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A differential Electromyographic analysis of Rectus Abdominis muscle segments during performance of different test movements: A randomized within participants experimental study

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ABSTRACT

Objective: To compare surface EMG activity of upper & lower portion of Rectus Abdominis activity during 4 test movements viz, trunk curl up(TCU), Leg Lowering, Abdominal Muscle Lift (AML) , Leg Raise .To provide the biomechanical basis for rationalized clinical testing & training of abdominals. To find out an activity producing optimal & maximal activation of abdominals. **Methods:** Study design & setting: Randomized, repeated measure within subject, experimental study .All measurements were performed in hospital EMG laboratory. **Study population:** 20 normal healthy female chosen randomly who were capable to perform all test movements comfortably. **Procedure**: EMG data was collected from Upper &Lower portion of Rectus Abdominis muscle during performance of 4 tests movements by the subjects. **Outcome measures:** Peak EMG amplitude during maximum recruitment of muscle. **Results:** Study showed differences in the activation of rectus abdominis during 4 tasks. Amongst all the exercises Abdominal muscle lift (95% CI=82.5-93.8, 89.7-98.2) showed greater activation followed by Trunk curl up (95% CI=80.4-97.3, 74.8-93.3), Leg raise (95% CI=57.2-74.09, 63.3-79.4) & leg lowering (95% CI=53.8-70.4, 52.9-71.7). **Conclusion:** No significant differences in the activation of two portions. Rectus Abdominis activity is maximum during abdominal muscle lift.

Key words: Rectus Abdominis; EMG activity; Abdominal muscle testing; Abdominal muscle lift.

INTRODUCTION

Rectus abdominis is broad & long muscular strap descending throughout the abdominal wall. It acts to support the viscera, helps in respiration [1]. It is most active in crook lying curl up [2].

Apart from its action as the flexor of torso [1] it has recently been defined as movement synergist & global stabilizer of the spine [3, 4]. Muscle also bears great share of load of pregnant uterus & undergoes great amount stretching & widening [5].

Strengthening of this muscle has been given prime importance not only in the rehabilitation of low back pain population but also in fitness testing & training in sportsperson. Its testing & training involves curling of trunk & leg exercises for upper & lower portion of muscle resp [6,7].

Various studies have been conducted to quantify the activation level of upper & lower portion of RA during various exercises. One such study Showed that curl type exercises activates upper rectus while pelvic tilting type of exercises activates lower rectus to the greater extent [8]. Another study examined upper, medium, lower rectus abdominis during seven abdominal exercise tasks [9]. Significant differences in activation of the different portion

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were observed. While other evidences suggest no such differences between its portions, significant difference was present amongst the exercises with regard to activation of RA muscle as a whole [10]. In another study, little differences (20%) were found which were attributed to geometric & postural changes rather than preferential activation of upper & lower portion [11].

Present study, attempts to examine the extent of activation of upper & lower portion of rectus abdominis during performance of 4 different task. These include basic exercises used to test the muscle in its upper & lower portion differently. Such a trial have neither been attempted before nor does any subtle evidences exist to support the view that this exercise preferential activate portions of RA differently.

Present study was an attempt to analyze normalized Electromyographic activity of upper & lower segments of rectus abdominis muscle. Spinal curvature & torso geometry was maintained constant. This was done to obtained constant force output making data comparable.

METHODS

Study design: Structured, randomized, Prospective, Comparative, study [12].

Sampling techniques: Simple random sampling.

Study population: 20 healthy female resident volunteer, undergraduate students of physiotherapy. (Age=19.45+ 0.4, BMI=16.75+1.3)

Study set up : EMG lab, Shree Swaminarayan College of physiotherapy, Kadodara, Surat. Local ethical committee of college approved the study.

Inclusion criteria

Healthy females with their informed consent to participate in study. Only female subjects were studied because the variation in the amount and distribution of subcutaneous tissue between the sexes could have confounded the results.

Exclusion criteria

Subjects having BMI > 24.9.Subjects giving H/O recent injury, any kind of musculoskeletal impairment (structural & functional), recurrent backaches, abdominal colic of any origin etc. Subject who did not give informed consent to participate in study.

Subject selection: 20 subjects satisfying above criteria.

PROCEDURE

Assessment:

Participants were subjected to strength testing of the RA.

For this purpose basic test movement (TM) were used [7].

TM 1: Trunks curl up test as follows:

Subjects were positioned in crook lying position with knees flexed to 90 degree. They were asked to perform following movements.

Grade 1: Lifting of head in an attempt to look towards the toes hold it for 6 sec.

