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Effect of Electrode Position on EMG Recording in Pectoralis Major

by

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Despite the relatively long history of electromyography (EMG) application in a wide variety of disciplines, there are still discrepancies on a preferred position of EMG electrodes. The aim of this study was to determine an optimal position of bipolar surface electrodes for muscle pectoralis major. The recording was done during an isometric (static) effort of pressing the barbell from a lying position. The muscle activity was compared in 9 cases (3 positions of electrodes setting for 3 muscle compartments), recorded at a 1.6 s interval. The highest averaged value of integrated EMG for external, central and medial placement of electrodes, independent from the muscle (clavicularis, sternocostalis and abdominalis), was observed in the latter case of electrode positioning.
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Introduction

Despite the relatively long history of EMG application in biomechanics, little information is available in the literature on an optimal location of recording electrodes (De Luca, 1997). For surface electromyography, the decision where to place the electrode is more complex (Cram and Kasman, 1998; Błaszczyk, 2004). Some researchers have advocated the use of the site where the muscle can be most easily stimulated (motor point), where maximum amplitude of potentials would be assessed. Basmajian and De Luca (1985), however, claimed that this location would not yield the greatest signal amplitude. Similarly to Gath and Stalberg (1976), Basmajian and De Luca recommend 1 cm spacing between surface electrodes.

Davis (1959) suggested specific anatomic locations for electrode placement. Among the original explorers of the effect of electrode positioning on skin, in reference to bioelectrical points, were Zuniga et al. (1970). Using a bipolar technique they identified a part of a muscle with the largest myotonus. They also determined the relationship between amplitude of mean potential EMG and longitudinal position and the bipolar electrode in equal spacing between centers of different bipolar electrodes. More recently, Zipp (1982) specified other locations for EMG electrodes. He presented a set of figures with placement of the surface EMG electrodes, for all but two superficial muscles. Zipp also provided an algorithm for placement normalization based on body dimensions. This approach was accepted in this study. Zipp, however, did not recommend a location of electrodes for pectoralis major, which was a muscle of primary interest in this study.

The main aim of this research was to determine the most convenient placement of bipolar surface electrodes for pectoralis major. For this purpose, bioelectric activity of the muscle was studied with an array of multi-electrodes in the isometric (static) task of pressing the barbell from a lying position.

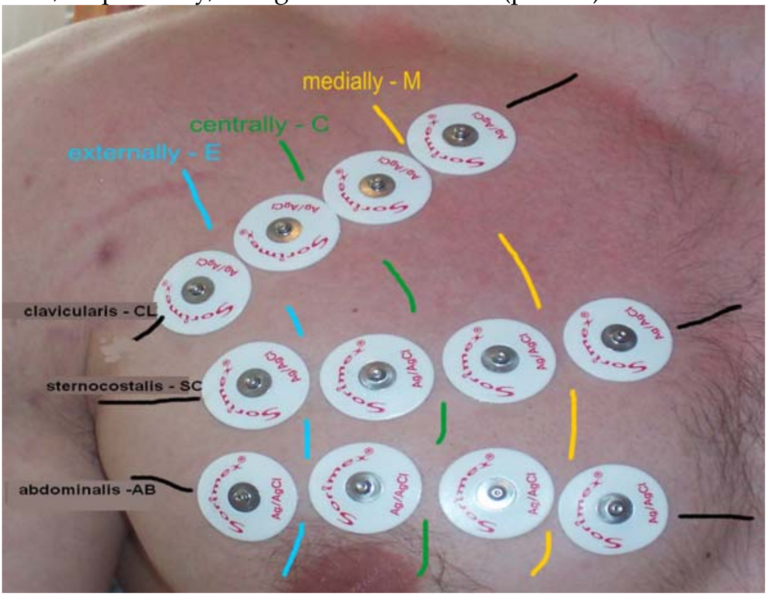
Material and methods

A group of 14 male force track-athletes training mainly throws, with different experiences in strength training were tested. A signed consent from for all subjects was obtained.

