INFLUÊNCIA DO POSICIONAMENTO DE ELECTRODOS ELECTROMIOGRAFICOS SUPERFICIAIS DURANTE TESTES DE ACTIVIDADE MUSCULAR

INFLUENCE OF THE sEMG ELECTRODE POSITIONING DURING MUSCULAR ACTIVITY TESTS

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 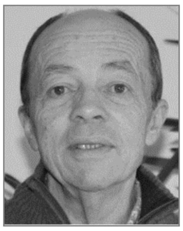 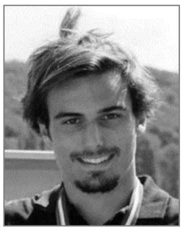   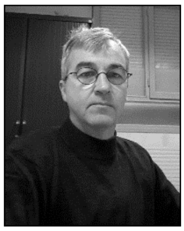

RESUMO

As técnicas de eletromiografia tem vindo a ser utilizada em estudos biomecânicos como uma forma de avaliação da actividade muscular durante a realização de exercícios. Diversas abordagens foram sugeridas ao longo dos anos para o correcto posicionamento dos elétrodos. Além disso a influência do operador tem sido negligenciada durante o medição da actividade muscular de um determinado músculo. Neste sentido, o presente estudo pretendeu avaliar a influência do operador aquando de um mau posicionamento do elétrodo de superfície. Dois músculos diferentes foram avaliados (biceps e erectores espinais do tronco). Observou-se que um mau posicionamento em translação nos biceps é critico enquanto que nos erectores espinais do tronco são as rotações acima de 30° que pode afectar os resultados uma vez que a fibra muscular a medir não é alcançada.

ABSTRACT

The electromyography has been used in biomechanical studies as a technique to evaluate the muscular activity since a long time. Several propositions along the years have been suggested according to the correct positioning of the electrodes. Furthermore, the operators' influence has been neglected during the muscular activity analysis. According to this, this study intended to evaluate the operators' influence when a misplacement of the electrode occurs. Two different muscles were evaluated (biceps and erector spinae). It was observed that the translational misplacement in the biceps muscles is the critical misplacement error in this muscles. On the other hand, taking into account the erector spinae, the rotational displacement above 30° influences the results due to the fact that the right muscular fiber was not reached.

1. INTRODUCTION

The electromyography (EMG) is a measurement technique used to evaluate the muscular fiber response during muscular contraction. Its' use allows to evaluate the muscular activity during dynamic exercises which permits to evaluate the muscular performance (Armand and Bonnefoy 2014; Clarys et al. 2012; Luca 1997). The EMG electrode detects an electrical difference of potential signal generated by the target muscular fibers when they are activated during movements (Bing and Khan 2012; Swinnen et al. 2012).

This biomechanical technique gained some relevance in the recent years with a the growing number of scientific publications in different fields (Van Damme et al. 2014; Martens, Figueiredo, and Daly 2015; Musalem et al. 2015).

Presently there are two different approaches, the invasive and non-invasive EMG techniques. The invasive electrodes, which are more precise, require a skin puncture which causes pain to the volunteer precluding it to be largely used during muscular activity tests. In contrast, the use of surface electrodes is a painless method, however its precision strongly depends on three different kind of factors: causative (electrode configuration, muscle edge, fiber orientation, fiber diameter, electrode location), intermediate (volume detection, superposition, signal crosstalk) and deterministic factors (muscle fiber interaction, recruitment stability) (Armand and Bonnefoy 2014; Luca 1997).

So, the electrode positioning, is an important issue to obtain credible results. The electrode terminals should be aligned along the muscular fibers of the analyzed muscle. Additionally, depending on the explored muscle anatomy, the electrode positioning task could be difficult to reach due to surrounding tissues and fibers orientation. According to that the operators expertise is directly linked to the success of the results obtained.