Grade 2: Lifting of head & curling of shoulders off the plinth & hold it for 6 sec.

Grade 3: Hands towards knees lifting of head &curling of shoulders with rib cage off the plinth until lower angle of scapulae clears plinth & hold it for 6 sec.

Grade 4: Hand across the chest lifting of head & curling of shoulders with rib cage off the plinth until lower angle of scapulae clears plinth & hold it for 6 sec.

Grade 5: Hands behind head curling of shoulders with rib cage off the plinth till lower angle of scapulae

clears plinth & hold it for 6 sec.

Maximum possible grade that subjects were able to perform was noted.

TM 2: Bilateral leg lowering test

Position of subjects: Crook lying position with hip flexed to 70-degree position. BP cuff placed below lumber spine. Subjects were asked to perform posterior pelvic tilting action. Mercury level was noted. Subjects were asked to maintain pelvic tilt so that mercury level at any time does not fall below the noted reading + 10 mm of Hg while lowering the legs [15].

Maximum grade was noted as follows:

Grade1: hip flexed to 90 degree.

Grade 2: hip flexed to 60 degree.

Grade 3: hip flexed to 45 degree.

Grade 4: hip flexed to 20 degree.

Break of 4 min was given between each grade. [7].

Subjects were kept in their predetermined test position (max grade possible on TCU & leg lowering test).Skin was prepared for the application electodes. Cathod was placed appx. 3 cm lateral & 5 cm superior& inferior to umbilicus for upper & lower portion of rectus abdominis resp on rt. side[8,13].

Instrumentation

Surface EMG (double channel , Neuroperfect Medicaid System) was used to record the muscle activity of upper & lower portion of rectus abdominis at simultaneously while execution of task. Filter settings were adjusted to 20 Hz to 2Kz with sensitivity at 500 UV. Electrode movement was avoided by keeping posture constant & collecting data during isometric hold.

Data Collection

Subjects were passively kept in their predetermined test position for TCU & Leg Lowering Activity. Raw EMG data was collected from URA & LRA when subjects exerting actively to hold the

TM 1: Trunk curl up test (TCU)

TM 2: Bilateral Leg Lowering Test

TM 3**:** Abdominal Muscle Lift test.

position in predetermined grades. Similarly, Data was also collected for abdominal muscle lift & leg raise activity. During leg raise Pelvic tilting was monitored same as in leg lowering activity. Subjects were trained for both the activities just prior to data collection.

TM 4: Leg Raise

Abdominal muscle lift is the activity similar to trunk curl up .Only difference is that the neck lies in line with trunk .Subject attempts to lift the trunk off the plinth. Starting position remains similar to the TCU activity [13].

Leg raise is activity where subject has to bilaterally raise the legs without curling of the back, which was monitored through the pressure cuff [7].

Outcome parameters: Raw EMG data was collected over 2 sec for each of 4-test activities. Data of each subject for URA & LRA separately was then normalized to max EMG activity noted during any of four tasks. Same procedure was followed for all 20 subjects. Thus, actual data used for comparison was the % of max EMG activity of upper & lower

Table1: Showing demographic data of subjects included in study

	weight	height	TCU	LL	BMI
Mean	43.45	161.25	4.15	1.7	16.72
Lower95% CI	42.16	158.95	3.8	1.35	16.09
Upper 95% CI	44.73	163.54	4.49	2.04	17.4
S.D	2.74	4.89	0.74	0.73	1.39
S. E	0.61	1.09	0.16	0.16	0.31

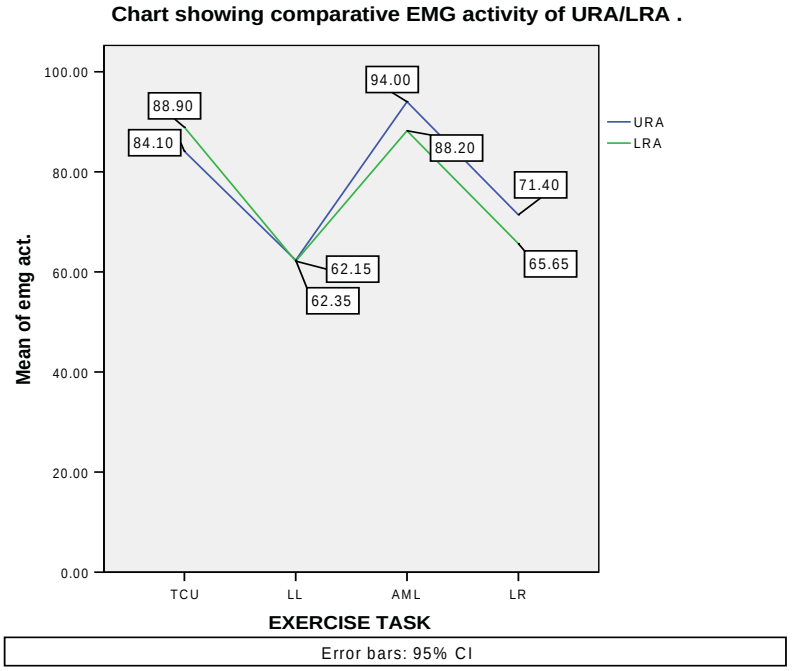
Table 2: Descriptive analysis of URA for all test movements

