

Electromyographic (EMG) Activity of Transverse Abdominis Muscle During Core And Non-Core Exercises In Healthy Subjects

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ABSTRACT

Purpose of this study is to find out the activation of Transverse abdominis muscle during core exercise and noncore free weight exercises in healthy subjects using SEMG. Method: Thirty healthy subjects (age 23.9 ± 2.8 years; BMI: 20.4 ± 1.4) participated in study. Noncore muscle exercises were performed with 60% of 1-RM. Result: The result showed significant activation of TrA muscle during core muscle activities. Among core exercises Bent Knee Sit up activates TrA the best followed by Bird Dog exercise followed by Plank and noncore free weight exercises. Limitation: The internal oblique muscle fibers blends with TA muscle, so it may be considerable for EMG cross talk.

Key words: Core muscle, exercise, Spine, Stability.

INTRODUCTION

Recently, there has been a significant increase in core stability training for both sports conditioning programs and the general population as a result of fitness professionals emphasizing training the core region of the body.^{1, 2} Prior to this, core training exercises were reserved mainly for individuals with low back problems in physical therapy clinic because active exercises established effective approach in prevention and rehabilitation of the low back injuries³. It is important to identify individuals or patient's optimal performance to ensure training specificity and emulate specific muscle activation^{4,5,6}. Lumbar spine segmental stability is related to both of these systems during body movements. Core stability involves synergistic relation between global and local stability.⁷

The anatomical core is defined as axial skeleton and all soft tissues with proximal attachment in originating on the axial skeletal, regardless of whether the soft tissue terminates to the axial or perpendicular system^{8,9,10}. It is important that the correct level of balance is maintained between strength and function of muscle for decrease the risk of injury and to achieve the optimal function^{4,11}. To decrease the load and improving trunk and core strength physical fitness exercises have been recommended with

emphasis on core stability.¹²

In LBP population the core muscle are most to be considered due to their role in carrying out both simple and complex activities. LBP and various back disorders are result of weak muscle strength and endurance of the core muscles.^{4,11,13}.LBP, delay activation and contraction of spinal stabilizing muscle associated with reduced work ability, poor spinal and abdominal muscle control^{14, 15,16} .Core stability and strengthening help in balanced synergistic pattern of deep and superficial muscle function which act as a corset for lumbar spine.^{17,18} Delayed onset in abdominal muscle has been associated with LBP. Low load exercises volitionally activate the transverse abdominis to restore trunk muscle activation deficits.^{19,20}.Rehabilitation protocols or performance enhancement training should be based on the principle that musculoskeletal system will produce specific adaptation within the system^{21,22,23} .consequently, it is still being debated which exercises are best for activation and improving core strength and stability^{24, 25,26,27} . Further investigations are required for the validity of both the concept of core stability and the optimal training protocols.¹

Some of major muscles of the core with proximal and distal attachments in the lumbosacral region of the axial skeletal include the Lumbar multifidus(LM),Transverse Abdominis(TrA), Erector Spinae(ES), Quadratus lumborum(QL), external oblique(EO), Internal oblique(IO), Rectus abdominis(RA), Psoas major and pelvic floor muscles. Of the various core muscle LM, TrA, QL appear to be most meaningful muscles for fitness professionals and clinicians who prescribe exercises to improve physical performance and manage musculoskeletal disorders.^{1,5}

TrA muscle is local deep muscle of core^{3, 4, 27} . As it is part of local system therefore provide direct lumbar segmental stabilization²⁸ .They are associated with the segmental stability of the lumbar spine during whole-body activities and postural adjustments²⁹ . Transverse abdominis muscle increases the vertebral stiffness by coactivation with global muscle which is important for improving the stability of lumbar spine^{30,31} . Lack of motor control activity and weakness of deep trunk muscle (transverse abdominis and lumbar multifidus) is major cause of chronic low back pain.^{32,33} The attachments of the transversus abdominis and internal oblique into the thoracolumbar fascia may enhance spinal and pelvic stabilization, because when these muscles contract they tense the thoracolumbar fascia.^{5,34}

