Efficacy of progressive core strengthening exercise on functional endurance tests and hypertrophy of multifidus, transverses abdominis in healthy female subjects with low core endurance

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Abstract

Objective: Aim of the present study was to find out the efficacy of core strengthening training on hypertrophy of core group of muscles (i.e) transverses abdominis (TA) and multifidus (MF) and on trunk flexor as well as extensor endurance tests in normal healthy low core endurance females. **Methodology: Study Design:** Single blind randomized control trail. **Sample size:** Convenient sample of 20 female college students with low core endurance. They divided into two groups. **Intervention:** Experimental group received six weeks progressive core stabilization exercise while control group received no treatment. **Out come measurement:** Pre and post reading of right and left side cross sectional area (CSA) of MF at L_4 and L_5 level and TA using ultra sound image. Flexor and extensor trunk isometric tests were too taken for functional improvement. **Statistics:** Related t- test were used to compare means within the group and unrelated t-tests were used to compare means between two unrelated groups. The significance level was set at $p \leq 0.05$. **Results:** Prior to the intervention there was no significant difference in CSA between the groups. After 6 weeks there was no significant improvement in control group. In experimental group, after six weeks on and average 35.41% improvement in CSA with MF L_4 left being most improved site (53.50%) and TA left being least improved site (9.01%). All improvements are statistically highly significant with $p<0.001$. When the experimental group post values were compared with control group post values all MF CSA values were statistically highly significant ($p<0.001$) but TA CSA were not. **Conclusion:** The present study results supports that 6 weeks progressive core stabilization can be used as prehabilitation to prevent LBP in normal healthy female students.

Key Words: **Stabilization exercise; Core training; Lumbar stabilization; Low back pain; Core endurance**

Introduction

Rapid growth in technology in the last couple of decades has lead to constant reduction in physical activity and increased sedentariness in lifestyle. This in turn has reduced the work of certain muscles that were once strong and were responsible for good posture & prevented injuries. This is especially true to the trunk and hip muscles that helped to maintain erect posture against the gravity. Balance between anterior and posterior group trunk and hip muscles is essential for normal postural alignment. However, habitual wearing of high heels by young women results in definite biomechanical and musculoskeletal changes that are manifested by reduced base of support, increased anterior pelvic tilt, increased lumbar lordosis, short hip flexor and trunk extensor, weak abdominals and gluteal muscles. The resulting decreased core stability has been suggested to contribute to the etiology of lower extremity injuries in females (*Leeton et al., 2004*).

A specific type of exercise called as core stability exercise is

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gaining rapid popularity among the clinical therapists (*McGill, 2001*). These exercises are used to target specific muscle groups (i.e) transverse abdominis (TA), internal oblique (IO), multifidus (MF), quadrates lumborum, pelvic floor muscles in the trunk so as to prevent not only the low back pain, but other injuries in lower extremity (*Heidt et al., 1999; Hewett et al., 2000; Nadler et al., 2002; Cowan et al., 2004; Ferreira et al., 2004; Akuthota and Nadler, 2004; Zazulak et al., 2007; Muthukrishnan et al., 2010; Hides et al., 2011*). Studies support the activation of TA and MF prior to the movement of shoulder and hip in order to stabilize low back (*Hodges and Richardson, 1996 and 1999*). Above mentioned muscles are attached directly to the lumbar vertebrae and are the parts of motion segment in lumbar region. So they are beleved to be responsible for providing segmental stability by controlling the lumbar segments during movement. When all these local muscles contract together they keep the spine in its most stable position (the neutral zone), so called local stability system, and aid in preventing injury (*Fredericson and Moore, 2005; Zazulak et al., 2008*). Apart from injury prevention, core stability also improve the sports performance in certain sports (*Hedrick, 2000; McGill, 2001; Nadler et al., 2002; Myer et al., 2005; Kibler et al., 2006; Marczinka, 2007*). It is also important for normal day to day physical activities such as throwing, jumping, lifting, walking and running etc.

