces (CSTU) on physical fitness in school-aged boys and girls.

Methods: In this study, 72 (36 males, 36 females) untrained healthy subjects (mean age: 14±1 years, age range: 13–15 years) were randomly assigned to a CSTS group for stable surface (n = 36; 18 males and 18 females) or a CSTU group for unstable surface (n = 36; 18 males and 18 females). Core strength training performed on stable as compared to unstable surfaces were assessed on pre- and post-tests. Training period lasted 6 weeks (2 sessions/week). The components of physical fitness were assessed using standing long jump test, stand-and-reach test, 20-m sprint test, jumping sideway test, and y balance test.

Results: This study showed significant results in increased components of physical fitness in both CSTS and CSTU groups (p<0.05). The increase of physical fitness for CSTU was better than CSTS (p<0.05). There were differences of physical fitness between gender in both groups (p<0.05) except for stand-and-reach test (p>0.05).

Conclusions: Core strength training performed on unstable and stable surfaces increases all components of physical fitness in youths. Core strength training performed on unstable surface can better improve the physical fitness compared to the stable surface. There were differences of physical fitness between gender in both groups except for stand-and-reach test.

Keywords: Resistance training, physical fitness, gender

Introduction

Exercise physiology experts have agreed that exercises performed routinely in a scalable and programmed manner will affect the growth and development of children.[1,2] A study in Indonesia found that different physical activity levels affect physical fitness in boys and girls aged 13–15 years.[3]

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Anatomically, core can be represented as the muscular box with the abdomen in the front, the paraspinals and gluteus at the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom.[4,5] Functionally, the core can be thought of as the kinetic link that facilitates the transfer of torques and angular momentum between the lower and upper extremities that is of vital importance for sport-specific and everyday activities in different age groups.[4,6,–8] The core strength training may have the potentials to improve the core muscle strength as well as health-related (i.e., strength, flexibility) and skill-related (i.e., balance, coordination, speed) components of physical fitness in youth.[4,9]

Several daily and sports-related activities may occur on relatively unstable surfaces such as walking on cobblestone pavements jumping on uneven natural turf, landing on sand during beach-volleyball, and kicking a ball while being impeded by an opponent. Thus, according to the concept of training specificity, training must attempt to closely address the demands of these activities.[4] In this regard, Behm and Colado-Sanchez have propagated strength training using unstable surfaces and/or devices to enhance performance and increase the musculoskeletal health in youth and old adults.[4,10] In a recent study, a group performing 9-week progressive core strength training on unstable surfaces in community-dwelling old adults (age: 63–80 years) was compared to a passive control group. The intervention group presented significantly improved measures of trunk muscle strength, spinal mobility, functional mobility, and dynamic balance. It was concluded that core strength training conducted on unstable surfaces is a feasible and effective exercise program for attenuating age-related performance decrements among older adults.[4,11] The use of unstable surfaces during youth strength training might be particularly beneficial due to the fact that the balance and coordination are not yet fully developed in school-aged children.[12] Unstable elements in strength training exercises lead to substantial force decrements while at the same time overall muscle activity appears to remain unchanged.[13,14] That reduced loads combined with high repetitions still represent a sufficient training stimulus in youth which is why strength training performed on unstable surfaces seems to be well-suited for the promotion of health-related and skill-related components of physical fitness in youth.[7,8,14]

Therefore, this study aimed to investigate the effects of core strength training performed on stable (CSTS) compared to unstable surfaces (CSTU) on physical fitness in school-aged boys and girls.

Methods

This was randomized controlled study with 72 boys and girls participated in this study. The experimental procedures were explained (Fig. 1a). The participants included 8th grade students in SMPN 27 Bandung, a public junior high school in Bandung, who were recruited between September and October 2015. All participants could be classified as physically active according to the PAQ-C questionnaire. Characteristics of the study population were also described (Table 1). All participants were eligible for inclusion in this study because the participants had no history of musculoskeletal, neurological or orthopedic disorders that might affect the ability to perform physical fitness tests and core strength training. Furthermore, none had previously participated in systematic strength or balance training. Parents' and participants' informed consents were obtained before the start of the study. Ethical approval was given by the Health Research Ethic Committee, Faculty of Medicine, Universitas Padjadjaran.

