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Effect of core stabilization exercises in addition to conventional training on core stability and running performance

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Abstract. There is a lack of studies pertaining to performance enhancement is noted, specifically regarding training of the core for runners. This study would be necessary in order to contribute information about how core stabilization training affects the athleticism of a runner as well as introducing formal core training in addition to conventional regime for improvement of running performance and core stability. *Material and Method*. Thirty healthy male athletes (18.80±1.26) were divided into 2 groups, 15 subjects in core stability enhanced conventional Experimental Group (I) and 15 subjects in conventional Control Group (II) only. The study designed as a two groups Pre-Test and Post Test study for three session/week during 5 weeks. Dependent variable: 100m sprint test for running performance, Back Extensor test, Abdominal Fatigue test, Side Bridging test to the right, Side Bridging test to the left measured -pre training and -post training. *Results.* The analysis revealed that Experimental Group shows better improvement then Control Group: the Running Performance of Control Group = 0.1280±0.02ms, Experimental Group = 0.6153±0.02ms with t=27.83; the Back Endurance test of Control Group = 4.54 ±0.50s, Experimental Group 25.72±2.3s with t=34.78; the Abdominal Fatigue test of Control Group =0.4.037±.21s, Experimental Group =22.08±0.34s, with t=171.77; the Side Bridging test for right side of Control Group = 9.77±.98s, Experimental Group =16.80±0.51s with t=24.50 and of Left Side of Control Group = 5.092±0.21s, Experimental Group =16.13±0.26s with t=125.21. Correlation of Core Stability and Running Performance of Control Group of Running performance - 1.000, Back Extensor Test 0.871, Abdominal Fatigue test 0.881, Side bridging test Right 0.801, Side bridging test Left 0.868 and of Experimental Group of Running Performance - 1.000, Back Extensor Test 0.817, Abdominal Fatigue test 0.852, Side bridging test Right 0.872, Side bridging test Left 0.852. *Conclusion.* Our results clearly emphasize the fact that core stabilization exercises in runners not only improves Core stability but it may also significantly affect running performance. The results also demonstrating that there is significant correlation between running performance and core stability, confirmed that better core stability lead to improved running performance.
Key words: *core stability, running performance, exercises*.

Introduction

Running is the most common fitness sport involve balanced and powerful movements of the body propelling itself forward and catching itself in the complex motor patterns-a strong foundation of muscular balance is essential (1).

There is lumbo-pelvic-hip complex motion with respect to the phases of the running cycle. A complete running cycle is made up of stance and swing phases (2). The stance phase can be subdivided into periods of propulsion and absorption. The swing phase can be subdivided into periods of initial and terminal swing. The various phases of stance and swing make up approximately 40 and 60% of the running cycle respectively (2).

Lumbo-pelvic support during running comes from key stabilizing mechanisms of the core: thoracolumbar fascia, intra-abdominal pressure, the paraspinal muscles (interspinales and intertransversarii) and the deep lumbar musculature (multifidus, lower longissimus and iliocostalis) (2). The core musculature is composed of 29 pairs of muscles that support the lumbo-pelvic hip complex (1). These muscles help to stabilize the spine, pelvis and kinetic chain during functional movements. When the system works efficiently, the result is appropriate distribution of forces; optimal control and efficiency of movements; adequate absorption of excessive compressive, translational or shearing forces on the joints of the kinetic chain (1).

Sports based program often stress the importance of a strong mid-section (core musculature) to enhance sports performance and reduce the risk of back injury (3). Synergistic contraction of all abdominal muscles, which occurs during running, creates tension on the rectus sheet in the abdomen. Tension within the sheet increases abdominal air pressure through movement of the viscera and diaphragm. Intra-abdominal pressure is active during running along with transversus abdominis activation. Additionally, the deep lumbar muscles are active throughout full lumbar spine motion and during movements of the lower and upper limbs. It is evident that the transversus abdominis, multifidus, internal oblique, external oblique, paraspinals, and pelvic floor musculature play an important role in stability of the pelvis and lumbar spine during running (1).

Muscle weakness/dysfunction in the core would reduce the efficiency of the running cycle and possibly increase the risk of lumbar, pelvic and lower extremity injuries. Poor lumbo-pelvic stability during running has been cited as being a contributor to lower back pain in athletes (2).