Hicks et al., (2005) & Akuthota et al., (2008) advise the core stability exercise program to younger age population (25 to 45 years) with greater general flexibility which young women population has. Further female population with weak core is more susceptible to ACL injury and other lower limb injuries thus incorporation of core strengthening program in their life style is essential (*Leeton et al., 2004; Hewett et al., 2000*). The current literature supports the importance of core strengthening, in fact the endurance, in the injury rehabilitation (*Hides et al., 1996; Daneels et al., 2001*) and sports performance (*Hedrick, 2000 McGill, 2001; Kibler et al., 2006; Marczinka, 2007*). However, there is no study that deals with normal young women population who might have subclinical level muscular imbalance in trunk due to relative high heel foot wear usage and wider pelvis. More over, current literature lacks in consensus regarding what constitute a core strengthening program, how it differs from normal strengthening exercises, how it has to be progressively increased over the period of time, its effect on muscular cross sectional area in normal population. Thus, aim of the present study was to find out the efficacy of core strengthening training on hypertrophy of core group of muscles (i.e) TA and MF and on functional trunk endurance tests in normal healthy low core endurance females.

Materials & Methods

Study design: Present study was a single blind randomized control trial with convenient sampling technique. 20 healthy female collegiate students aged between 18-26 years were recruited after passing inclusion and exclusion criteria.

Inclusion and exclusion criteria: The inclusion criterion was female students without any regular training atleast one year before the time of intervention. They should possess low static trunk extensor

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endurance (endurance tests less than 100 sec), whereas main exclusion criteria were LBP in the last 3 months before the study and LBP that resulted medical intervention in the past, Contraindication to abdominal muscle strengthening like-glaucoma, pregnancy, hypertension, osteoporosis, spinal tumors, inflammatory diseases.

Sample characteristics: Mean (SD) of age, height and weight of the sample were 22.2 (2.21) yrs, 162.5(6.00) cm and 55.1(3.01) kg respectively.

Procedure: The sample was randomly divided into two groups, experimental & control & consisted of 10 persons each. Experimental group received 6 weeks of progressive core stabilization exercise whereas the control group received no treatment during the period of the study. Cross sectional area (CSA) of Multi Fidus (MF) and Transverse Abdominis (TA) as well as functional endurance test for both lumbar flexor and extensor groups were the out come measurements of the present study. These were measured two times with six weeks duration apart.

Ultra sound measurement- Technique: Ultrasound images were used to measure CSA of MF and TA muscles bilaterally by an independent radiologist blind to the content of the study. Ultrasound imaging assessment was conducted using Xario ultrasound imaging apparatus equipped with a 10- MHz curvilinear transducer (Toshiba, Japan).

For MF muscle thickness the subject was positioned in prone lying, with a pillow placed under the abdomen to minimize the lumbar lordosis. The MF muscle was imaged in para saggital section, as per (*Hides et al. (1992) and (1995); Stokes et al., (2005))* allowing visualization of the zygpophyseal joints, muscle bulk, and thoracolumbar fascia. The left and right MF muscle was separately imaged at the L4-5 vertebral level, then the images were saved and measurement of cross sectional area was taken.

Assessment of TA was done as per *Ferreira et al., (2004); Teyhen et al., (2005); Rankin et al., (2006); Hides et al., (2006) and Teyhen et al., (2008)*. The subject was positioned in supine lying position, and was asked to maintain relaxed position while images were taken. The center of the transducer was placed in a transverse plane just superior to the iliac crest, in line with the mid-axillary line. To standardize the location of the transducer, the hyperechoic interface between the TA and the thoracolumbar fascia was positioned in the right side of the ultrasound image, and the image was taken at the end of expiration. Images of both left and right sides were saved and measurement of thickness of TA was taken later.

Static endurance tests- measurement: To test flexor endurance test the subject was positioned in supine with the knees and hips flexed at 90° so that their torso could be flexed to 60°. The feet was secured under foot straps or held by the examiner. Subjects were asked to hold this position, 60º flexion, for as long as possible. Failure occurs when the subject's torso falls below 60°, the duration for holding the position was noted using digital stop watch (*McGill, 2002; Evans et al., 2007*).