The two programs were supervised and conducted by 2 physiotherapists. The ratio of participant-to-supervisor was kept small for both intervention groups with 2 supervisors to 9 participants. Both programs include circuit training with each instructor supervising 4–5 participants. Both training programs lasted 6 weeks and 2 training sessions per week with a total of 12 training sessions. Each training session lasted 30 min, starting with warm-up and ending with a cool-down program. Both groups mainly conducted the "big 3" exercises (curl-up, side bridge, and quadruped position). A detailed description of the core exercises was portrayed (Fig. 1b).

During the training weeks 1–2, participants from the CSTS and CSTU groups performed exercises with 3 sets per exercise and 40 s contraction time or 20 repetitions. During training weeks 3–4, the contraction times and repetitions were increased to 45 s or 23 repetitions. During training weeks 5–6, the contraction times and repetitions were increased to 50 s or 25 repetitions. The rest between sets was similar to the respective contraction time (e.g., 40 s during weeks 1–2). An additional 2–3 min rest was given between exercises.

Prior to pre- and post-tests, all participants underwent a standardized 5-minutes warm-up consisting of skipping exercises. Thereafter, physical fitness tests were assessed.

Standing long jump test has been considered a general index of muscular fitness in youth. Subjects were instructed to stand with both feet right behind a starting line and to jump as far as possible. The best trial in terms of maximal distance was from the starting line to the landing point at heel contact.

Maximum effort sprints were assessed from a stationary start. Subjects were instructed to stand with one foot right behind the starting line and to accelerate at maximum effort to the finish line.
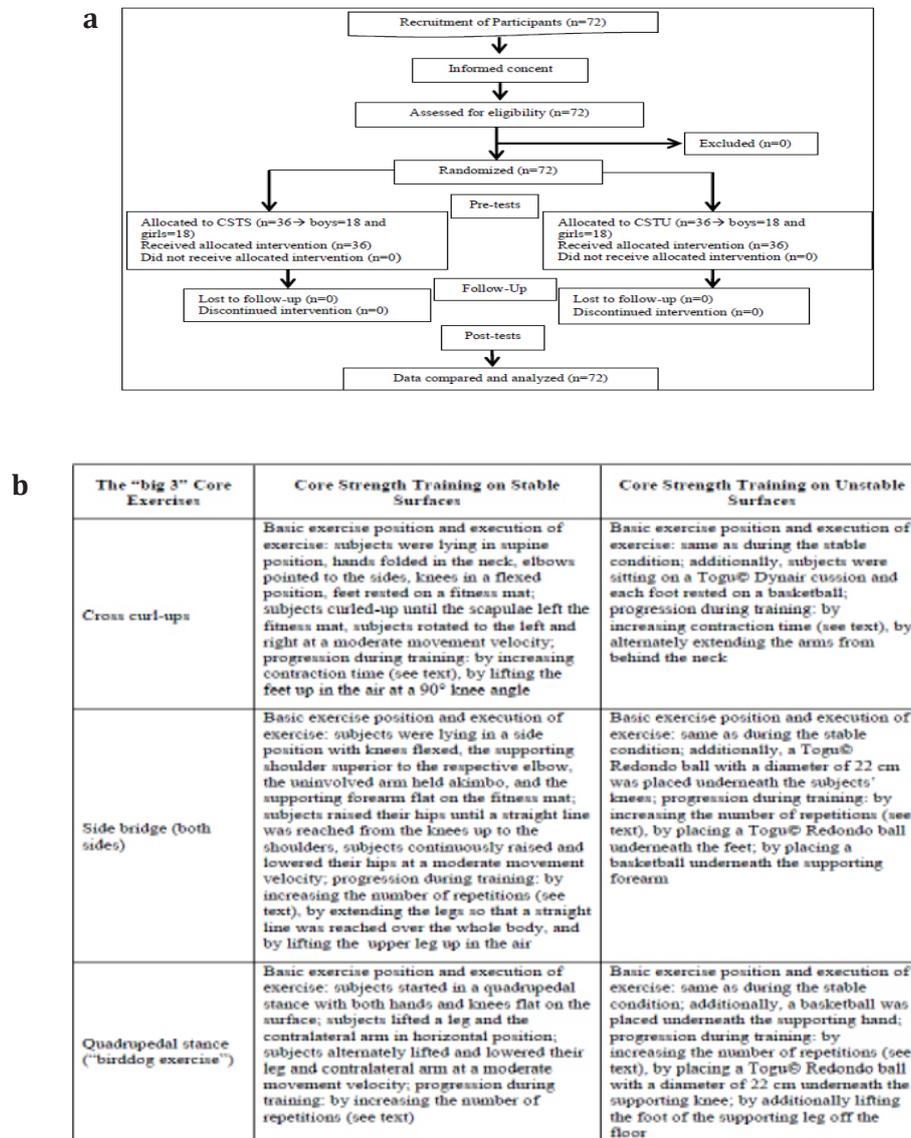
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The "big 3" Core Exercises	Core Strength Training on Stable Surfaces	Core Strength Training on Unstable Surfaces
Cross curl-ups	Basic exercise position and execution of exercise: subjects were lying in supine position, hands folded in the neck, elbows pointed to the sides, knees in a flexed position, feet rested on a fitness mat; subjects curled-up until the scapulae left the fitness mat, subjects rotated to the left and right at a moderate movement velocity; progression during training: by increasing contraction time (see text), by lifting the feet up in the air at a 90° knee angle	Basic exercise position and execution of exercise: same as during the stable condition; additionally, subjects were sitting on a Togu© Dynair cussion and each foot rested on a basketball; progression during training: by increasing contraction time (see text), by alternately extending the arms from behind the neck
Side bridge (both sides)	Basic exercise position and execution of exercise: subjects were lying in a side position with knees flexed, the supporting shoulder superior to the respective elbow, the uninvolved arm held akimbo, and the supporting forearm flat on the fitness mat; subjects raised their hips until a straight line was reached from the knees up to the shoulders, subjects continuously raised and lowered their hips at a moderate movement velocity; progression during training: by increasing the number of repetitions (see text), by extending the legs so that a straight line was reached over the whole body, and by lifting the upper leg up in the air	Basic exercise position and execution of exercise: same as during the stable condition; additionally, a Togu© Redondo ball with a diameter of 22 cm was placed underneath the subjects' knees; progression during training: by increasing the number of repetitions (see text), by placing a Togu© Redondo ball underneath the feet; by placing a basketball underneath the supporting forearm
Quadrupedal stance ("birddog exercise")	Basic exercise position and execution of exercise: subjects started in a quadrupedal stance with both hands and knees flat on the surface; subjects lifted a leg and the contralateral arm in horizontal position; subjects alternately lifted and lowered their leg and contralateral arm at a moderate movement velocity; progression during training: by increasing the number of repetitions (see text)	Basic exercise position and execution of exercise: same as during the stable condition; additionally, a basketball was placed underneath the supporting hand; progression during training: by increasing the number of repetitions (see text), by placing a Togu© Redondo ball with a diameter of 22 cm underneath the supporting knee; by additionally lifting the foot of the supporting leg off the floor

