International Journal of Physical Education, Sports and Health 2017; 4(4): 153-157

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2017; 4(4): 153-157

www.kheljournal.com
Received: 28-05-2017
Accepted: 29-06-2017

Pruthviraj R
M.S.P.T., Principal
RV College of Physiotherapy,
Bangalore, Karnataka, India

Paul Daniel VK
MPT, Professor
RV College of Physiotherapy,
Bangalore, Karnataka, India

Correspondence
Pruthviraj R
M.S.P.T., Principal
RV College of Physiotherapy,
Bangalore, Karnataka, India

Electromyographic analysis of exercises proposed for differential activation of rectus abdominis muscle components

Pruthviraj R and Paul Daniel VK

Abstract
The main objective of the study is to assess the activation of the upper and lower portions of rectus abdominis muscle during three different abdominal exercises and also to facilitate controlled quantification of segmental difference.
Abdominal exercises are usually prescribed for fitness training program and also as a rehabilitation program for low back ache. Movements and stability of trunk are controlled by complex array of different individual muscles. The activation of these Muscles is task specific. There are many abdominal strengthening exercises, but controversy exists about exercises and clinical tests that attempt to differentially activate the Upper and Lower Portion of Rectus Abdominis Muscle.
A repeated Measure design was used to analyze the effects of 3 abdominal exercises [Shoulder Curl Up, Leg Raise and Posterior Pelvic tilt Exercises] on the mean EMG amplitude of different portion of rectus abdominis muscle. 30 subjected were selected for study out of which 15 were sedentary subjects [Group A] and 15 were athletes [Group B]. Subjects were with low subcutaneous abdominal fat and normal abdominal muscle strength. Subjects performed 3 task [Shoulder Curl Up, Leg Raise and Posterior Pelvic tilt Exercises] 5-6 trials of each task with 3min rest between task to allow adequate recovery from the effects of fatigue. The pace performance was sounded out by a beep control. Before performing the data analysis the amplitude of each exercises for each component of the Rectus was normalized to the amplitude obtained at the maximum voluntary Isometric contraction performed prior to the exercises movement tasks.
The results of the exercises movement task revealed that upper rectus abdominis EMG activity showed statistically significant difference in % MVIC between the three exercises in athlete group conversely the same was not true in sedentary groups. The activation of lower rectus abdominis between the three exercises was statistically not significant for both the groups.

Keywords: EMG, Rectus Abdominis, Abdominal Exercises.

Introduction
Abdominal exercises are usually prescribed as a rehabilitation program for low back pain and fitness training program [1, 2]. A key component to evaluate and treat LBP involves specific strength assessment of upper and lower portions of Rectus Abdominis [3]. Rectus abdominis is the major flexor of the torso compared to other muscles of abdominal wall and it plays minor role in spinal stability [4]. Rectus abdominal Muscle connects the anterior part of the thorax with the anterior part of the pelvis. With the spine dorsally extended form erect position the COG will be located behind the bilateral axis of the low back and the rectus abdominis muscle will activated.
From kinesiological point of view, Rectus Abdominis muscle is important for movements between lumbar vertebras and also between 5th lumbar vertebra and sacrum [5]. The coordination between Rectus Abdominis and erector spinal muscle avoids overloading in some of the tissues in the spine. E.g. IVD. Many studies conclude, Good strength of abdominal Muscles is favourable as a prophylaxis against back Disorders. Strength training of these muscles is most often a part of rehabilitation program.
Theoretically, sit-up and trunk curl up exercises are practised to strengthen the Upper Rectus Abdominis and double leg raising/ posterior pelvic tilt exercises to strengthen Lower Rectus Abdominis muscle and it because, the metameric nerve supply of the Rectus Abdominis

muscle is supplied by the anterior primary rami of lower 6 or 7 thoracic nerve [6].