To test the torso extensors subjects were positioned in a prone position with trunk outside the table. The pelvis hips, and knees were secured on a table. The upper body was held out straight over the end of the table. The subjects were asked to extend their back

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and maintain this position for as long as they could. Failure occurs when the upper body falls from horizontal into a flexed position, then the measurement of duration for how long they could hold this position was noted (*Moreau et al., 2001; McGill, 2002*).

*Progressive core endurance exercise-procedure: A t*otal of 6 weeks duration was divided into 3 stages with each stage lasting for 2 weeks. The segmental approach we have devised develops through three stages of segmental control, with each stage exposing the individual patient to increasing challenges to her joint protection mechanisms (*Myer et al., 2005; Richardson et al., 2005; Norris, 2008; Luque-Suárez et al., 2012*). Table 1 shows the type of exercises performed at each stage of the progression. Justifications for selection of exercises were given in our previous publication (*Kulandaivelan and Chaturvedi, 2014*). Before starting each exercise session warm up session of about 5 min in the form of jogging was given. Duration of each session was around 45-60 min in a day. Frequency of exercise was 5 times a week for 6 weeks. Subjects were allowed 2 days rest period after completion of 5 sessions of exercise in order to provide adequate rest from exercise. The abdominal drawing-in maneuver was performed in conjunction with each of the dynamic exercises because of its ability to facilitate coactivation of the TA and MF muscles when stabilizing the trunk and its clinical use as a foundational basis for lumbar stabilization exercises. In dynamic exercises each exercise was of 10 repetitions (2 sec concentric contraction with expiration, 8 sec hold with normal breathing, 3 sec eccentric contraction with inspiration with 5 sec rest) per set and 3 sets per session (total 30 repetitions). Whereas static exercises were on 10 sec hold (30-40 % of maximal voluntary contraction as intensity) followed by 5 sec rest for 10 repetitions per set and 3 sets per session (total 30 repetitions) (*Koumantakis et al., 2005*). There was a 60 sec interval between sets and 3 min rest between each exercise (*Hicks et al., 2005; Willardson, 2006; Akuthota et al., 2008; ACSM, 2009; De Salles et al. 2009*).

Table 1: Exercise Programme

Stage	Name	Static	Dynamic
Stage I	Core Control	1. Abdominal 'tuck in' in crook lying position 2. Abdominal 'tuck in' in sitting position with tactile cue on back 3. Abdominal 'tuck in' in quadruped position	1. Bridging on the floor without leg extension 2. Bird dog exercise in quadruped position 3. Abdominal crunches on floor (hands behind head)
Stage II	Core stabilization	Abdominal 'tuck in' in sitting position	1. Back bridging onswiss ball without leg rise 2. Wall squat with swiss ball 3. Abdominal crunches on swiss ball (hands over chest)
Stage III	Core strengthening	Abdominal 'tuck in' in standing against the wall	1. Back bridging onswiss ball with leg rise 2. Bird dog exercise on swiss ball 3. Abdominal crunches on swiss ball (hands behind head)

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Statistics: Data were analyzed using SPSS version 11.5. Data is presented by mean ± Standard deviation (SD). Related t- test were used to compare means within the group and unrelated t-tests were used to compare means between two unrelated groups.The significance level was set at p ≤ 0.05.

Results & Discussion

Table 2 compares experimental group and control group, pre and post exercise period readings in CSA of muscle groups at different sites. There was no significant difference in pre and post readings in control group. There was a significant improvement in CSA of muscle groups at all sites in experimental group's post exercise period (p<0.001 in all but TA left which was p<0.01). However, when the post values of experimental group was compared with control group, significant difference was observed only at multifidus muscle not in TA muscles.

Table 2: Comparison of control and experimental groups' pre and post exercise period readings in CSA of muscle groups at different sites.