	N	Mean	S.D	S.E.	95% C.I.
TCU	20	84.1	19.76	4.42	74.84-93.35
LL	20	62.35	20	4.47	52.98-71.71
AML	20	94	8.98	2	89.79-98.2
LR	20	71.4	17.15	3.83	63.37-79.42
Total	80	77.9	20.68	2.31	73.36-82.56

Table 3: Descriptive analysis of LRA for all test movements

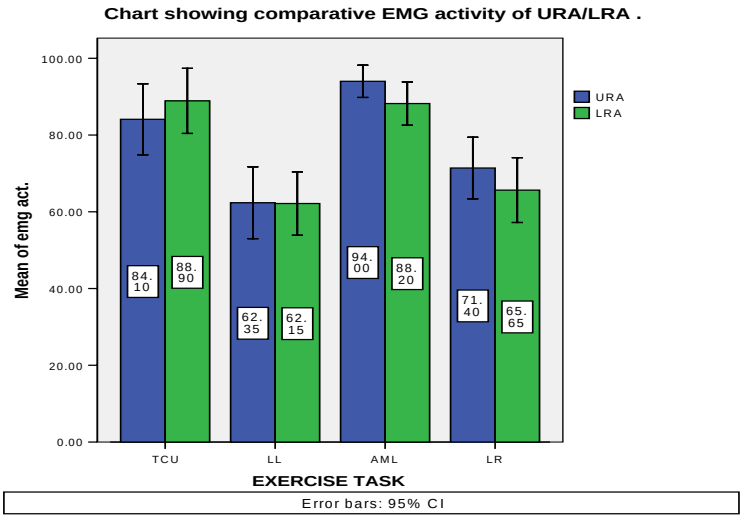
	N	Mean	S.D	S.E.	95% C I
TCU	20	88.90	18.13	4.05	80.41-97.38
LL	20	62.15	17.66	3.94	53.88-70.41
AML	20	88.20	12.06	2.69	82.55-93.84
LR	20	65.65	18.03	4.03	57.20-74.09
Total	80	76.22	20.56	2.29	71.64-80.80

portion. This enabled us to rectify the individual differences of strength as well as making the data comparable [8, 11, 13].



Paired Samples Test

Test Mov.	Mean diff	S.D	95% C I	t	Sig. (2-tailed)
TCU	-4.80	22.04	-15.11-5.51	-0.97	0.34
LL	.20	17.90	-8.17-8.57	0.04	0.96
ABM	5.80	12.71	-0.15-11.75	2.04	0.05
LR	5.75	23.02	-5.02-16.52	1.11	0.27



DATA ANALYSIS

Normalized EMG data was analyzed to compare the activity of upper & lower portion of RA during an exercise task .Also all 4 activities were compared for the extent of activation of rectus abdominis.

Comparison of URA amongst all 4 activity through ANOVA: F=13.30, P=0.000.CI =73.36-82.56. Comparison of LRA amongst all 4 activity through ANOVA: F=14.7, P=0.000.CI =71.64-80.80.Bonferroni Post hoc test suggest that TCU activates muscle to the similar extent as abdominal muscle lift task for LRA (P=1.000, CI=-13.58-14.9) & URA (P=0.4, CI=-24.5-4.7).Leg lowering activates muscle to the similar extent as leg raise task for LRA (P=1.000,CI=-17.7-10.78)& URA (P=0.58,CI=-5.57-23.67).

Chart:1

Table 4: Comparison of activation between upper & lower portion of RA during performance 4 exercise task.