The necessary mechanics and strategies utilized in runners are widely known but through a systematic review of the literature, lack of studies pertaining to performance enhancement is noted, specifically regarding training of the core. Only a few studies supported the use of a core stabilization program in athletes. Piegaro (4) found improvement in a four-week core stabilization program with exercises based on a foam roll and Swaney and Hess (5) found positive results with posture after a nine-week core stabilization program implemented with swimmers and Stanton R et al (9). Examine the effectiveness of a six week core stability program on athletes twice a week and saw changes in running economy and found positive results in improving core stability. Based on Jeffrey's (7) techniques a core stabilization program protocol has been created specifically toward athletes. Although these exercises are believed to produce the desired effect, they remain relatively unstudied and the exercises at times in training neglect the core stability aspect of running and thus core has not found its correct place in training regimes of runners.

As can be seen there is a lack of focus on core strengthening, hence, a study examining the effectiveness of core stabilization is warranted in runners since running efficiency and core are essential to enhance running performance. Therefore, it would be interesting to observe whether formal core training in addition to conventional regime has any beneficial effects on running performance and core stability.

Material and Method

Sample. Thirty male healthy young athletes with a mean age of with a mean age of 18.80±1.26 years (ranging from 16 to 22 years), average weight 69.13±2.90 kilograms, mean height of 173.53±3.16cm completed the study. They were divided into 2 groups, 15 subjects in core stability enhanced conventional Exercise Group (I) and 15 subjects in conventional Control Group (II) only. They were from Jawaharlal Lal Nehru Stadium, SAI.All the male subjects with normal grading of trunk MMT, having 2-3 years of experience of running and of state level were included. Subjects with any presence of pain in the upper limb, lower limb or any part of the body at rest or during activity, any medical condition due to which the athlete is on medication at the time period of study, current or previous involvement in a formal core stability program, planning to change his exercise program in near future or change in environmental conditions during or planning to start or quit taking dietary supplements during study period were excluded. The study designed as a two phases, Pre-Test and Post Test study. 100 m sprint test for Running Performance, Back Extensor Test, Abdominal Fatigue Test, Side Bridging Test to the Right, and Side Bridging Test to the Left were taken as Dependent Variables.

Warm Up Procedure. A warm up was performed by each subject. The warm-up session was followed by a five minute stretching protocol. They performed a warm up consisting of five minute jogging, on toe walk and 20m sprint, on heel walk and 20 m sprint, back kicking, high knee jump, front kick and 20m sprint. Then neck rotation, shoulder rotation, hip and ankle rotation, and general stretching exercises were performed. This was sourced from their routine Conventional Training Protocol.

Pre and post-testing

The back extensor test. In this test the subject was placed in a prone position so that the upper body is cantilevered out over a test bench with the lower legs secured. The arms were folded across the chest with hands held on opposite shoulders. The test was terminated when the subject falls below the horizontal position (9-15). The test scores were then calculated into seconds for each subject to determine the length of time they were able to perform the test.

The abdominal fatigue test. It was performed with both the subject's knees and hips flexed to a 90° angle, with the feet fixed securely to the bench by a canvas strap. A towel over the bare feet was used to protect the athlete's feet from chafing. The subject's arms were folded across the chest with the hands placed on opposite shoulders. A 4-inch thick rubber pad was wedged between the subject's back and the 45° back rest.

The supporting wedge was removed before the test began. Once the wedge was removed the subject was instructed to maintain their body position. The test was terminated when the upper body could no longer be maintained at a 45° angle (9, 10, 15). The test scores were then calculated into seconds for each subject to determine the length of time they were able to perform the test.
The side bridging test. The subject was placed in a side lying position with legs extended on top of a 2-inch thick foam-padded mat. The top foot was placed in front of the lower foot for added support. The subjects were instructed to support themselves with only the use of the elbow, forearm, and feet. The hips were raised up off the table as a straight body position is maintained in the frontal plane. The non supporting arm was held across the chest with the hand being placed on the opposite shoulder. The test ends when the hips began to sag and the body position was no longer maintained, or when the lower leg started to rest on the mat. This test was performed on both the athlete's right and left sides (9-15).
100m Sprint Test. There would be 100m dash run on track. The time was recorded with digital timer.by the coach. The three trials were taken for the best running performance (16-21).
Preventive Measures. For DOMS-proper warm up and stretching were given. Compliance for testing instructions were checked before each test.