To evaluate the strength of both upper & lower portion of Rectus Abdominis Muscle, only clinical trials determine whether exercise results in better outcome and such information is obtained by recording Myo-electrical activity of a muscle via EMG [7]. Electrical Potentials can be recorded from normal contracting muscles by the means of electrode either inserted in to the muscle, as with concentric needle electrode or connected to the surface electrode. All the muscles of motor unit contract simultaneously and cause MUAP [Motot unit Action Potential]. The Action Potential are recorded on graph, Surface electrode placed on Rectus Abdominis Muscle pick up the AP of all active motor units of the muscle representing the active motor units [9].

In training these Muscles, Specificity has to be taken in to account and also one has to know not only specific muscles engaged in particular exercises but also to what extent. There are many abdominal strengthening exercises, but controversy exists about exercises and clinical tests that attempt to differentially activate the Upper and Lower Portion of rectus Abdominis Muscle.

Methodology

The sample consists of 30 healthy Male subjects out of which 15[Group A] were sedentary subjects belonging to the age group of 18-28 years and 15 [Group B] were athletes [short and middle distance runners] belonging to the age group of 18 -21 years. Subjects with low subcutaneous abdominal fat and normal abdominal muscle strength were included and subjects with any history of back pain during last one year, abdominal and back Surgery were excluded. A repeated- measure design was used to analyze the effect of 3 abdominal strengthening on the mean EMG amplitude of different portions of Rectus Abdominis muscle. The subjects performed 3 different abdominal exercises during a single testing session. The order of the exercises was randomised. Nor axon inc. USA, My system 1200 EMG machine was used record the EMG signals.

Subject preparation & Electrode Placement [10]

The skin was prepared by shaving and cleansing with isopropyl alcohol. The EMG signals were collected using disposable bipolar silver chloride disc surface electrodes with a diameter of 5mm that were placed parallel to the muscle fibres with a centre to centre spacing of 2.5cms. Electrode placement was standardized by placing 4 pairs of disposable bipolar EMG electrodes on the following sites over rectus abdominis muscle:

- In the upper portion of the rectus abdominis muscle[~3cms lateral and to the left of midline on the second to top most rectus "bead"]
- Similarly on the upper portion of the right rectus Abdominis Muscle
- In the lower portion of the rectus abdominis muscle [~3cms lateral and to the left of the midline and 2cms inferior to the umbilicus]
- Similarly on the lower portion of the right rectus abdominis muscle
- The ground electrode was placed on the forehead.

Procedure

After initial warm-up, the MVIC [maximum voluntary isometric contraction] of rectus abdominis muscles was recorded by making the subjects, lie in crook-lying position with feet restrained and knee bent at 90degress, the subject then performed a maximum curl-up against a resistance provided by the experimenter, maintaining the maximum intensity of contraction for up to 6 seconds and then subjects performed the following exercises.

1. **Shoulder curl-up:** The subject in crook lying position lies with arms by side and finger behind the ear, hips flexed approximately 45degree and knee flexed approximately 90 degree with flat on plinth. Subjects were instructed to curl head, shoulders and upper trunk up until shoulder blades cleared the plinth. Fingers behind the ears and elbow were maintained in the line with the head throughout the movements, omitting any jerky movements.
2. **Leg raise:** Subjects in supine position were asked to raise both leg the 25cms off the supporting surface and then lowered the legs without dropping them, in a controlled fashion.
3. **Posterior pelvic tilt:** Subjects were postioned in crook lying position with feet off the ground, hip and knee flexed at 90degree and thigh are kept without moving throughout the exercises. The exercise consists of pelvic tilt contracting abdominal muscles to roll the pelvis backwards while pulling the pubic symphysis up towards the chest. The lumbar region touches the mat, and the sacrum bone, iliac crest and buttocks are raised from the couch [11].

Each exercise was performed for 5 to 6 repetition with 3 min rest period. The pace of performance was sounded out by a beep control to speed of 60 beeps per minute, 1 repetition every 3 second.

