EVALUATION OF SURFACE ELECTROMYOGRAPHY DURING THE PERFORMANCE OF FOUR DIFFERENT ABDOMINAL EXERCISES

Ismael Baldissera, Jonas Gurgel, Flávia Porto, Gustavo Sepúlveda, Felipe Flores, Fabiano Gonçalves, Thais Russomano

Aerospace Biomechanics Research Group, PUCRS, Porto Alegre, Brazil

This study aimed to evaluate muscle's response to four different abdominal exercises by means of surface electromyography (sEMG). Six male volunteers (24 ± 4,47 yo) with at least 6 months experience in the performance of regular abdominal exercise participated in this study. sEMG data was collected by means of a 4 channel electromyography. Data was normalized by the mean of each channel and was analyzed using ANOVA and Sheffé Post Hoc test ($p < 0.05$). The results of this study showed that the two conventional abdominal exercises presented a higher sEMG signal in the supra, rather than in the infra umbilical area. During the infra and complete abdominal exercises, the stronger sEMG signals were observed in the external oblique and rectusfemoral muscles.

KEY WORDS: abdominal exercises, surface electromyography, time domain.

INTRODUCTION:

Abdominal and dorsal muscle groups are essential for the maintenance of a good posture. In gym exercise programs, the abdominal muscles are always stimulated to increase their strength. This is important not just for an adequate posture but also to avoid or to minimize lumbar pain. The back pain syndrome is more common in individuals with weak back muscles (Zatsiorsky, 1999). According to Kraemer & Häkkinen (2004), exercising the abdominal muscles keeps the dorsal area healthier. This is essential for athletes and astronauts since microgravity exposure causes discomfort and pain in the lumbar region, as a result of the stretching of soft tissues surrounding the column.

The scientific literature emphasizes that some areas of the rectusabdominal and oblique muscles respond differently to exercise (Ross *et al.,* 1993; Pardal *et al*., 2003). Willett *et al*. (2001) showed that the external oblique muscle respond equally to exercises of abdominal flexion and rotation, but differ during hip flexion. Hildenbrand et al. (2004) pointed out that this difference could be related to a more intense torque during hip exercises.

This study aimed to analyze the activation pattern by means of surfaceelectromyography (sEMG) during 4 types of exercises commonly used in gyms (conventional abdominal, conventional abdominal with feet support, infra and abdominal complete).

METHODS:

Data Collection: Six healthy male volunteers (age 24 4,47; weight 77,15 4,85 Kg; fat of 10,15 1,13 %) participated in this study. All volunteers had performed at least 6 months of abdominal exercise and are not under any steroid or illicit drugs use. They were asked not to consume alcohol 24 hours prior to the test, and caffeine 2 hours before the test. A physical evaluation was conducted, including posture evaluation, body fat profile and flexibility (Wells Bank). Any posture alteration or muscle problem was considered a criterion for exclusion. Body composition was taken by means of Jakson & Pollock protocol (1978) and the predictive equation of Siri (Pollock & Wilmore, 1993).

A 4 channel electromyography device (Miotool 400, Miotec Equipamentos Biomédicos®), with a sample acquisition of 2000Hz per channel was used. Signals were processed via a specific software (Miographic 2.0, Miotec Equipamentos Biomédicos®), with a pass band filter and a cut off frequency of 20Hz and 500Hz. After the filter use, the Root Mean Square (RMS) of the signal was calculated and they were normalized using the mean of each signal.

Surfacepediatrician electrodes were used (Ag/AgCl, Meditrace) with a 30 mm distance between the center point of the electrodes, which respected the protocol of Araújo (1998). Channels were divided as following: channel 1 = 2nd area of abdominal rectum; channel 2 =