Training Protocol (Table 1.1)

Table 1.1. Core stabilisation exercises

	EXERCISE	SET AND REPS.
WEEK 1	supine abdominal contractions; quadruped abdominal contractions; side plank	3X20 2X15 1X6/EACH SIDE (10 SEC HOLD)
WEEK 2	dying bug; bridging; seated medicine ball rotation	3X20 3X15 3X15
WEEK 3	seated on Swiss ball; squat with Swiss ball; superman	3X20 3X15 3X15
WEEK 4	multidirectional lunge; oblique pulley with side shuffles; standing wall cross toss	3X15 3X15 3X20
WEEK 5	diagonal curls on Swiss ball; twist on Swiss ball; standing on unstable surface	3X10 3X15 4X10

Results

Back Extensor Test. Again the analysis revealed that both groups improved during study period, but Experimental Group (I) shows better improvement then Control Group (I) (Table 1.2, 1.3 and Figure 1.1).
Within group analysis of Control Group before training 100.86±2.28s, after training 105.40±2.70s, t=34.91 and of Experimental Group before training 99.34±4.30s, after training125.06± 6.67 s, t=43.25. Between group analysis of Control Group 4.54± .50s, Experimental Group 25.72± 2.3s with t=34.78, p<.000.

Table 1.2. Descriptive Statistics for Back Extensor Test

	PRE TEST			POST TEST	t- Value
	MEAN	S.D.	MEAN	S.D.	
Experimental Group (I)	99.34	4.30	125.06	6.57	43.27
Control Group (II)	100.86	2.28	105.40	2.70	34.91

Table 1.3. Between Group Comparison of Change in Back Extensor Test after training

	MEAN	S.D.	t-Value
Experimental Group (I)	25.72	2.3	34.78
Control Group (II)	4.54	.50	

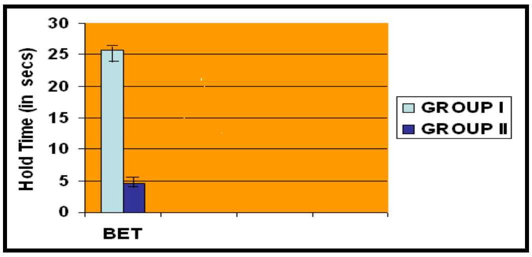

Figure 1.1. Back Extensor Test. Change in Mean Score
Abdominal Fatigue Test

The analysis revealed that both groups improved during study period, but Experimental Group shows better improvement then Control Group (Table 1.4, 1.5 and Figure 1.2). Within group analysis of Control Group before training 169.65±2.28s, after training 173.69±2.16s, t=74.37 and of Experimental Group before training 170.240±3.05s, after training 192.32±3.12s, t=.245.55. Between group analysis of Control group .4.037±.21s, experimental group 22.08±.34s, with t=171.77, p<.000.

Table 1.4. Descriptive Statistics for Abdominal Fatigue Test

	PRE TEST			POST	t- Value
	MEAN	S.D.	MEAN	S.D.	
Experimental Group (I)	170.24	3.05	192.32	3.12	245.55
Control Group (II)	169.65	2.28	173.69	4.037	.210

Table 1.5. Between Group Comparison of Change in Abdominal Fatigue Test after training

	MEAN	S.D.	t-Value
Experimental Group (I)	22.08	.51	171.77
Control Group (II)	4.037	.21	

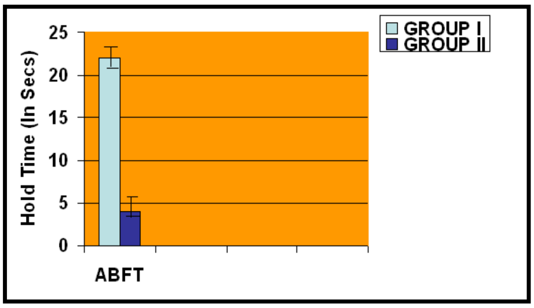

Figure 1.2 Abdominal Fatigue Test- Change in Mean Score

Side Bridging Test. Again the analysis revealed that both groups improved during study period, but Experimental Group shows better improvement then Control Group (Table 1.6, 1.7 and Figure 1.3). Within group analysis of Control Group before training 53.85 ±2.14s, after training 63.63 ±2.22s, t=38.42 and of Experimental Group before training 52.38±2.87s, after training 69.18±3.30s, t=127.45. Between group analysis of Control Group 9.77±.98s, Experimental Group 16.80±.51s with t=24.50, p<.000.