Fig. 1 Flow Chart of Participants (a), Description of the Two Programs (b)

Spinal and pelvic flexibility was then tested using the stand-and-reach test. All subjects were instructed to start the test in a standing position on an elevated platform while putting their feet together. They were then asked to bend over using their maximal range of motion. During the test, knees, arms, and fingers were fully extended. A tape measure was attached to the platform.

The jumping sideways test evaluates motor coordination under time pressure. Subjects were instructed to jump as many times as possible over a period of 15 s with both legs together back and forth across a strip of wood that was attached to a mat (50 × 100 cm).

The Y balance test is a dynamic test that requires the subjects to maintain a single leg stance while reaching as far as possible with the contralateral leg in 3 positions: anterior, posteromedial, and posterolateral positions. The distance from the centre of the grid to the touch point was manually measured and

Table 1 Participant Characteristics

Characteristic	Groups		Total n (%)	p Value
	CSTS	CSTU		
Sex				
Boy	18	18	36 (50)	
Girl	18	18	36 (50)	
Age (years)				0.280μ
M±Std	13.36±0.59	13.17±0.38		
Median	13	13		
Range	13–15	13–14		
Total	1410	1218		0.872β
Body height (cm)				
M±Std	151.64±7.75	151.97±9.62		
Median	151	150		
Range	139–176	136–170		0.640μ
Body mass (kg)				
M±Std	46.17±7.37	46.03±10.93		
Median	47.5	43,5		
Range	33–63	31–72		0.589μ
Total	1355.5	1272.5	17 (23.6)	
Body mass index (kg/m^2)			55 (76.4)	
Overweight	9	8		
Normoweight	27	28		
M±Std	20.01±2.75	19.70±2.97		
Median	19.1	19.1		0.839μ
Range	15.8–25.9	15.6–25.3	67 (93)	
Total ranking	1362	1266	5 (7)	
PAQ-C				
Very low (1)	34	33		0.054μ
Low (2)	2	3		
Range	1–2	1–2		
Total	1296	1332		
Leg length right (cm)				0.054μ
M±Std	82.58±4.62	85.36±4.71		
Median	83	84.5		
Range	73–93	78–100		
Total ranking	1143	1485		
Leg length left (cm)				
M±Std	82.58±4.62	85.36±4.71		
Median	83	84.5		

