

Electromyographic Comparison of Abdominal Muscle Activation during Sit-Up Exercise and Ab Crunch

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Abstract. This study was designed to compare the effects of sit-up and ab crunch exercises on muscular activity of the rectus abdominal. A pairs of surface electrodes were placed unilaterally on four quadrants of the rectus abdominal, in ten male subjects (mean and [SD] age, height and weight were 20.6 yrs [1.90], 167.00 cm [4.92] and 62.0 kg [2.45] respectively). Electromyographic (EMG) recordings were taken while the subjects performed sit-up and ab crunch exercises. The exercises analyzed were: 1) sit-up (bent knee), and 2) ab crunch (straight leg). It was hypothesized to have a specific effect on one of the four quadrants of the rectus abdominal. Statistical Analysis ANOVA on the EMG activity demonstrated significant differences between the sit up and ab crunches as well as in the four different quadrants. Further the t-test on different quadrants during the two exercises revealed that there were significant differences in epigastrica and hypogastrica during sit-up and ab crunch. Hence, we conclude that ab crunch is a better abdominal exercise specific for strengthening epigastrica and hypogastrica muscle quadrants of the rectus abdominal.

Keywords: electromyographic, rectus femoris, abdominal, quadrants sit-up, crunch,

1. Introduction

A well developed muscle of the abdominal is an essential ingredient to the type of complete physique for any sports performance. The anatomical and kinesiological studies have revealed that abdominal muscles are the stabilizer of the pelvis, the lumbar spine and the thorax and are prime mover for the trunk flexion and rotation (Whiting & Rugg, 2006). In sports training and related sciences, much attention has been given to these muscles and the best ways to strengthen them. The greatest challenge for physical educators, coaches, trainers, therapists and physicians is in the selection of appropriate exercises and variations, to best isolate a targeted muscle or muscle groups. The sit-up and ab crunches have most often been used to develop strength of the abdominal muscles.

The use of electromyography has been an important tool in understanding the muscles activity. Experimental research uses electromyographic (EMG) methods to characterize the activation of muscles (Juker, et al. 1998). Electromyographic (EMG) assessment of anterior trunk muscles, most frequently the rectus abdominal has been widely reported across a range of activities, including lifting (Nussbaum, et al., 2000; Whiting, et al., 1999) and various types of sit-up exercises in adults (Hussain, et al., 2006; Sternlicht & Rugg, 2003; Piering, et al., 1993).

The general purpose of the present study was to compare on young male players the activation p attern of abdominal muscles into different exercises, the sit-up and the ab crunch.

2. Methods

2.1. Participants.

Informed consent from ten male (age $X=20.6$ yrs. $SD=1.90$; height $X=167$ cm, $SD=4.9$; weight $X=62$ kg, $SD=2.45$), was taken. All participants were Indian Intervarsity Level players of hockey, soccer and track & field. The subject selection was limited to individuals with prominent abdominals indicating sufficiently low subcutaneous adipose tissue.

2.2. Experiment design.

The experimental design used for the study was repeated measures design. The subjects were explained about the proper technique of execution of the exercises. Each subject practiced the proper technique with the correct sequence of beat on which they were to perform the sit-up exercise. After a practice prior to the study, all the subjects performed series of three cycles for each exercise: sit-up (trunk flexion with bent knee, the feet were flat on the floor, legs bent with knee at 110°) and ab crunch (straight leg i.e. leg and trunk movement simultaneously). The arms were placed on the chest crossed.

2.3. Measurements.

A standard electromyography (EMG) system (Student Physiograph for Group experimentation and research, Biodevices, Ambala) was used to measure the muscle activity. The exercises were performed at a pre-set rhythm of amplified watch beats. The duration of one cycle of exercise (concentric and eccentric phase) was 6sec. one cycle of each exercise was selected for analysis. Bipolar silver chloride surface electrodes of diameter of 1.3 cm were placed on the skin overlying the right side of the quadrants of rectus abdominal are epigastria, upper umbilical, lower umbilical, and hypogastria. An unshielded ground electrode was placed on the skin overlying the lateral malleolus. The electrodes were oriented parallel to the muscle fibers and an inter-electrode distance was maintained consistent from subject to subject. Both sets of electrodes were centered from medial to lateral. Prior to electrode application; the skin over each muscle was shaved and cleansed with sprit to reduce the impedance at the skin electrode interface. Prior to the measurements for the study, the EMG signals were normalized. The mean data of anthropometrics description are presented in table-1.