Table 1.6. Descriptive Statistics for Side Bridging Test (Right)

	PRE TEST		POST TEST		t- Value
	MEAN	S.D.	MEAN	S.D.	
Experimental Group (I)	52.386	2.87	69.187	3.30	127.45
Control Group (II)	53.85	2.14	63.63	2.22	38.42

Table 1.7. Between Group Comparison of Change in Side Bridging Test (Right) after training

	MEAN	S.D.	t-Value
Experimental Group (I)	16.80	.51	24.50
Control Group (II)	9.77	.98	

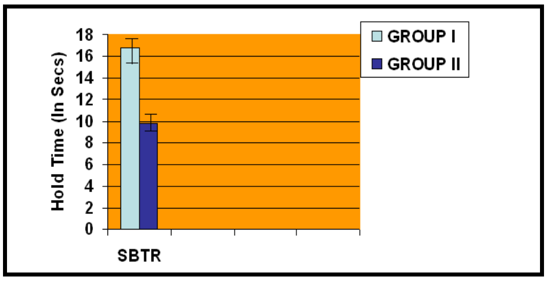

Figure 1.3 Side Bridging Test (Right Side) - Change in Mean Score

Side Bridging Test. The analysis revealed that both groups improved during study period, but Experimental Group shows better improvement then Control Group (Table 1.7, 1.8 and Figure 1.4). Within group analysis of Control Group before training 55.55 ±2.20s, after training 60.65 ±2.11s, t=71.62 and of Experimental Group before training 55.41±2.90s, after training 71.54±2.78s, t=232.10. Between group analysis of Control Group 5.092.±.21s, Experimental Group 16.13±.26s with t=125.21, p<.000.

Table 1.6. Descriptive Statistics for Side Bridging Test (Left Side)

	MEAN	S.D.	t-Value
Experimental Group (I)	16.13	.26	125.21
Control Group (II)	5.092	.21	

Table 1.8. Between Group Comparison of Change in Side Bridging Test (Left Side) after training

	PRE TEST		POST TEST		t- Value
	MEAN	S.D.	MEAN	S.D.	
Experimental Group (I)	55.411	2.90	71.544	2.78	232.10
Control Group (II)	55.559	2.20	60.65	2.11	71.629

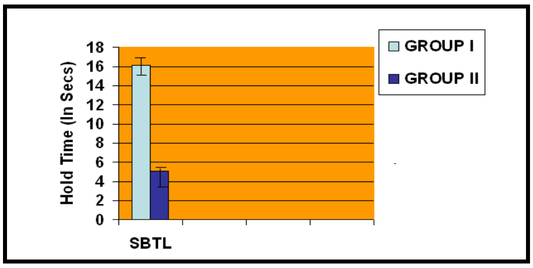

Figure 1.4. Side Bridging Test (Left Side) - Change in Mean Score

Running Performance (100 m sprint test). The analysis revealed that both groups improved during study period (Table 1.9, 1.10 and Figure 1.5). Within group analysis of Control Group before training 13.05±1.10s, after training 12.93±1.10s, t=27.83 and of Experimental Group before training 13.04±1.18s, after training 12.43±1.18s, t=119.44. Between group analysis of Control Group .1280±.02ms, Experimental Group .6153±.02ms with t=27.83, p<.000.