Range	73–93	78–100
Total	1143	1485

Note: M = mean; Std = standard deviation; t test (β); Mann Whitney test (μ)

documented after each reach. A composite score was measured by using the formula of (CS) = [(maximum anterior reach distance + maximum posteromedial reach distance + maximum posterolateral reach distance)/(leg length × 3)] × 100.

Initially, descriptive statistics were done for all variables, followed by the normality test using the Saphiro-Wilks test. Hypothesis test of physical fitness before and after core exercise for both kinds of surfaces. If there are differences between the gender in the physical fitness test the hypothesis then separated for girl and for boy.

Analysis of the data used in this study is the t-test to compare the difference between two average data that were independent and normally distributed between the core exercise group on stable and unstable surfaces. For data that were not normally distributed, Mann Whitney test was used. To tests the difference in the average value before and after practice, the t-test was used when the data was normally distributed while the Wilcoxon Match Pair test was used for data that were not normally distributed. The significance level was set at p≤0.05.

Results

The results for all outcome variables in pre- and post-intervention results for all outcome variables are described (Table 2). In this study, no statistically significant differences were found in the baseline between the 2 intervention groups (p>0.05). A significant difference (p<0.05) for all variables was found in the pre- and post-intervention for both groups. All variables of physical fitness tests on CSTU group were higher than those of the CSTS group after intervention and for 20-m sprint test, the CSTU group was faster than CSTS group.

No significant difference in characteristics was found between boys and girls participated in this study (p>0.05) for all variables, except that the participants in CSTS group significantly different (p<0.05) for the length of the right leg and left leg length were described (Table 3).

There were significant differences in almost all physical fitness test results between boys

and girls in the CSTS group both in pre- and post-intervention (p<0.05), except for stand-and-reach test (p>0.05) (Table 4).

There were also significant differences in almost all physical fitness test results between boys and girls in the CSTU group both in pre- and post-intervention (p<0.05), except for stand-and-reach test in pre-intervention results (p>0.05) (Table 5).

Discussion

The main findings of this study are that (1) performance in physical fitness tests (i.e., standing long jump test, 20-m sprint test, stand-and-reach test, jumping sideways test, Y balance test) was significantly improved in both intervention groups over the 6-week training period; (2) CSTU as compared to CSTS has additional effects on physical fitness; (3) there are differences in physical fitness between gender except for the stand-and-reach test.

The present results are in accordance with the literatures regarding the effects of core strength training on TMS and physical fitness in youth. Following 6 weeks of core strength training (e.g., low plank obliques, push-up jacks) conducted during physical education classes (1 session/week), Allen *et al*.[9] have found significant performance enhancement (f=0.27–0.69) in 5 different trunk muscle endurance tests (i.e., Parallel Roman Chair Dynamic Back Extension, Prone Plank, Lateral Plank, Dynamic Curl-Up, Static Curl-up) in healthy untrained children with a mean age of 11 years. In a randomized controlled trial, Hoshikawa *et al*.[15] investigated the effects of a combined core strength training (e.g., prone and side bridging on elbows) and soccer training (e.g., technical drills, interval runs) as compared to soccer training only (e.g., technical drills, interval runs) in male outfield soccer players aged 12–13 years. Both intervention groups exercised for 6 months. The combined training group conducted 4 core strength training and 5 soccer training sessions per week, while the soccer training group performed 5 soccer training sessions per week only. Before and after training, subjects were tested for their hip flexors/extensors