The width of the barbell grip in every subject was 81 cm and muscles were contracted isometrically at a 90 degree angle in the elbow joints.

Surface electromyography was applied to record the muscle electrical activity, using standard surface electrodes with a 1 cm diameter, and with 2 cm spacing between them.

In three parts of the pectoralis major (pars clavicularis - part CL, pars sterno-costalis – part SC and pars abdominalis – part AB), three pairs of electrodes were placed, respectively, along the muscle fibres (phot. 1).



Phot. 1

The placement of electrodes in particular parts of pectoralis major

Due to technical limitations, the activity was recorded separately in subsequent trials from the electrodes placed in every part of the muscle:

- first position: electrodes placed nearest the sternum (medially - M),
- second position: electrodes placed in the center, between the sternum and the shoulder (centrally - C),
- third position: electrodes placed nearest the shoulder (externally - E).

Each subject performed 6 trials (two trials for three settings of electrodes: M, C, E). The muscle activity was compared in 9 cases (3 places of electrodes setting for 3 parts of muscle) recorded at a 1.6 s interval. Then the EMG recordings were processed off-line to determine a mean value of integrated myographic signals (IEMG) with a 0.1 s time constant. The mean and maximal values of the IEMG were calculated. Analysis of variance was performed to determine the relationship between electrode placement and IEMG (Statistica v.5.0 StatSoft Inc. U.S.A., Stanisz, 1998).

Results

IEMG-means

Presented in Table 1 and in Figure 1 results show that in chosen isometric position during the barbell press from a lying position:

1) The highest mean values of integrated EMG in the whole time interval ($IEMG_{mean}$) for external (E), central (C) and medial (M) placement of the electrodes, regardless of the muscle part (CL, SC and AB), were observed in the latter case of electrode positioning.

Table 1

Mean value (±SD) of integrated electrical activity [Vs10^{-4}] of pectoralis major calculated in a 1,6s interval in isolated electrode position*

Position of electrode	Mean	SD	Part of muscle	Mean	SD
E	0.437	0.198	CL	0.457	0.222
			SC	0.387	0.117
			AB	0.468	0.234
C	0.430	0.230	CL	0.490	0.224
			SC	0.288	0.096
			AB	0.513	0.268
M	0.525	0.166	CL	0.568	0.175
			SC	0.470	0.163
			AB	0.537	0.149

Where: E – external position of electrodes, C – central position of electrodes, M – medial position of electrodes, CL – pars clavicularis m. pectoralis major, SC – pars sternocostalis m. pectoralis major, AB – pars abdominalis m. pectoralis major

However, when the electrodes were fixed medially, values were significantly larger compared to the central setting ($IEMG_{mean}M - IEMG_{mean}C = 0.095Vs*10^{-4}$; $p<0.0013$) and the external settings ($IEMG_{mean}M - IEMG_{mean}E = 0.088Vs*10^{-4}$; $p<0.0011$).

2) The lowest values of $IEMG_{mean}$ was registered for the SC part of the pectoralis major. Though absolute differences were not large they exceeded external (E), central (C) and medial (M) placement of the electrodes on the muscle. In the central location the differences of $IEMG_{mean}$ between SC and the two remaining AB and CL locations were statistically significant ($IEMG_{mean}AB - IEMG_{mean}SC = 0.225Vs*10^{-4}$; $p<0.0001$, $IEMG_{mean}CL - IEMG_{mean}SC = 0.202Vs*10^{-4}$; $p<0.00001$). In case of medial (M) electrode position significant differences were

observed between pars clavicularis and pars sternocostalis ($IEMG_{mean}CL - IEMG_{mean}SC = 0.098Vs*10^{-4}$; $p<0.0173$).