Table 1.9. Descriptive Statistics for Running Performance

	MEAN	S.D.	t-Value
Experimental Group (I)	.615	.02	70.57
Control Group (II)	.1280	.02	

Table 1.10. Between Group Comparison of Change in Running Performance after Training

	PRE TEST		POST TEST		t- Value
	MEAN	S.D.	MEAN	S.D.	
Experimental Group (I)	13.045	1.18	12.430	1.18	119.4
Control Group (II)	13.059	1.10	12.931	1.10	27.83

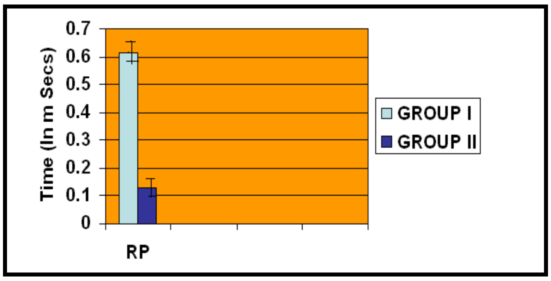

Figure 1.5. Running Performance-Change in Mean Score

Core stability and Running Performance. Using a Pearson Product Moment correlation test on the data, the analysis show significant correlation between Running Performance and Core stability (Table 1.11, Figure 1.6 and 1.7). The *r* value of Control Group of dependent variables: Running performance - 1.000, Back Extensor Test .871, Abdominal Fatigue test .881, Side bridging test Right .801, Side bridging test Left .868ms. The r value of Experimental Group of dependent variables: Running Performance - 1.000, Back Extensor Test .817, Abdominal Fatigue test .852, Side bridging test Right .872, Side bridging test Left .852ms. As score of core stability increases, the score of Running Performance decreases, the analysis show significant negative correlation between Core stability and Running Performance.

Table 1.11. Pearson Correlation of Core Stability and Running Performance

	RP	BET	ABFT	SBTR	SBTL
Experimental Group (I)	-1.000	.817	.852	.872	.852
Control Group (II)	-1.000	.871	.881	.801	.868

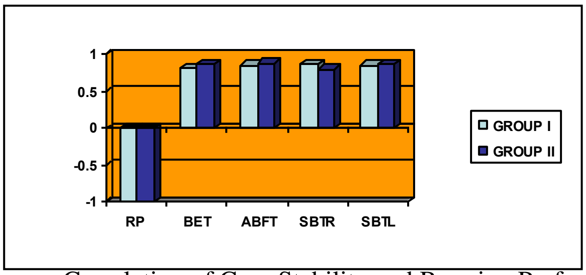

Figure 1.6. Pearson Correlation of Core Stability and Running Performance

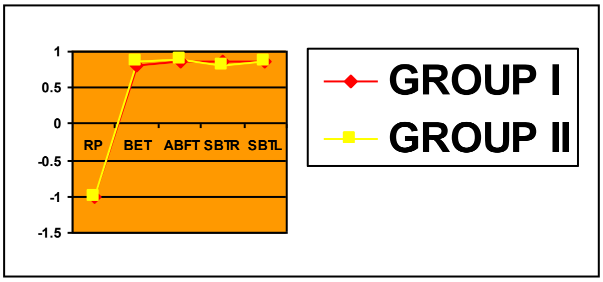

Figure 1.7 Pearson Correlation of Core Stability and Running Performance

Legend. RP: Running Performance; BET: Back Extensor Test; AB.FT: Abdominal Fatigue Test; SBTR: Side Bridging Test (right); SBTL: Side Bridging Test (left).Group I: Core Stabilization Exercises in addition to Conventional Training Group. 2-Group II: Conventional Training group only.

Discussion

Core stabilization has become an important component in the athletic arena. Lumbo-pelvic support during running comes from key stabilizing mechanisms of the core musculature. As it is evident that core musculature play an important role in stability of the pelvis and lumbar spine during running (10).

Our results clearly emphasize the fact that core stabilization exercises in runners not only improves Core Stability but it also significantly affects running Performance. These findings are in accordance with the previously conducted researches. A prospective study by Stanton (9) was conducted to examine the effect of a six week Swiss ball training program on core stability and running economy in an athletic population. Following a six-week training program there was statistical improvement for a VO2max test performed on participants in the core exercise group .The core program included the Sahramann core stability test.

It is possible that conventional training of athletes had component of Core Stabilization exercises because they do have many lumbar exercises in their regime but significant difference in the improvement level between two groups suggests that if we specifically target core, the performance may be enhanced further.