Table 2 Effects of the Two Programs on Measures of Physical Fitness

Variables	CSTS			CSTU			p-value CSTS-CSTU (Post)
	Pre	Post	p Value	Pre	Post	p Value	
YBORL (%)			0,000μ*			0.000μ*	0.007μ*
Mean±Std	90.45±15.43	97.55±15.56		91.00±10.42	102.44±11.45		
Median	90.27	98.18		91.69	102.18		
Range	60.21–131.2	65.10–139.19		63.46–125	73.58		
Total		1073			1555		
YBOLL (%)			0.000μ*			0.000μ*	0.010μ*
Mean±Std	89.89±15.21	97.53±15.55		90.95±10.43	102.12±11.34		
Median	90.3	98.15		91.69	101.74		
Range	60.26–131.34	65.05		63.45–125.88	73.55–140.99		
Total		1085			1543		
SAR (cm)			0.000μ*			0.000β*	0.005μ*
Mean±Std	95.58±4.93	98.94±5.48		95.64±3.71	102.42±3.78		
Median	94.5	97.5		96	102		
Range	86–104	90–110		90–105	95–110		
Total		1064.5			1563.5		
20-m sprint (s)			0.000μ*			0.000β*	0.007μ*
Mean±Std	4.95±0.58	4.13±0.54		4.97±0.732	3.78±0.59		
Median	5	4.28		4.97	4.02		
Range	3.43–6.03	2.99–4.91		3.31–6.96	2.39–5.19		
Total		1552.5			1075.5		
JS			0.000 μ*			0.000μ*	0.000μ*
Mean±Std	23.03±2.75	32.00±3.14		22.97±2.92	37.11±4.77		
Median	22	32		22.5	36		
Range	20–30	25–39		18–36	30–56		
Total		859.5			1768.5		
SLJ (cm)			0.000μ*			0.000β*	0.021μ*
Mean±Std	173.03±29.58	186.22±29.62		172.56±33.51	204.17±31.82		
Median	180	193		175	205		
Range	119–224	132–238		112–236	147–268		
Total		1230			1519.5		

Note: Significance value based on the p-value <0,05 (*).
Notes: YBORL= Y balance on right leg, YBOLL= Y balance on left leg, SAR= stand-and-reach, JS= jumping sideways, SLJ= standing long jump

Table 3 Characteristics of Boys and Girls

Variables	CSTS			CSTU		
	Boys	Girls	p Value	Boys	Girls	p Value
Age (Years) Total	296	370	0.242μ	315	351	0.569μ
Body height (cm) Mean	153.28	150	0.359β	153.72	150.22	0.327β
Body mass (kg) Total	345.5	320.5	0.692β	344.5	321.5	0.716μ
Body mass index Total	330	336	0.924μ	325	341	0.800μ
PAQ-C Total	351	315	0.570μ	360	306	0.390μ
Leg length right (cm) Total	261	405	0.023β*	330.5	335.5	0.937μ
Leg length left (cm) Total	261	405	0.023β*	330.5	335.5	0.937μ

Note. Significance value based on the p-value <0,05 (*)

strength, cross-sectional area of trunk muscles, and athletic performance. With respect to hip strength and physical fitness measures, both intervention groups showed significant but similar performance enhancements in peak torque of the hip flexors (combined training group: f=0.45, isolated training group: f=0.74) and in 15-m sprint test (combined training group: f = .56, isolated training group: f=0.40) following training. However, the relative change in peak hip extensor torque was found to be significantly higher in the combined (f=1.26) as compared to the isolated (f = 0.68) training group. Furthermore, significant gains in squatting (combined training group: f=0.33, soccer training group: f=0.06) and countermovement jump heights (combined training group: f=0.62, soccer training group: f=0.12) were observed in the combined training group only.[15] Our findings extend the existing results in as much as we additionally observed improvements in the measures for the flexibility, coordination, and balance following core strength training in youths. With reference to the literature and our own findings, core strength training appears to be a well-suited conditioning program to promote the health- and skill-related physical fitness in youth. [9,10] The positive effects of core strength training on the physical performance of the lower extremities can most likely be explained by the specific role of the trunk as a linkage between upper and lower extremities. During every-day or sports-related rotational torso movements, trunk muscles generate torque along diagonal proximal to distal path to enhance the extremity force production. 9,10