DISCUSSION

Descriptive analysis suggests no significant differences between upper & lower portion of rectus abdominis activity (table4) (chart2), although the differences exist in the level of its recruitment amongst the tested exercise task. (Table 2, 3).One of the study showed similar findings in which Rectus Abdominis did not show any differences concerning its upper & lower portion recruitment during curl up exercise. However, extent of its recruitment amongst 4-exercise task showed differences. On the other hand, same study showed reduced EMG activity during reverse curl up, leg lowering, & rolls out task [10].

In present study, attempt is made to compare basic test movements i.e. TCU & leg lowering with abdominal muscle lift, which haven't been tried before. Amongst the 4 tested exercise task; abdominal muscle lift showed overall greater activation of upper &lower part of rectus abdominis followed by trunk curl up as compared to leg lowering & leg raise activities .(Table3,4). Differences are statistically significant. The exercise tasks selected for the present study are the activities used to test the upper & lower portion of Rectus Abdominis muscle differently [7, 14].

However, findings of present study suggest that the lifting of upper torso type of activity activates the rectus abdominis in the better way as compared to leg lowering & leg raising task. One of the study supports this finding in which significant differences were observed between upper & lower portion of rectus abdominis muscle during performance of certain exercise task [13].

Results also suggest that abdominal muscle lift was the activity has a tendency to recruit rectus abdominis to maximum extent consistently followed by trunk curl up. (Table 3, 4)

Findings presented by sarti et al, showed the preferential recruitment of lower rectus abdominis during posterior pelvic tilting exercises in highly trained individuals. While upper portion of rectus recruited more during trunk curl, type of exercises. [8]. In his study , author had assigned the subject to a group of highly trained correct performers, so it is highly doubtful that to which extent the above findings can be made generalized to the population where fitness characteristics are varied & non uniformity exist amongst the demographic characteristics of the subjects. In our study, we selected the physiotherapy female students of average built, who were not under any training programme. (Table1)

Our main concern was to study the activity of lower portion of rectus abdominis recruitment during trunk curl up & abdominal muscle lift.

It was noted that lower portion was activated to similar extent as the upper portion of rectus in fact its recruitment was greater during this two activities as compared to leg raise &leg lowering activity, which was significant statistically (table3). The result does not support the belief that leg raise & lowering are necessary conditions to activate the lower portion of rectus abdominis. That the strength & endurance adaptation occurring at one section should occur in other section too [13]. During leg raise & leg lowering activity overall Rectus Abdominis activation was although the lesser than as compared to other two task; both the upper & lower portion were activated the similar extent. (Table 4) Thus, even the upper part of rectus can be stimulated through the leg raise & leg lowering exercises. Thus, we can say that as lower portion gets activated to the similar extent as upper portion through AML & TCU, upper portion gets activated to the similar extent as lower one in leg raise & leg lowering. Further selection then depends on whether eccentric muscle work or concentric muscle work is required & determine by the effects of specificity of training. Thus, lower portion of rectus testing & training can be achieved satisfactorily through trunk curl up & abdominal muscle lift exercise.

It was shown that curl up activity at least activates 20-50% of MVC of rectus abdominis, which is sufficient to stimulate force production (strength) & endurance. In same study 20% differences in differential recruitment of upper & lower portion of rectus abdominis were observed. This was attributed to geometric & postural changes [11].

Thus, to bring about an activity whether it is to curl up the torso or lift & lower the leg, both the portions of rectus are recruited to almost similar extent in general population of average strength. (Table 4).The scope for its clinical application in certain situation should be searched out .e.g. diastasis of recti where rectus testing & training cannot be undertaken thought trunk curl up exercise .In this situation leg lowering or its lowest sub grades can be used to test & train the muscle.If any portion becomes preferentially weak as occurs in the diastasis of lower portion of recti 2 possibility exists. First, not only leg raise but trunk curl will also be weak. Second, strong portion must be compensated for the weak part to bring an activity creating undue overloading of the respective part of thoracolumber spine. Amongst 4 exercises, all the activities tested muscle concentrically except leg lowering task where muscle works eccentrically. Trunk curl up & abdominal muscles' lift checks muscle ability to raise the torso while leg raise & leg lowering checks its ability to stabilize the pelvis ability to against the moving limb.(static action). Hence, each of the exercise bears unique biomechanical characteristics. This should be a deciding factor while undertaking the testing & training procedure for the rectus abdominis. This possibilities advocates further research & needs to be tested clinically.

CONCLUSION

Traditional exercises employed for the differential testing of rectus abdominis recruits both portions to similar extent. In such situation, purpose of testing, training, & biomechanical characteristics of an exercise should be a consideration. Given priority to theses aspects, one should use realistic testing procedures in certain special situations.

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