This study intended to evaluate the influence of the positioning of the tripolar surface electromyography (sEMG) electrode in terms of translation and rotation relatively to its ideal positioning during the muscular activity tests in two different geometrical muscles.

2. MATERIALS AND METHODS

In order to evaluate the influence of the positioning of the sEMG electrode two differrent muscles were evaluated. A superficial and large muscle as the biceps and a non-superficial and thinner muscle as erector spinae were evaluated.

In this study three rotational displacements of 30°, 60° and 90° were considered in order to replicate the possible users' errors during the placement of the electrodes. Also a 5cm horizontal displacement was considered in order to replicate the maximum possible errors observed during the sEMG electrode placement.

2.1. Biceps activity analysis

Four tripolar sEMG electrodes (Kine, Iceland) were placed along the right arm in order to measure the biceps muscle (figure 1). The electrode number 2 was placed on the ideal position according to the manufacture and considered the electrode of reference. Anatomically, the electrodes 1, 2 and 4 were aligned along the same biceps muscular fiber. The electrode 5 was laterally displaced (5cm) relatively to the electrode 2. Five flexion-extension movements were performed using a 6kg mass. Five measures of 10 seconds each were performed in a subject with a normal body mass index (BMI=22,88kg/m2).

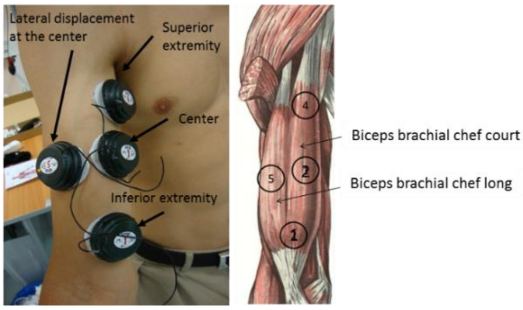

Fig 1- sEMG electrode placement on the biceps muscles.

2.2. Erector spinae analysis

Three tripolar sEMG electrodes (Kine, Iceland) were placed along the left side of the trunk (figure 2) in order to measure the erector spinae muscles at C7, L3 and S1 vertebral level. The electrodes along the erector spinae were placed according to the procedure previously validated by De Sèze et al (de Sèze et al. 2008). It was asked to the subject to perform five flexion-extension exercises during 15 seconds. Five repetitions were performed in a subject with a normal body mass index (BMI=24,77kg/m2).

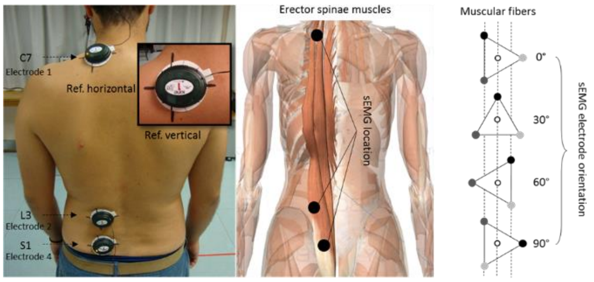

Fig 2- sEMG electrode placement along the erector spinae muscles.

Two different types of displacements were performed according to the ideal positioning. The three electrodes placed along the trunk were clockwise rotated in three different orientations, 30°, 60° and 90° according to the position of reference. Additionally, the three electrodes were horizontally displaced 5cm.

2.3. Data analysis

The exploited raw data were high-passed filtered (30Hz), rectified and low-passed filtered (3Hz) using a fourth order butterworth filter through the use of Awara, a software developed by the Institut de Neurosciences Cognitives et Intégratives d'Aquitaine (INCIA) of the Université de Bordeaux and the Bordeaux Neurocampus (BRAIN).

3. RESULTS

The biceps and erector spinae muscular electrical signal was analyzed according to the translation and rotation effect relatively to the ideal positioning.

3.1. Biceps activity analysis

In this muscle was possible to observe (figure 3). that the electrical signal from the sEMG electrodes placed along the biceps muscle presented different muscular activity levels.