Konin *et al.* referred to this as serape (or "shawl-like") effect. Scientific evidence was provided by Kibler who was able to show that 51% of total kinetic energy and 54% of total force are developed in the hip and trunk muscles during the tennis serve of professional athletes.[6,16] Young *et al*.[17] stated that the muscles belonging to the global system (e.g., erector spinae, rectus abdominis, internal/external obliques, latissimus dorsi) primarily generate torque in a serape-like manner during the rotational movements (e.g., throwing). Moreover, the trunk acts as a kinetic link that facilitates the transfer of torques and angular momenta between upper and lower extremities during the execution of whole body movements as part of sports and occupational skills, fitness activities, and activities of daily living. There is evidence for this hypothesis which indicates that during normal human movement, trunk muscle activations (e.g., musculus transversus abdominis) are organized well ahead (110 ms) in anticipation of movement or perturbation to balance in healthy young adults.[17] Hodges and Richardson argued that this anticipatory muscle activation helps stiffening the spine to provide a foundation for the functional movements. Therefore, muscles that belong to the local system (e.g., lumbar multifidus, transversus abdominis) appear to primarily provide proximal stability of the trunk for distal mobility of the limbs. It should be kept in mind, our core strength training protocols comprising multiple sets with many repetitions or long contraction times may have specifically induced adaptive processes in muscles of the local system (deep muscles) since those

Table 4 Effects of the Two Programs on Measures of Physical Fitness in Boys and Girls in CSTS Group

| Variables | CSTS | | | | | |
| | Pre | | | Post | | |
	Boy	Girl	p Value	Boy	Girl	p Value
YBORL (%)			0.007μ*			0.009μ*
Mean±Std	96.46±17.75	84.44±9.94		103.17±18.21	91.93±9.99	
Median	94.23	86.42		98.68	94.06	
Range	60.21–131.20	60.23–97.21		65.10–139.19	66.83–104.47	
Total	418	248		416	250	
YBOLL (%)			0.027μ*			
Mean±Std	95.31±17.72	84.47±10.00		103.16±18.21	91.91±9.98	0.009μ*
Median	91.53	86.38		98.6	94.23	
Range	60.26–131.34	60.48–97.49		65.05–139.85	66.67–104.88	
Total	403	263		416	250	
SAR (cm)			0.548μ			0.537μ
Mean±Std	96.17±5.95	95.00±3.71		99.61±6.38	98.28±4.48	
Median	95.5	94		98	96.5	
Range	86–104	90–102		90.00–110.00	93–107	
Total		314		352.5	313.5	
20-m sprint (s)			0.000μ*			0.000μ*
Mean±Std	4.63±0.60	5.28±0.33		3.76±0.47	4.50±0.30	
Median	4.74	5.25		3.73	4.52	
Range	3.43–5.75	4.65–6.03		2.99–4.55	3.69–4.91	
Total	216.5	449.5		199.5	466.5	
JS			0.045μ*			0.001μ*
Mean±Std	24.17±3.29	21.89±1.41		33.67±3.01	30.33±2.30	
Median	23.5	22		34	30.5	
Range	20.0–30.0	20–24		28.00–39.00	25–35	
Total	396.5	269.5		435	231	
SLJ (cm)			0.000μ*			0.000μ*
Mean±Std	195.44±16.84	150.61±21.29		208.83±16.30	163.61±21.41	
Median	199	153		212.5	165	
Range	157.00–224.00	119–186		170–238	132–199	
Total	477	189		480	186	

Notes: YBORL= Y balance on right leg, YBOLL= Y balance on left leg, SAR= stand-and-reach, JS= jumping sideways, SLJ= standing long jump

Table 5 Effects of the Two Programs on Measures of Physical Fitness in Boys and Girls in CSTU Group