Table 1: Anthropometrics Description

	No.	Sex	Age (Yrs)	Height (cm)	Weight (Kg)
Subjects	10	Male	18-24	160-174	56-64
<i>Mean</i>			20.6	167.00	62.00
SD			1.90	4.92	2.45

2.4. Data analysis.

The sensitivity for EMG recording was set at 100µv/cm, with amplitude signals bandwidth of 50Hz and the speed of the paper set at 25mm/sec. The data collected over the EMG to measure muscle activity was used for analysis. The raw EMG was calculated for concentric (upward) and eccentric (downward) phase, and divided for the respective phase duration to obtain the amplitude value and then added to be considered as one cycle activity.

2.5. Statistical methods.

Two-way Analysis of variance (ANOVA) with repeated measures test was performed to compare the EMG activity of the sit-up and ab crunch exercises; and to compare the muscle quadrants (muscle sites) during the sit-up and ab crunch exercises t-test was performed. The statistical significance of the exercises and four muscle sites were examined at $p \leq 0.05$.

3. Results

The result of the statistical analysis, two-way analysis of variance with repeated measures performed reveals that there were significant difference between two exercises i.e., sit-up and ab crunch, $F = 6.081$; and significant difference were also found between different muscle quadrants (epigastria, upper umbilical, lower umbilical, and hypogastria), $F = 15.424$ (table-2).

Table 2: Two-Way Analysis of Variance (Dependent Variable: EMG)

Source	Type III Sum of Squares	df	Mean Square	F
Corrected Model	1288.118(a)	07	184.017	8.279
Intercept	28477.472	01	28477.472	1281.144
MusSite	1028.543	03	342.848	015.424*
Exercise	135.174	01	135.174	6.081*
MusSite * Exercise	124.401	03	41.467	1.866
Error	1600.427	72	22.228	
Total	31366.018	80		
Corrected Total	2888.545	79		

* Significant

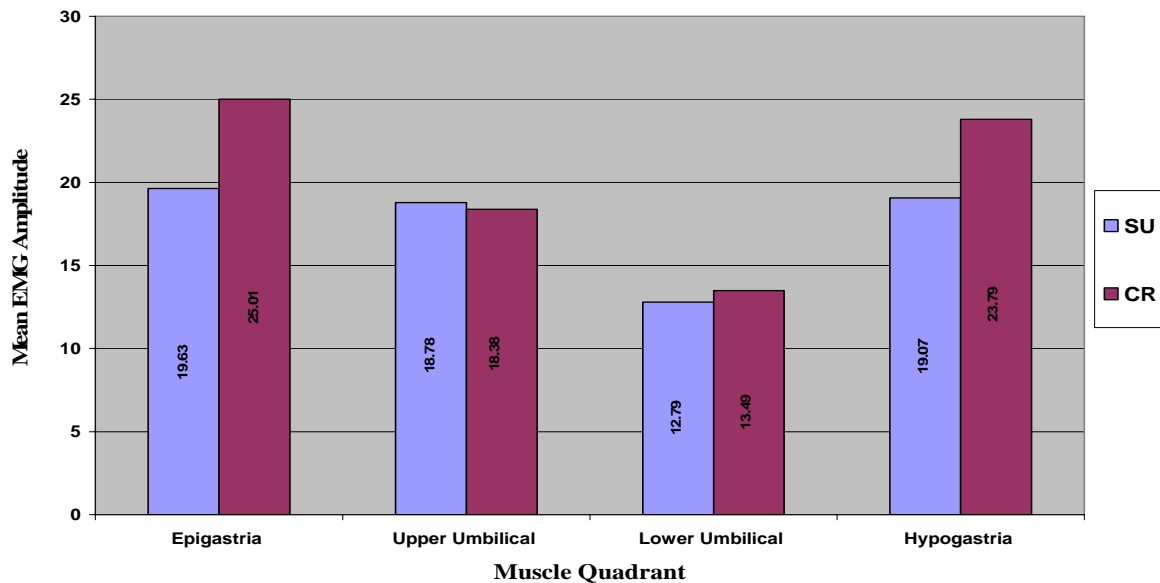
The t-test analysis was performed to find out which of the muscle site has significant differences during sit-up and ab crunches. The averages of EMG activity of epigastrica, upper umbilical, lower umbilical, and hypogastrica during sit-up exercise were 19.63 μ v, 18.78 μ v, 12.79 μ v, and 20.17 μ v; and during ab crunches are 25.01 μ v, 18.38 μ v, 13.49 μ v, and 23.79 μ v respectively (Figure-1) with a mean difference (MD) of 5.38 and standard deviation (SD) 5.56 for epigastrica, (MD) of 0.40 and (SD) 5.55 for upper umbilical, (MD) of 0.70 and (SD) 3.41 for lower umbilical, and (MD) of 4.72 and (SD) 4.96 for hypogastrica (table-3).