The sEMG electrode 2 was placed on the ideal location according to the manufacture indications and it was considered as the reference electrode. According to that it was possible to observe that at the inferior (sEMG 1) and superior (sEMG 4) extremities the muscular activity increased between 28% and 11% respectively. Additionally, the sEMG electrode 5, registered also higher values when compared with the electrode of reference.

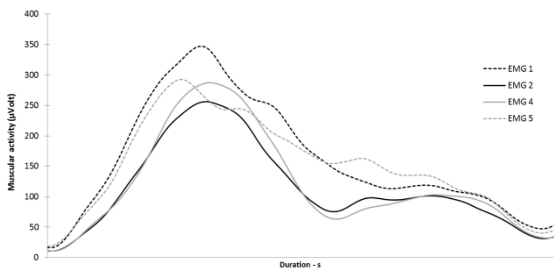

Fig 3 - Muscular electrical signal along the biceps muscle (translation analysis)

Comparing the electrical signal on the biceps when the electrode 2 was rotated (figure 4) it was observed that a 30° rotation slightly influence the results obtained. On the other hand, a rotation of 90° of the electrode 2 permitted to observe that the muscular electrical intensity decreased 57%.

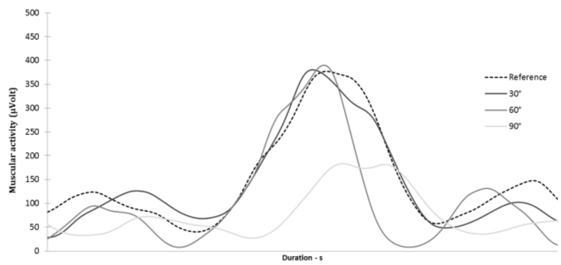

Fig 4 - Muscular electrical signal on the biceps muscles during the rotation of the sEMG electrode 2.

3.2. Erector spinae analysis

The results on the electrode 1 (figure 5) allowed to observe that when a rotation of 30° and 90° was performed the muscular electrical signal decrease 21% and 28% respectively. In contrast, when the electrode was turned 60° the muscular electrical signal increased 15%.

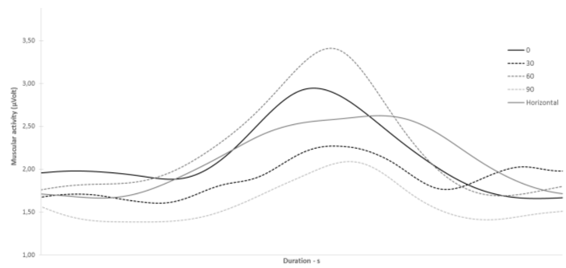

Fig 5 - sEMG electrode 1 muscular electrical signal

Additionally, observing the muscular electrical signal when the electrode 1 was displaced 5cm horizontally it was possible to see that there was a reduction of 10%.

Observing the results concerning to the electrode 2 (figure 6) it was possible to observe that when the electrode was 30° and 60° turned a difference of 53% and 36% was observed. On the other hand, when it was turned 90° it was observed that the muscular electrical signal decreased 25%.

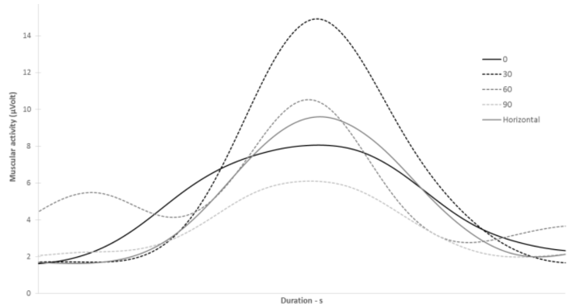

Fig 6 - sEMG electrode 2 muscular electrical signal

Regarding the horizontal displacement it was possible to observe an increase of 20%. At the S1 vertebral level, the sEMG 4 electrode (figure 7) when turned presented lower electrical muscular activity (40%).