The choice of the dependent variables was inevitable since the only measure of running performance which was measurable in our research settings was time. For Running Performance, the other test could have been conducted like VO2max test but due to lack of infrastructure, these devices were not used and also because of the fact that the sports fraternity considers time as the most important measure of performance. For measuring Core Stability, the Back Extensor Test, Abdominal Fatigue Test, Side Bridging Test have been used and thus we included them on the part that back extensor test is shown to be consistently reliable as a measure for low back endurance. In the study conducted by McGill, a reliability coefficient of r = .98 for back extensor test, for Abdominal Fatigue Test r is 0.97 when performing the test for five consecutive days. When performing five consecutive days of testing he found a reliability coefficient of r = .99 for both the right and left side bridging test (10).

Considering the theoretical foundation for core muscle exercises according to Callaghan et al noted that exercises involving trunk extension produce the highest joint forces and muscle activity levels (22). The exercises included in the Conventional Training during their gymnasium sessions were inclined sit ups, trunk extension, Leg Press, Bench Press, push-ups, Hamstring curls, Leg curls, Hand curls, Half squat and Abdominal curl ups. McGill observed that curl-ups challenges mainly the rectus abdominis, with the psoas and abdominal wall (internal and external oblique, transverse abdominis) muscle activity being low (23). Sarti (24) and Konrad (25) had similar findings that curl-ups produced sufficient and isolated activation of upper rectus abdominis. Wilson et al noted that the full squat achieve high levels of activation specific to gluteus maximus (26). These significant improvement in the control group for running performance and core stability may be due to the inclusion of these exercises in their conventional training regimen. Though it is also possible that the other factors, like wind resistance or variation in shoes of runners, could affect performance, but the consistent improvement in all the subjects of experimental group indicates that the core definitely helped to improve the core stability and running performance.

Other than the study conducted by Stanton (26) in the study conducted by Samson (6) was studied the effect of a five week core-stabilization program on dynamic balance. Exercises included multidirectional lunges, wall squats, crunches on a stability ball, as well as many others. The results of study showed that there was a significant difference in dynamic balance from pre-test to post-test.

The differences in means were more profound in the experimental group who underwent the core-stabilization training program. This again indicate that core stabilization exercises does translate into dynamic balance. Piegaro (4) showed improvements in semi dynamic balance. The core muscle not only includes endurance with holding the body up but also in functional outcomes with proprioception, balance, and energy transfer from the trunk to the lower extremity.

The result of Pearson correlation test demonstrated that there is a significant correlation between running performance and core stability. Subjects who had good core strength based on relevant tests consistently had better running performance.

This research shows a positive trend in enhancing core stability and running performance by including core stabilization exercises in addition to conventional training in runners training program. In addition, the type of program used in this study may serve as a viable adjunct or progression in traditional training programs. There would be a further scope to include this core stabilization training program in improving back endurance and better alternatives like VO_2max can be used in future studies.

Our research is also of value to health professionals and coaches, by creating advance training programs by super setting various types of exercises for the trunk not only for runners but to various other sports also. We would also like to bring to light an important aspect related to core stability which is incidences of athletic injuries.

Many recent research works have emphasized the fact that athletic injuries may be reduced to some extent by core musculature training. It has been proposed that efficient limb movement require a stable trunk. Core stabilization exercises thus form a stable platform for efficient limb movement thereby reducing injuries specially those related to overuse. There is a scope of future studies on the effect of core stabilization training on sports injuries.

Conclusion

After discussion we are in a position to accept our hypothesis which says that "the core stabilization training group in addition to conventional training will lead to better core stability and running performance".

According to our knowledge this is the first study of its own kind until now. Our results clearly emphasize the fact that core stabilization exercises in runners not only improves Core Stability but it also significantly affects running performance. It is possible that conventional training of athletes had component of Core Stabilization exercises because they do have many lumbar exercises in their regime but significant difference in the improvement level between the two groups suggests that if we specifically target the Core Stabilization, the performance may be enhanced further. The result of Pearson correlation test demonstrated that there is a significant correlation between running performance and core stability. Subjects who had good core strength based on relevant tests consistently had better running performance.

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