However a consequence has not been reached regarding the exercises that are most effective at stimulating the activity of the TrA muscle. Establish consequences on this topic would facilitate dissemination and implementation of standardized training approaches by strength and conditioning coaches, which could result in more effective core training across multiple setting thereby improving performance and preventing injury.¹

METHODS

Experimental approach to the problem

The study was approved by RRC and Ethical Committee of Indian Spinal Injuries Center. After obtaining consent from healthy subjects and later famirlization of subjects were done before one week of testing procedure.^{10,35}

Subjects

Thirty healthy subjects (age 23.9 ± 2.8 years; BMI: 20.4 ± 1.4) participated in this study. Subjects of both the genders with age between 18-30 years with normal BMI level 19-22 were included. Subjects with any history of low back pain, injury or major trauma to lower limb, upper limb and Spines were excluded and was given information regarding the procedure of each exercise and their after effects if any.

Testing procedure

Subjects were tested for transverse abdominis muscle activation (using sEMG) among core and noncore muscle activities after warm up.

Participant were given a 10 min warm up protocol which include the 4-6 times upper limb activities and self stretching of lower limb and back muscles. Later activities of upper limb with light weight are added.

Famirlization and calculation of 1-RM^{35,36}

First subjects were asked to do biceps curl 10-15 times without fatigueness with maximum weights in both hands in sitting position. If subject was not fatigued in 1st trial then rest period of 1 min was given prior to next attempt with heavier weight.

Second after the rest period the 1 RM for shoulder press was calculated. Subjects were asked to do shoulder press in standing with maximum weight 10-15 times without fatigueness but failed to attempt or not completed the 16th trial. If subjects did not fatigue in 1st attempt progression was done with heavier weights. 60% of one RM for each biceps curls and shoulder press were calculated.

Familiarization procedures for noncore core exercises²⁸

Demonstration of core exercises was given to subjects and they were asked to perform 3 exercises (plank, crunch, bird dog) on mat and instructions were given to correctly perform the exercises. ^{5, 28, 36}

Electromyography

Surface electrodes were used to collect EMG data Using Delsys TrignoTM wireless system (Delsys Inc, Natick Massachusetts, USA) at 2000HZ.

Prior to applying the electrodes, the skin was cleaned with alcohol swab to reduce skin impedance and shaved if necessary. Electrode was placed along the longitudinal axis of Transverse abdominis (along the line joining ASIS to pubic symphysis).



Figure 1-Bent knee position



Figure-2 Bent knee position



Figure-3 Plank



Figure -4 Non Core exercises.

For transverse abdominis muscle the electrode was placed 2 cm inferior and 3 cm lateral to the mid line where it blends with internal oblique muscle.^{37,38} Transverse abdominis muscle was palpated medial and inferior to the ASIS. A wireless EMG sensor was affixed using Trigno adhesive skin interfaces. The sensor have 1mm thick Ag-AgCl.

The EMG data were collected using EMG works acquisition 4.5.1 and then exported into EMG work analysis software. 3 good trials were collected and data were exported into excel to be further processed using MATLAB

Data analysis

The EMG signals was band pass filtered between 20-50 Hz using 7th order Butterworth filter. The Root mean squares (RMS) of EMG signals were calculated over a window width of 20msec in MATLAB. The peak was estimated and average value was 0.25 seconds before and 0.25 seconds after the peak of 3 trials was calculated. The average of three trials was used for final analysis. The files were visually cross checked for signals correctness.

Statistical analysis

Normality of data was checked using Shapiro Wilk test.

In case of non parametric testing wilcoxon signed rank test was used. To compare the three core exercises with Biceps curl and Shoulder press, the p value was adjusted as 0.05/6 whereas to rank the core exercises amongst themselves, the p value was adjusted as 0.05/3 to avoid alpha inflation (Type 1 error).