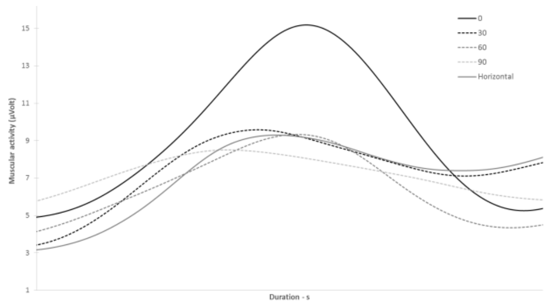

Fig 7- sEMG electrode 4 muscular activity signal

4. DISCUSSION

Despite the factors that may influence the muscular electrical signal obtained through the sEMG electrode, the operators' influence during the positioning of the electrode in the precise location is one of the most critical factors. Davis (Davis 1959) and Zipp (Zipp 1982) suggested specific locations for the placement of the sEMG electrodes which are taken into account by the manufactures, however, according to the muscle intended to be measured and the operators' expertise some errors may arise.

Based on the results, it was possible to observe that depending on the surface size and geometry of the analyzed muscle the electrode placement by the operator could origin erroneous results due to his expertise.

According to that, the muscular electrical signal on the biceps presented a higher sensibility when a rotation was performed. Based on the results it was observed that the lateral displacement changes the maximum intensity of the reference signal between 11% and 28% respectively. Also, it was observed that a rotational displacement between 30° and 60° barely influence the maximum intensity of the muscular electrical signal. However, the rotation of the electrode 60° influenced the duration of the activation time of the muscle.

Additionally, a 90° rotation strongly influence the muscular electrical signal. Thereby, it is possible to state that rotational displacements till 30° in the biceps muscle slightly influence the signal electrical recorded.

This behavior was related with the fact that the muscular fibers considered by the sEMG electrode 2 and 5 were parallel and consequently they work as one, sharing the necessary efforts and consequently originating the same muscular electrical signal. Finally the results observed when the electrode was rotated 90° showed higher difference if compared with the reference position. In this case one observed that the ground terminal was not in a stable contact with the skin and consequently the reason of the lower muscular electrical signal observed.

Comparatively, the erector spinae as a thinner and deeper muscle presented different results. Comparatively to the biceps muscle, the erector spinae was analyzed in three distinguished regions (C7, L3 and S1 vertebral levels). At the C7 level (sEMG 1) it was possible to observe that the horizontal displacement creates a smaller influence on the muscular electrical signal than the rotation.

At L3 level (sEMG 2) it was observed that a rotation between 30° and 60° creates a greater influence than when it was turned 90° or horizontally displaced.

Finally at S1 level (sEMG 4) it was observed that the electrode's displacement horizontally or in rotation creates a significant influence on the muscular electrical signal registered.

The muscular electrical signal in the different levels of the erector spinae is related with the geometry of the muscle which is thinner on the top (C7 level) and on the bottom (S1 level). Also, using a tripolar sEMG electrode when a turn of 90° was performed it was possible that two of the electrode terminals still aligned along the erector spinae muscle, even if the muscular fiber change. Additionally, the horizontal displacement of 5cm permitted to maintain the sEMG electrode on the same muscle when a C7 and L3 level was considered.

5. CONCLUSION

This study allowed to evaluate the influence of the positioning of the electromyography electrode during muscu-lar activity in two different geometrical muscles.

One observed that the manipulation and placement of the electrode along the muscular fibers by the operators may influence the results obtained.

According to the results it was possible to conclude that in a muscle as biceps the operator should take into account the translational displacement of the sEMG electrode. However, when the erector spinae is taken into account the rotational displacements may create an erroneous results. According to this, one may state that in this muscle a maximum rotational displacement below 30° was acceptable.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the funding of ANRT and the support of Lagarrigue S.A. Pessac

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