Results

Table 1: comparison of %MVIC EMG activity between athletes URA and LRA

Abdominal exercises		%Mean MVIC	SD	Standard error	T value	Level of significance
Shoulder curl up	URA	67.03	12.072	3.117	0.6341	NS
	LRA	69.91	12.738	3.289		
Leg raise	URA	56.70	14.880	3.842	2.5350	P<0.05
	LRA	70.30	14.502	3.774		
Pelvic tilt	URA	54.07	14.672	3.788	3.1488	P<0.01
	LRA	70.00	12.992	3.554		

Table 2: comparison of %MVIC EMG activity between sedentary URA and LRA

Abdominal exercises		%Mean MVIC	SD	Standard error	T value	Level of significance
Shoulder curl up	URA	61.70	11.317	2.922	0.7389	NS
	LRA	65.17	14.216	3.671		
Leg raise	URA	56.07	19.443	5.020	1.50	P<0.05
	LRA	66.83	19.883	5.134		
Pelvic tilt	URA	50.67	16.064	4.148	2.4743	P<0.01
	LRA	63.93	13.160	3.398		

Table 3: comparison of %MVIC EMG activity between athletes left RA Vs right RA

Abdominal exercises		%Mean MVIC	SD	Standard error	T value	Level of significance
Shoulder curl up	Left RA	67.93	10.316	2.664	0.0171	NS
	Right RA	68.00	11.011	2.834		
Leg raise	Left RA	61.87	13.948	3.601	0.00	NS
	Right RA	61.87	11.329	2.925		
Pelvic tilt	Left RA	61.23	13.899	3.589	0.3978	NS
	Right RA	63.33	14.997	3.872		

Table 4: comparison of %MVIC EMG activity between Sedentary left RA Vs right RA

Abdominal exercises		%Mean MVIC	SD	Standard error	T value	Level of significance
Shoulder curl up	Left RA	64.13	9.944	2.567	0.6295	NS
	Right RA	61.53	12.529	3.235		
Leg raise	Left RA	72.07	17.214	4.445	0.2357	NS
	Right RA	60.63	16.067	4.149		
Pelvic tilt	Left RA	58.00	15.021	3.879	0.3997	NS
	Right RA	60.07	13.245	3.420		

Table 5: comparison of %MVIC EMG activity of left RA between Athletes Vs Sedentary

Abdominal exercises		%Mean MVIC	SD	Standard error	T value	Level of significance
Shoulder curl up	Athletes	67.93	10.316	2.664	1.0272	NS
	Sedentary	64.13	9.944	2.567		
Leg raise	Athletes	61.87	11.329	2.925	0.0376	NS
	Sedentary	62.07	17.214	4.445		
Pelvic tilt	Athletes	61.23	13.899	3.589	0.6119	NS
	Sedentary	58.00	15.021	3.879		

Table 6: comparison of %MVIC EMG activity of right RA between Athletes Vs Sedentary

Abdominal exercises		%Mean MVIC	SD	Standard error	T value	Level of significance
Shoulder curl up	Athletes	68.00	11.011	2.843	1.5015	NS
	Sedentary	61.57	12.529	3.235		
Leg raise	Athletes	61.87	13.948	3.601	0.2245	NS
	Sedentary	60.63	16.067	4.149		
Pelvic tilt	Athletes	63.33	14.997	3.872	0.6323	NS
	Sedentary	60.07	13.245	3.420		

Table 7: Comparison of % MVIC EMG activity of URA during shoulder curl up, leg raise and posterior pelvic tilt among Athletes

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	67.03	12.072	3.117	Difference b/w exercises	4.129	P<0.05
Leg raise	56.70	14.880	3.842			
Pelvic tilt	54.07	14.672	3.788	Difference b/w subjects	1.41	NS

Table 8: Comparison of % MVIC EMG activity of LRA during shoulder curl up, leg raise and posterior pelvic tilt among Athletes Individuals

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	69.90	12.732	3.287	Difference b/w exercises	0.0054	NS
Leg raise	70.30	14.502	3.744			
Pelvic tilt	70.00	12.992	3.354	Difference b/w subjects	2.5276	NS

Table 9: Comparison of % MVIC EMG activity of URA during shoulder curl up, leg raise and posterior pelvic tilt among Sedentary Individuals

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	61.70	11.317	2.922	Difference b/w exercises	2.0786	NS
Leg raise	56.07	19.443	5.0220			
Pelvic tilt	50.67	16.064	4.148	Difference b/w subjects	1.4789	NS

