ASSESSMENT OF SPATIAL DISTRIBUTION OF ERECTOR SPINAE MUSCLE ACTIVATION DURING INDOOR ROWING: A SINGLE CASE STUDY

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SUMMARY

Coordinated activation of back muscles seems crucial for the boat stabilisation and the prevention of low back pain in rowers. From a single, inexperienced rower we report the feasibility of using large arrays of surface electrodes to characterise the spatial activation of erector spinae muscles during indoor rowing. Our array of electrodes revealed marked spatio-temporal differences in activation both within and between back muscles. The electrode configuration herein proposed, therefore, seems crucial for the assessment of back muscles activity during rowing.

INTRODUCTION

Coordinated activation of back and hip muscles is crucial for effective rowing. Disproportionate activation of the erector spinae muscles has been argued, for example, as a key potential cause of back pain in rowers [1]. On one hand, asymmetrical activation of erector spinae might lead to inappropriate loading of back muscles and ligaments. On the other hand, differential activation of these muscles in the left and right body sides might assist rowers in ensuring boat stability, in particular during the recovery phase. In an attempt to understand the contribution of back muscles to boat stabilisation and speed, it seems relevant to study the spatial distribution of activation within and between back muscles during indoor rowing. Here, we report the feasibility of using large arrays of surface electrodes to characterise the activation of erector spinae muscles during exercises on an indoor rowing machine. With this pilot report, we aim to set the grounds for studying the bilateral activation of back muscles in professional, elite rowers.

METHODS

A single male subject participated in this feasibility study (24 years old; 83 kg; 180 cm), who provided written informed consent prior to participation. This participant had no previous experience in indoor rowing and did not report any musculo-skeletal impairment. After extensive familiarisation with the rowing gesture, under supervision of an experienced rowing instructor, the subject performed 3 min of indoor rowing (SkiffPlus Carnielli, Italy) at a rate of 18 strokes/min.

Surface electromyograms (sEMG) were recorded with four arrays of 16 silver bar electrodes (10 mm interelectrode distance). Two arrays were positioned on the left and two on the right (Figure 1 A-C). The most medial array on each side was located 3 cm laterally to the vertebral spinous process and roughly spanned skin regions from L5 to T10. The lateral arrays were positioned alongside the medial arrays (Figure 1 A-C). Such arrays of electrodes and their positioning were sought to ensure low sensitivity of sEMG to variations in the relative muscle-electrode position [2].

Three inertial sensors (MTx, XSens, Netherlands) were used to quantify the changes in trunk and oar position in relation to the rowing cycle. Specifically, one XSens sensor was tightly fixed to the left oar brace of the rowing machine, the second was attached on the left thigh, whereas the last was positioned at the level of the L3 vertebra (Figure 1 B), where the opposing rotations of the thorax and pelvis are most effectively neutralised [3]. Oar and trunk angles were calibrated in correspondence of the end/start of the drive/recovery phase (where 0 deg means trunk at slight hyperextension).
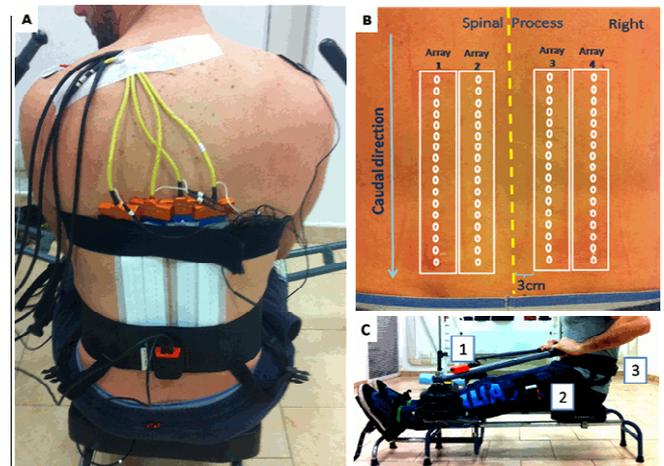

Figure 1: Experimental setup showing: (A) the positioning of electrode arrays on the back;. (C) locations where inertial sensors were positioned (1 – oar; 2 – thigh; 3 – trunk). Specific locations of each array is illustrated in (B).

Single differential sEMG were amplified by 2000 and sampled at 2048 Hz using a 12 bit A/D converter (EMG-USB Amplifier, LISiN and OTBioelettronica, Turin, Italy). Data were sampled from the inertial sensors at 100 Hz. A common trigger signal was issued and recorded by both instruments to allow synchronisation of sEMG and kinematics.

Activation of erector spinae muscles was analysed in terms of the envelope of sEMG amplitude. After rectification, sEMG were low pass filtered at 4 Hz with a 2nd order, zero-lag Butterworth filter. Descriptive analysis of envelopes and trunk position in relation to the rowing cycle was considered to test for the potentialities of arrays of electrodes in sampling back muscles activity during the dynamic, rowing task. We were specifically interested in checking for occurrences of changes in the spatial distribution of sEMG amplitude during the rowing cycle.