Variables	CSTS					
	Pre			Post		
	Boy	Girl	p Value	Boy	Girl	p Value
YBORL (%)			0.000μ*			0.001μ*
Mean±Std	96.59±8.55	85.42±9.19		108.25±10.39	96.69±9.52	
Median	96.09	87.43		107.1	99.81	
Range	85.89–125.83	63.46–96.39		89.84–140.95	73.58–106.40	
Total	452	214		441	225	
YBOLL (%)			0.000μ*			0.001μ*
Mean±Std	96.54±8.53	85.36±9.21		107.66±10.51	96.59±9.46	
Median	95.99	87.53		107.16	99.65	
Range	85.43–125.88	63.45–96.73		89.64–140.99	73.55–106.83	
Total	453.5	212.5		434	232	
SAR (cm)			0.353β			0.046β*
Mean±Std	96.22±3.42	95.06±3.99		103.67±3.34	101.17±3.87	
Median	96.5	95		104	101	
Range	91–104	90–105		98–110	95–110	
Total						
20-m sprint (s)			0.000β*			0.000β *
Mean±Std	4.56±0.63	5.38±0.55		3.35±0.45	4.21±0.37	
Median	4.71	5.4		3.38	4.15	
Range	3.31–5.67	4.45–6.96		2.39–4.07	3.50–5.19	
Total						
JS			0.035β*			0.000μ*
Mean±Std	24.00±3.58	21.94±1.59		39.56±5.44	34.67±2.17	
Median	23.5	22		38	35	
Range	20–36	18–25		35–56	30–38	
Total	399.5	266.5		453.5	212.5	
SLJ (cm)			0.021μ*			0.002β*
Mean±Std	185.22±32.95	159.89±29.77		220.06±29.13	188.28±26.49	
Median	194.5	155		225	190	
Range	112–228	118–236		163–268	147–242	
Total	409.5	256.5				

Notes: YBORL= Y balance on right leg, YBOLL= Y balance on left leg, SAR= stand-and-reach, JS= jumping sideways, SLJ= standing long jump

muscles are characterized by a relatively high proportion of type I (slow-twitch) fibers.[10] Interestingly, the performance during physical fitness tests significantly improved although postural positions during training and testing conditions were different (i.e., horizontal lying during training vs. upright standing during testing). Despite this difference, transfer effects were noticed from the core strength exercises performed in vertical directions while lying in horizontal positions to proxies of physical fitness predominately performed in vertical position.[18] Future studies have to elucidate whether core strength training programs conducted in an upright standing position (e.g., Romanian deadlift) may be even more effective in enhancing components of physical fitness in adolescents. By integrating unstable surfaces in our CSTU exercise protocol, we specifically aimed at activating the deep muscles that are responsible for trunk stability. Nevertheless, our findings indicate that CSTU as compared to CSTS has only limited additional effects (i.e., stand-and-reach test) on physical fitness. In this regard, the previous study compared trunk muscle activities (which inludes rectus abdominis, external or internal oblique, transversus abdominis, erector spinae) during resistance exercises (i.e., back squat, dead lift, overhead press, curl lifts) performed on stable ground versus the BOSU Balance Trainer in trained young men.[18] The main finding of this study was that no significant differences were found in activity across all examined muscles and lifts when performing the resistance exercises on the BOSU Balance Trainer as compared to stable ground. The authors concluded that the tested resistance exercises can be performed on stable ground without losing the potential trunk muscle training benefits. Our findings regarding the limited additional effects of CSTU as compared to CSTS are in line with the results of this cross-sectional study. To the authors' knowledge, there is no other study available in the literature that compared the effects of CSTS versus CSTU on measures of physical fitness. Therefore, we will discuss a study that investigated the effects of lower extremity strength training using stable versus unstable surfaces on athletic performance in healthy, trained individuals. Both intervention groups performed the same exercises (e.g., squats, deadlifts, lunges, single-leg squats) at identical training volumes but on different training surfaces (stable vs. unstable). Following 10 weeks of training, findings were inconsistent in as much as the unstable group showed significantly greater improvements than the stable group in sprint time (stable group: f=1.33, unstable group: f=1.50) and in agility performance (stable group: f=0.97, unstable group: f=1.60). In terms of drop jump power performance, both groups showed similar performance enhancements (stable group: f =0.26, unstable group: f=0.11).[19]

Seryozha et al.[20] have conducted research in children aged 6–18 years. The result of the study stated that the standing long jump test results can be affected by age, BMI, and gender. Boys showed better results in the standing long jump test than girls and this defferences becomes greater with age. There is improved performance in several tests on boys than girls aged 13–15 in dashes (speed) and the shuttle runs (agility and speed); vertical, standing long jumps and distance throw (coordination and explosive strength); flexed arm hang and sit-ups (local muscular endurance); beam walk and flamingo stand (balance).[20]

In summary, the results of this study have illustrated that the core strength training is a training modality that produces marked increases in health (i.e., strength, flexibility) and skill-related (i.e., balance, coordination, speed) components of physical fitness in healthy male and female youths. CSTU can enhance physical fitness better than CSTS. There are differences in physical fitness between gender except for stand-and-reach test.

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