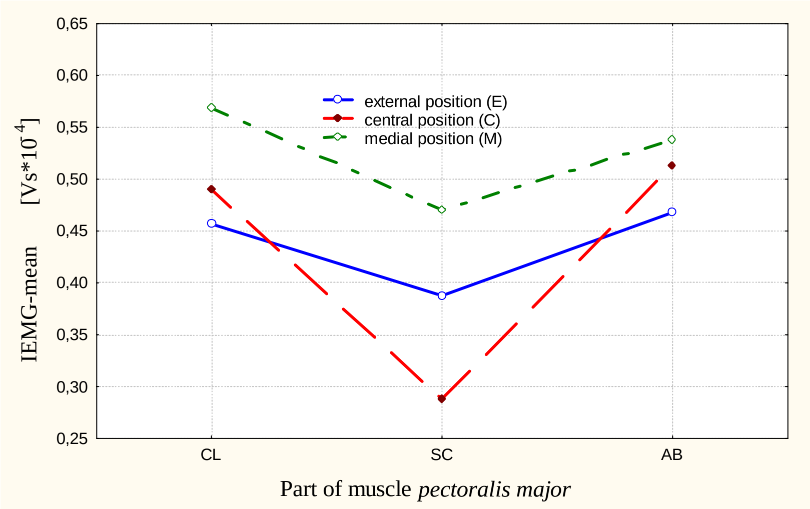


Fig. 1

Mean values of integrated electrical activity ($IEMG_{mean}$) of m. pectoralis major in isolated electrode position. On horizontal site: specific muscle locations: CL – clavicularis; SC – sternocostalis, and AB - abdominalis. Position of electrodes: externally (E), centrally (C), medially (M)

IEMG-max

In case of mean values of maximum integrated bioelectrical activity ($IEMG_{max}$, Tab. 2.; Fig. 2), beside the aforementioned differences, some additional differences with medial (M) placement of the electrodes was observed ($IEMG_{max}$ CL – $IEMG_{max}$ SC = $0.103Vs*10^{-4}$, $p<0.0488$; $IEMG_{max}$ AB – $IEMG_{max}$ SC = $0.131Vs*10^{-4}$, $p<0.0244$).

Analysis of Variance

In the search for an optimal EMG electrode position on pectoralis major an analysis of variance was performed. It showed that the mean integrated electromyography activity ($IEMG_{mean}$) depended significantly on both the position of the electrodes in respect to the sternum and shoulder and on specifications of the muscle. However, there was no interaction seen within specific muscle groups and electrode position throughout the muscle. The post-hoc showed that electrical activity of SC in central (C) position, differed from the activities recorded in both AB and CL. Similar patterns of activity were observed in external and medial positions. Only in the external position of the CL part of muscle there were no significant differences. Very similar patterns of activity were obtained from maximum integrated myographic signals - $IEMG_{max}$.

Table 2

Mean value (±SD) of maximum integrated electrical activity [Vs10^{-4}] of pectoralis major calculated in constant time window 0,1s, in isolated electrode position.*

Position of electrode	Mean	SD	Part of muscle	Mean	SD
E	0.607	0.283	CL	0.644	0.338
			SC	0.545	0.160
			AB	0.631	0.317
C	0.598	0.336	CL	0.723	0.399
			SC	0.396	0.134
			AB	0.675	0.324
M	0.725	0.240	CL	0.750	0.221
			SC	0.647	0.236
			AB	0.778	0.250

Discussion

Identification of optimal electrode positioning is very important, because according to Frołow (1976) "...the dispersion of electric activity of muscles in several movements in the same subject, and especially in different subjects is considerable". In this research the lowest electromyographic activity in reference to the central location of m. pectoralis major (pars sternocostalis) was surprising since this location generally accounts for the most activity during the bench press. According to expert's opinion, pressing from a lying position on a decline bench with a supine head, serves to recruit "abdominal" musculature, whereas pressing on a incline bench with the head up the "clavicular" musculature is more emphasized (Unger, 1996). When pressing on a horizontal bench, the function of the "sternal" musculature is emphasized, however the "clavicular" and "abdominal" locations, which work synergically, in accordance with the rule of parallel forces contribute to other muscles of the shoulder girdle, during the bench press. The reduced activities of the "sternal" pectoralis major in the static position, when pressing the barbell while lying on a horizontal bench, requires confirmation in further investigations. It seems necessary to verify whether similar patterns will be observed if are changed the positions and thus muscle forces.

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