RESULTS AND DISCUSSION

During the 3 min of rowing, the participant performed a total of 55 strokes (~18 strokes/min). Differently from elite rowers [4], our participant spent approximately equal amounts of time in both the recovery (48%) and drive (52%) phases. As typically observed for inexperienced rowers, his trunk extension commenced before the catch (i.e., when blades are dropped in water) and ended prematurely (i.e., flexed before the drive ending; Figure 2a). Notwithstanding these technical issues, changes in oar and trunk angles were marked consistently across cycles (coefficient of variation smaller than 10%).

The array of electrodes revealed marked spatial differences in muscle activation. Bursts of activation were crucially observed twice within the rowing cycles. The first burst appeared predominantly immediately before the catch and consistently with the earlier trunk extension discussed above (see 30-50% of rowing cycle in Figure 2A-B). The second burst appeared in correspondence of the beginning of the drive phase and ended abruptly (Figure 2B). Such temporal profile of activation is consistent with previous findings on untrained subjects [5]. The local representation of activity within and between arrays is of marked interest (Figure 2B). Lateral differences in sEMG amplitude suggest stronger activation of erector spinae in the right side. On the contrary, differences between rostral and caudal sEMG could be due to different muscle activation during the rowing cycle (i.e. more caudal in 40-60% and more rostral in 70-90%). Finally, arrays in the same trunk side sampled from different muscles/motor units. Although not reported in Figure 2, the spatial distribution of sEMG amplitude appreciated in arrays 1 and 4 did not correspond to those observed in arrays 2 and 3, respectively.

CONCLUSIONS

The electrode configuration herein proposed detected spatial changes of activation within and between erector spinae muscles located at both sides of the spine. Such a protocol is currently being applied to a sample of elite Italian rowers, at Olympic and international levels.
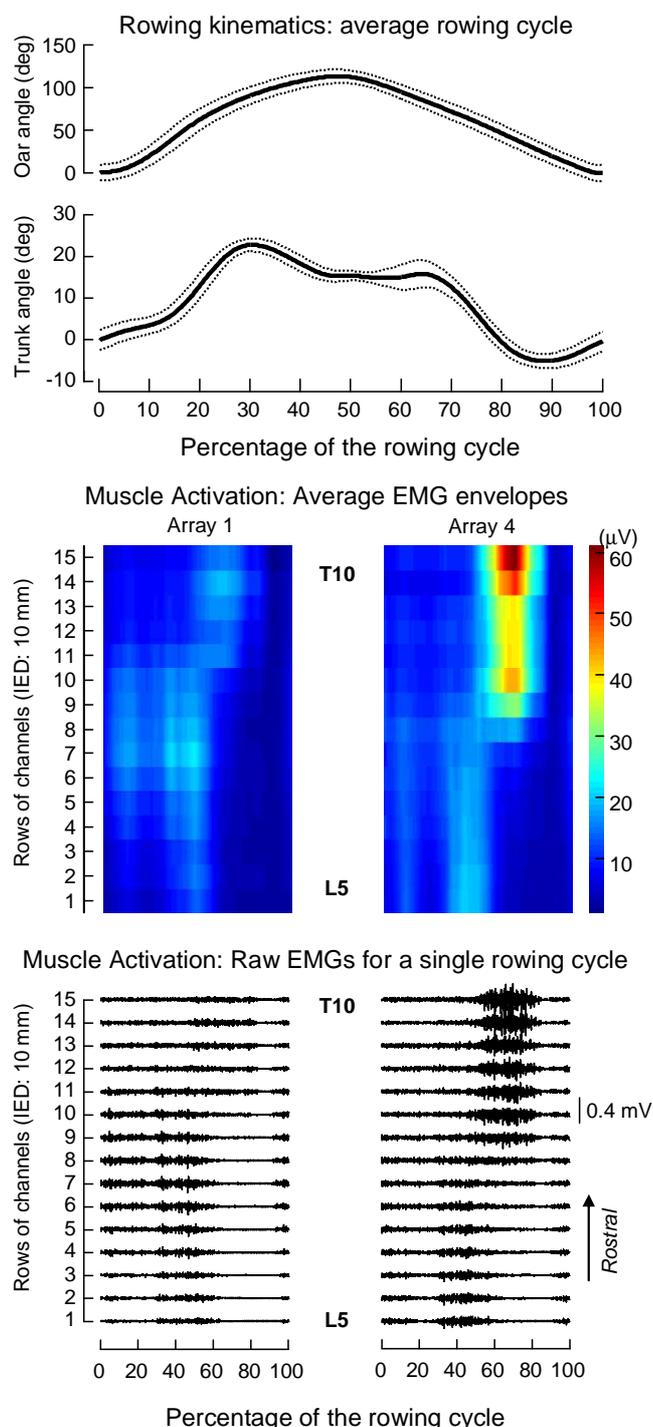
ACKNOWLEDGEMENTS

Figure 2: Profiles of oar and trunk angles (A) and of sEMG envelopes obtained from the lateral arrays 1 and 4 (B), averaged across the 55 rowing cycles. (C) Raw sEMG obtained for a single rowing cycle are shown.

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