Table 10: Comparison of % MVIC EMG activity of LRA during shoulder curl up, leg raise and posterior pelvic tilt among Sedentary Individuals

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	65.17	14.216	3.671	Difference b/w exercises	0.1632	NS
Leg raise	66.83	19.883	5.134			
Pelvic tilt	63.93	13.160	3.398	Difference b/w subjects	1.9585	NS

Table 11: Comparison of % MVIC EMG activity of Left RA during shoulder curl up, leg raise and posterior pelvic tilt among Athletes Individuals

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	67.93	10.316	2.664	Difference b/w exercises	2.5865	NS
Leg raise	61.87	11.329	2.925			
Pelvic tilt	61.23	13.899	3.589	Difference b/w subjects	3.3929	P<0.01

Table 12: Comparison of % MVIC EMG activity of right RA during shoulder curl up, leg raise and posterior pelvic tilt among Athletes Individuals

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	68.00	11.011	2.843	Difference b/w exercises	1.2550	NS
Leg raise	61.87	13.948	3.601			
Pelvic tilt	63.333	14.997	3.872	Difference b/w subjects	2.4105	NS

Table 13: Comparison of % MVIC EMG activity of Left RA during shoulder curl up, leg raise and posterior pelvic tilt among Sedentary Individuals

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	64.13	9.944	2.567	Difference b/w exercises	0.9931	NS
Leg raise	62.07	17.214	4.445			
Pelvic tilt	58.00	15.021	3.879	Difference b/w subjects	2.2209	NS

Table 14: Comparison of % MVIC EMG activity of right RA during shoulder curl up, leg raise and posterior pelvic tilt among Sedentary Individuals

Abdominal exercises	%Mean MVIC	SD	Standard error	anova	T value	remarks
Shoulder curl up	61.53	12.529	3.235	Difference b/w exercises	0.0515	NS
Leg raise	60.63	16.067	4.149			
Pelvic tilt	60.07	13.245	3.420	Difference b/w subjects	1.7089	NS

Discussion

The main objective of the study is to assess the activation of the upper and lower portions of rectus abdominis muscle during three different abdominal exercises viz shoulder curl, posterior tilt and leg raise among high and low level physically fit subjects [sedentary and athletic subjects]

- The Upper Rectus Abdominis activity in the athletic group during the three abdominal exercises showed statistically significant differences in Shoulder curl exercises than posterior tilt and leg raise exercises [F-value 4.129,$p<0.05$] than sedentary group whereas the Lower Rectus Abdominis activity did not show statistical significant difference in both group. The Main reason for significant Upper Rectus Abdominis activity in the athletic group during shoulder curl up could be due to the fact that the athlete underwent regular shoulder curl up exercises as against leg raise and posterior pelvic tilt as a part of their training program. On the basis of the claims of kendall *et al* (1993) the shoulder curl would produce the greater amount of Upper Rectus Abdominis EMG activity. This study supported this only for Athletic group.
- Another significant finding of this investigation is the greater amount of activity in the lower rectus abdominis compared to Upper Rectus Abdominis during all exercises. The reason could be
- Firstly, the difference in the position of its location, as in curl-up the upper portion of the rectus acts first and contracts to the lift the head/torso off the couch, which are assisted by the head and torso muscles.
- Secondly, the difference in the stability of the insertion of the 2 portion of the rectus. The insertion of upper rectus fibres, the rib cage, is relatively mobile compared to the insertion of lower rectus, the pubic symphysis. This difference in mobility could have affected the action of the upper rectus.
- % MVIC of Lower Rectus Abdominis was greater than Upper Rectus Abdominis for all three exercises in both groups. However statistically significant differences between Upper Rectus Abdominis and Lower Rectus Abdominis for both the groups were found in exercises of leg raise and posterior pelvic tilt.
- Within the exercises compared, leg raise and posterior pelvic tilt exercises recruited greater % MVIC of Lower Rectus Abdominis as compared to Upper Rectus Abdominis in both the groups. However the activation of LRA was statistically not different for both groups when the comparison was between the exercises. These findings support the view of lehman and McGill who proposed that shoulder curl up can quickly activate the Lower Rectus Abdominis as compared to leg raise and posterior pelvic tilt exercises. The result of the present study are also in accordance with J.Ekholm *et al* (1979), whose results show that commonly used conventional exercises of the curlup from normal horizontal position gives higher activity in the lower rectus abdominis.
- When the activity from the corresponding muscles of both sides [right Rectus Abdominis and left Rectus Abdominis] is compared, a small difference is commonly seen in both the groups. This difference may be due to functional asymmetry; for example, the left rectus may be predominating in one movement, and the right rectus in another. However none of this was statistically significant.
- The activation of Upper Rectus Abdominis and Lower Rectus Abdominis showed no statistical significance between the groups. This provides the evidence that the abdominal muscles could be equally activated by the groups of varied physical activity background.
- The results also supported the findings of Guimaraes *et al* (1991) who found that leg rising was not strenuous exercises than curl up and sits up on the Lower Rectus Abdominis.
- The posterior pelvis tilt exercises prevented the use of hip extensor muscles to help to accomplish the posterior pelvic tilt movement. The ilio-psoas functioned as a stabilizer muscle maintaining flexed hip at 900 throughout the movement. As consequences; Rectus Abdominis action was isolated as the unique muscular agonist of posterior pelvic tilt to facilitate the study of its activation.