RESULTS

The TA muscle activation was significantly higher in core exercises ($p < 0.0001$). Bent knee sit up shows highest MVC % 26.6[3.86, 90.7]. The % MVC of Transversus Abdominis during Bent knee sit up 26.6[3.86, 90.7] was statistically higher that during plank 12.6 (1.27, 73.55) and bird dog 8.9(1.51, 47.73) which is significant.

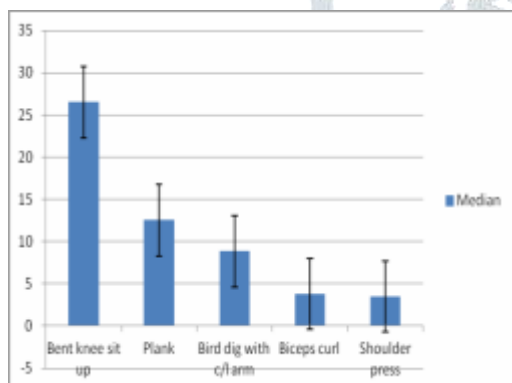
Table1: Descriptive analysis of variance

Variables	Mean ±S.D
Age (Years)	23. 9±2.8
Gender	[M-18],[F-12]
Height(Meter)	1.7±0.6
Weight(Kg)	58.5±5.5
BMI	20.4±1.4
Hand dominance	Right handed

Table2: % MVC analysis between core and noncore exercise of TA muscle.

Comparison of core and noncore muscle exercises	Significance
Biceps curl with bent knee sit up	0.000*
Biceps curl with plank	0.000*
Biceps curl with bird dog	0.000*
Shoulder press with bent knee sit up	0.000*
Shoulder press with plank	0.000*
Shoulder press bird dog	0.000*
*P value significant at p≤0.008	

Figure 5: Median of core and noncore exercises



DISCUSSIONS

The study analyzed the difference of activation of transverse abdominis muscle among three core and two noncore free weight exercises in asymptomatic healthy subjects. The results show that core exercises were significant for activation of transverse abdominis muscle. The findings are interpreting the EMG activation of transverse abdominis muscle between the core and noncore exercises at 60 % of 1- RM. There is significant activation of transverse muscle in core exercises than noncore exercises during EMG.

The Bent knee sit up produced the most activation of transverse abdominis 26.6[3.86, 90.7] muscle as compared to other core and other noncore exercises 3.9(0.91, 64.17). Interpretation of this study result that the bent knee sit up exercises activate the TrA most as it involves flexion activity of trunk. The

three core exercises plank, bent knee sit up, bird dog with dominant arm and contra-lateral lower limb already to be proven by Marshall and Murphy 2005 that these exercises are recruited the core muscle TrA (22%) and back extensor lumbar multifidus (5%)⁷ .

Plank and bird dog with contralateral limb raise might have activated more extensor muscle activation than flexor muscle to maintain the position. This study found difference in EMG activities TA muscle more in plank 12.6 (1.27, 73.55) than bird dog 8.9(1.51, 47.73) core exercises than noncore muscle exercises.

The EMG activity showed a percentage value of activation of transverse abdominis muscle during core muscle exercises when compare with noncore. These values are different from the results found in previous studies by Drake et al 2006 mentioned activation of lumbar multifidus is 23 % and TrA activation is 21% in bird dog with contralateral limb raise⁴⁰.

In biceps curl TrA muscle shows only 3.9(0.91, 64.17) % of MVC activation which is slightly more than shoulder press activity 3.5(1.10-25.54). both the exercises are performed in standing position in which flexor core muscle work is counteract by extensor muscle group to prevent sway and maintain balance in standing position. This might be responsible for the less activation of TrA in standing noncore muscle activities.