Table 3: The means of the EMG Amplitudes, Standard Deviation and t-test

Quadrant	SU	CR	Mean Diff.	SD	Cal = t
Epigastrica	19.63 μ	25.01 μ	5.38	5.56	2.42*
Upper Umbilical	18.78 μ	18.38 μ	0.40	5.55	0.16
Lower Umbilical	12.79 μ	13.49 μ	0.70	3.41	0.46
Hypogastrica	19.07 μ	23.79 μ	4.72	4.96	2.34*

Table t = 2.26 , * Significant

Computation of the t-test in sit-up and ab crunch of epigastrica, upper umbilical, lower umbilical, and hypogastrica revealed that there were statistical significant difference in muscle site of epigastrica and hypogastrica with a calculated-t value of 2.42 and 2.34 respectively, but there were no significant difference in the muscle site of upper umbilical and lower umbilical with a calculated value of 0.16 and 0.46 respectively. These results demonstrate that the ab crunch exercise generates greater muscle activity than sit-up exercise, thus ab crunch exercise is a better choice for training rectus abdominalis predominantly the epigastrica (upper most quadrant of rectus abdominis) and hypogastrica (lower most quadrant of rectus abdominis) muscles.



SU – Sit-up and CR – Ab Crunch

Figure 1: Graphical representation of The means of the EMG Activity in amplitudes of Epigastria (Epi), Upper Umbilical (Up.Um), Lower Umbilical (Lo.Um), and Hypogastrica (Hypo), Sit-Up (SU) and Crunch (CR).

4. Discussion

The results of this study apparently indicate a significant difference in muscle activity for different quadrants of rectus abdominal muscle (epigastria, upper umbilical, lower umbilical and hypogastrica) during sit-up and ab crunch exercises.

The ab crunch showed a higher EMG activity difference than the sit-up. The reason for the differences may be due to the vertical lift of the trunk and the leg simultaneously against the gravitational force that provided higher resistance to require substantial motor unit recruitment than the sit-up where only the trunk is lifted against the gravitational force required subsequently lower motor unit recruitment, thus the resistance produced during the abdominal exercises were enough to produce significantly comparable muscle activity.

The result in this study further verifies that the muscle activity in epigastria and hypogastrica quadrants of rectus abdominal muscle during sit-up and ab crunch exercises show significant difference and reveal that both these quadrants generate higher muscle activity during ab crunch than the sit-up exercises. Thus we can conclude that the ab crunch is a better exercise to strengthen epigastria and hypogastrica quadrants and as whole the rectus abdominal muscle than the sit-up exercises. As it is associated with a greater mechanical efficiency and maximizes the force exertion; the work performance; attenuate the mechanical effects of impact forces and reduce the tissue damage, pain and injuries associated with exercise (Roy, et al., 2003; Ng, et al., 2001; Kumar, et al., 1996).

5. Conclusion

In summary, abdominal muscle quadrants elicited different muscle activity during sit-up and ab crunch exercises when used with proper technique. The ab crunches elicit greater amount of muscle activity than the sit-up exercise, thus the ab crunch exercise is a better form of exercise to train all the quadrants of rectus abdominal.

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