Sno	Side & Site	Control		Experimental		'T'$^{A(SIG)}$	'T'$^{B(SIG)}$
		Pre	Post	Pre	Post		
1.	L4 MF Left	1.210 ± 0.175	1.314 ± 0.300	1.099 ± 0.327	1.687 ± 0.313	2.718*	4.524***
2.	L4MF Right	1.212 ± 0.209	1.212 ± 0.209	1.120 ± 0.305	1.676 ± 0.255	4.452***	5.553***
3.	L5 MF Left	1.347 ± 0.180	1.349 ± 0.179	1.237 ± 0.328	1.818 ± 0.233	5.044***	5.577***
4.	L5MF Right	1.421 ± 0.160	1.422 ± 0.166	1.300 ± 0.327	1.856 ± 0.277	4.424***	5.117***
5.	TA Left	0.317 ± 0.075	0.319 ± 0.075	0.333 ± 0.061	0.363 ± 0.057	1.468^{NS}	4.616**
6.	TA Right	0.321 ± 0.066	0.324 ± 0.064	0.322 ± 0.061	0.356 ± 0.056	1.185^{NS}	7.519***

t^A, $t^B$are post control-experimental, pre control-experimental, 't' values respectively. *, **, *** means 'p' values less than 0.05, 0.01, 0.001 respectively. NS means non-significant.

Table 3: Comparison of control and experimental groups pre and post exercise period readings of flexor and extensor endurance test.

S.No	Tests	Control		Experimental		'T'$^{A(SIG)}$	'T'$^{B(SIG)}$
		Pre	Post	Pre	Post		
1.	Flexor endurance test (in sec)	41.9±17	48.4±15	57.8±23	129.2±42	6.66***	5.72***
2.	Extensor endurance test (in sec)	58.7± 25	68.6 ± 15	49.2±29	108.9±39	7.93***	3.03**

t^A, t^B are post experimental-control, experimental pre-post 't' values respectively. *, **, *** are 'p' values less than 0.05, 0.01, 0.001 respectively. NS means non-significant.

Table 3 compares control and experimental group's pre and post exercise period values in flexor and extensor endurance test. There was no significant difference in pre and post values of control groups in both tests. But experimental group showed significant improvement in trunk endurance in both tests. The same trend continued when post exercise values of control and experimental group values were compared (all values were P<0.001).

In the present study, transverse abdominis thickness pre intervention values are observed to be significantly lower than the reference value reported by *Teyhen et al., 2008* but comparable to them only in post intervention

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experimental group. *McGill et al., (1999)* reported higher values for both flexor as well as extensor endurance tests. The normative values reported in their study achieved only in the experimental group after intervention. This indicates that present study population possessed low core endurance at the beginning of the study. The results of our study are in accordance with the previous work by *Daneels et al. (2001)*, who suggested that core strengthening programs of 10 weeks duration with a frequency of 3 times a week was enough to induce hypertrophy, core strengthening program of 6 weeks as used in the present study however has also been found to induce hypertrophy to the same extent. The reason for greater improvement of hypertrophy in MF compared to TA may be explained by *Grenier and McGill (2007)* study. They found lesser hypertrophy in TA using abdominal hollowing as compared to abdominal bracing and advised others to emphasis for the later. In contrast in the present study, more emphasis for abdominal hollowing over bracing was followed, which may be the cause of poor hypertrophy of TA. *Hides et al., (1996)* demonstrated that specific exercise training involving co-contraction of transverses abdominis and lumbar multifidus over a 4 week period demonstrated an increase in cross sectional area of the atrophied multifidus due to pain.

Abdominal hollowing is performed by transverses abdominis activation; abdominal bracing is performed by co-contraction of many muscles including the transverses abdominis, external obliques, and internal obliques (*Akuthota and Nadler, 2004*). *Urquhart et al., (2005)* reported that inward movement of the lower abdominal wall result in greater TA activation than drawing in maneuver (activation of both upper and lower abdominal wall). A recent study has demonstrated that as much as 70% MVC is needed to promote strength gains in abdominal muscle (*Stevens et al., 2008*). The novice patient is more likely to contract wide groups of abdominal muscles (*Urquhart et al., 2005*). All the above points may explain lack of or lesser improvement observed in TA muscle CSA in experimental group.

*Conclusions***:** The results of the present study show greater hypertrophy in multifidus than transverses abdominis after 6 weeks of progressive core strengthening program along with both flexor and extensor musculature endurance improvement. The results may help clinicians, physiotherapists to prescribe core strengthening exercises as prehabilitation for prevention of injuries in normal young women population with low trunk endurance.

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