In this study, the finding of activation of transverse abdominis muscle in core muscle is differing from noncore exercises. This result may indicate the core exercises are essential to activate the transverse abdominis muscle which is important in spinal stability. There was less activation of TrA muscle in noncore muscle activities are in noncore activities was compensated by extensor muscle activation.

The result of this study demonstrates that during bent knee sit up activity, the TrA muscle achieved the highest activation followed by plank and bird dog with left arm and right leg and among other non core activities with 60 % of 1-RM. The noncore muscle exercises are not considerable to activate significantly TA muscle as core muscle exercises.

There is analysis between core muscles also carried out to rank the core muscle activities. There is greater activation of TrA muscle in bent knee sit up than other two core muscle exercise but between the plank and bird dog exercise result shows no significant difference in result. Both plank and bird dog

muscle exercise involved more extensor activity to maintain the position than flexor activity.

Different core muscles exercise were also compared with stable and unstable surfaces exercises to check the core muscles activation. In a comparison of commercial and common abdominal muscle exercise Bent knee sit up shows activation of abdominals and oblique muscles.⁴¹

During plank use of swiss ball and stable surfaces result shows difference in muscle activation due to body position relative to gravity between ground and ball exercises. Due to extension torque during plank more extensor muscle activity has been generated to resist torque to prevent increase lumbar lordosis by gravity effect.⁴²

A randomized control trial study was carried out by Rajan Balakrishnan in 2016 in which core stability exercises (plank and bridge) on floor and swiss ball in NSLBP individuals were assessed to prevent low back pain. After four week of protocol there were significant difference between the post VAS score of group A (swiss ball exercises) was 2.26 which was lesser than post VAS value of group B 2.93. also shows the significant ODI value for group A. therefore core stability exercises with swiss ball play significant role to prevent LBP.⁴³

In one of the previous study done by Fabio Renovato et al in 2010 segmental stabilization exercises (focused on TrA and LM) and superficial strengthening (focus on RA, IO, EO, ES) in chronic low back pain patients. As the result compared the base line data the both groups shows significant relieving the pain and improving disability. The segmental stabilization group shows more significant gains in variables when compared with other group, it includes relative gain in TA is 48.3% and -5.1% in pain and disability relatively.⁴⁸ Core stability exercises were also compared with muscle energy techniques in LBP patients by Shivalika et al in 2013 which concluded that LBP patients were benefitted more by core stability exercises. The study explains the core stability exercises are more effective than manual treatment in term of reduce treatment period and improvement of individual. The core stability exercises aimed to train and activate the deep muscle and integration of deep and superficial system.⁴⁴

There is another study Brennan j. Thompson in 2009 which compare the curl and press with 50% of 1-RM at stable and BOSU, 75% of 1-RM. Result shows that TA, RA and EO muscle exhibit higher activity effect during 75% of 1-RM than both other conditions. TA muscle shows 25% more active

during 75 % of 1 –RM upon compared with stable 50 % 1 – RM and 42 % more active than 50% of 1 – RM at BOSU. curl shows 47% more activity during 75% 1 –RM than stable 50 % 1-RM and 57 % more active than BOSU 50 % 1-RM.⁴⁵ Future research is warranted use of NEMG to examine the TA muscle activity. Comparison of TA activation between healthy and LBP patient population can be need to explore. Study can be performed with some stability exercises protocol in between healthy and LBP patient population. Along with TA, QL muscle EMG activity also needs to explore. This study can be performed in larger population.

PRACTICAL APPLICATION

Based on EMG activation this study demonstrate TrA activation when core stability exercises were performed. Practitioner can incorporate these exercises to activate TrA muscle along with superficial muscle for stability and synergistic core muscle work. Patient with prior history of low back pain can use these exercises with caution.

CONCLUSION

The present study concluded that the core muscle exercises activates TrA significantly better than noncore free weight exercises as seen by electrographic activity of the muscle. Among core exercises Bent Knee Sit up activates TrA the best followed by Bird Dog exercise followed by Plank exercise.

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Conflict of interest

There is no conflict of interest.

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