Conclusion

The findings are relevant to the rehabilitation community because they confirm that simple curl-up exercises activates the upper and lower portion of the rectus abdominis muscle equally, and therefore strength and endurance adaptations occurring at one section should also occur in the other section. The results do not support the belief that straight leg raise are necessary condition to activate the lower portion of rectus abdominis muscle. These results along with the detrimental

spinal compression penalty associated with leg raise [axler *et al*., 1997] suggest caution when selecting leg rises in the context of rehabilitation or prevention of low back pain.

Reference

1. Jackson CP, Brown MD. Analysis of current approaches and a practical guide to prescription of exercises. Clin Ortho. Rel. Res. 1983; 179:46-54.
2. Smidt G, Herring T, Amundsen L, Rogers M, Russell A, *et al*. Assessment of abdominal and back extensor function; A quantitative approach and results for chronic low back patients, Spine. 1983; 8:211-219.
3. Kendall FP, McCreary EK, Provance PG. Muscles: Testing and Function. Philadelphia: Williams and Wilkens, 1993.
4. Juker D, McGill S, Krpot P, *et al*. Quantitative intramuscular myoelectric activity of lumbar portions of Psoas and the abdominal wall during a wide variety of tasks. Med. Sci. Sports. Exerc. 1998; 30(2):301-310.
5. Guimaraes AC, Vaz MA, De Campos MI, Maraantes R. The Contribution of the rectus abdominis and rectus femoris in twelve selected abdominal exercises. J. Sports Med Phys Fitness. 1991; 31:222-230.
6. Willams PL, Warwick R. Gray's Anatomy Barcelona Salvat, 1985.
7. Patridge MJ, Walters CE. Participation of the abdominal Muscle in various movements of the trunk in man. An electromyography study. Phys Ther Rev, 1959; 39:791-800.
8. Bankoff ADP, Furlani J. Electromyographic study of the rectus abdominis and external oblique Muscles during exercises. Electromyorg Clin Neurophysiology. 1984; 24:501-510.
9. Weddell, Feinstein. EMG history: In: Johnson EW; Practical Electromyography. Williams and Wilkinsons Balitimore, London. 1985 pg. 419.
10. Lehman GJ, McGill SM. Quantification of the differences in EMG activity Magnitude between the upper and lower portions of the rectus Abdominis muscle during selected trunk. Exercise Phys Ther 2001; 81:1896-1101.
11. Jan Ekholm, Arborelius U, Fahlerantz, Larsson AM, *et al*. Activation of abdominal Muscles during some Physiotherapeutic exercises. Scand J. Rehab. Med. 1979; 11:75-84.