4th area of abdominal rectum; channel 3 = external oblique; channel 4 = femoral rectum. The reference electrode was placed in the tibia tuberoses. All electrodes were placed on the right side of the volunteer.
The exercises were: (1) Conventional Abdominal – to flex the abdomen by 25° having the hip flexed 130° and keeping the hands behind the head; (2) Conventional Abdominal with feet support – similar to the previous one, but the hip should be flexed by 90° and the legs placed on a support (chair); (3) Infra Abdominal – the volunteer was in the supine position with arms along side of the body, the hip flexed at 90° and the abdomen moving towards the knees that were also moving in the direction of the body with an amplitude of 30°; (4) Abdominal Complete – the volunteer was in the supine position with the hands behind the head, hip flexed by 130° and the feet fixed on the floor. The individual had to flex the hip and the body till he was assuming the sitting position.
The volunteer had to perform 3 sets of 10 exercises per type of exercise. The exercises were randomized. The volunteer was asked to keep a normal breathing pattern in a pre-determined rhythm using a digital metrometer.
Calculation was based on the size of the body normalized to a standard individual (Porto, 2005). Measurements were from C7 to L5 vertebras. A training phase of 1 month was used to familiarize the volunteers with the exercise rhythm.

Data Analysis: ANOVA with Sheffé Post hoc test ($p < 0,05$) using software (SPSS 11.5 for Windows) was used.

RESULTS:

Table 1 shows the percentage of RMS, the mean and SD per volunteer per each channel.

Table 1: RMS percentage (Mean % RMS); Standard Deviation (SD); Significant difference to supra-umbilical abdominal (I); Significant difference infra-umbilical abdominal (II); Significant difference to external-oblique(III).

Abdominal Exercises	Supra-umbilical		Infra-umbilical		External-oblique		Rectus femoral	
	Mean % RMS	SD	Maen % RMS	SD	Mean % RMS	SD	Mean % RMS	SD
Conventional	110,98 (I)	18,91	98,27 (I, II)	16,86	42,44 (I, II, II)	17,57	13,00 (I, II, III)	3,73
Conventional Abdominal with feet support	101,38 (I)	17,78	86,20 (I, II)	12,03	34,39 (I, II, III)	10,25	24,62 (I, II, III)	13,80
Infra	93,97 (I)	20,88	108,10 (II)	27,59	179,81 (I, II, III)	42,90	156,95 (I, II, III)	88,91
Complete	93,89 (I)	22,20	101,00 (II)	23,04	144,25 (I, II, III)	27,09	216,56 (I, II, III)	78,27

DISCUSSION:

Data from this study is limited due to the small sample tested. During the performance of conventional abdominal exercise, the rectusabdominal muscle was more activated than the external oblique and rectusfemoral. The two conventional abdominal exercises presented higher sEMG signals in the supra than in the infra umbilical area. These findings are not in accordance to the ones obtained by Ross *et al.* (1993) and Willett *et al*. (2001) in which there was no difference in the performance of exercises. However, Pardal *et al.* (2003) showed that there was a more pronounced activation of the infra umbilical muscle. The infra

abdominal did not present any difference in relation to the two areas of the rectusabdominal muscle, which differ from the results of Willett *et al.* (2001).
Pardal *et al*. (2003) showed more activation in the supra umbilical area. The external oblique was more active when compared with rectusabdominal. Hildenbrand & Noble (2004) discussed that even a small elevation of the inferior region of the lumbar column causes a more intense torque that activates the external oblique. This also happened to the rectusfemoral muscle when the hip was flexed, which is in accordance with the data obtained by Ross *at al.* (1993). During the abdominal complete exercise, there was no difference between the superior and the inferior area of the rectusabdominal. It differed however, from the external oblique and rectusfemoral muscles, being more intense in the external oblique. These findings of this study were in agreement with the ones found by Hall *et al.* (1990) and Willet *et al.* (2001) since the movement of the hip and the torso activated more the rectusfemoral and external oblique due to the torque movement. Hall *et al.* (1990) concluded that the activation of the rectusabdominal is more intense because the feet were stabilized.

CONCLUSION:

The results of this study showed that the two conventional abdominal exercises presented higher sEMG signals in the supra rather than in the infra umbilical area. During the infra and complete abdominal exercises the stronger sEMG signals were observed in the external oblique and rectusfemoral muscles. These findings can be applied to evaluate muscle activity and situation for athletes, and also astronauts after a space mission. They also suggest that the two conventional abdominal exercises can be used to reduce the action of the muscles responsible for flexing the hip.
This is a preliminary study since the sample size was small. Further studies have to be conducted to clarify the results obtained.

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Acknowledgement

The Aerospace Biomechanics research Group would like thank Miotec Equipamentos Biomédicos®.