EMG evaluation of reproducibility of upper body motion of cross country ski on a custom-built ergometer

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INTRODUCTION
Evaluation and training of upper body power in cross country ski is usually performed by means of a traditional strength training apparatus. The movements performed on this equipment are however quite different from the specific motion. In order to reach a better reproducibility of the ski gesture, a new upper body ergometer has been built. The new apparatus is constituted by a system of cables, pulleys and an electric motor that act as load and is actively controlled by a personal computer on the basis of force and velocity sensors. This equipment would avoid some of the main limitation of the traditional strength training apparatus as the muscular activation during the recovery cycle. The aim of this study is to assess by means of electromyographic evaluations the similarity between cross country ski and ergometer upper body movements.

METHODS
Six male cross country skiers competing at international level participated to the study. Experimental field and laboratory data were collected in a single session in Pragelato (TO, Italy). Surface EMG of Biceps brachii, Triceps brachii and Deltoid muscles were recorded by means of a portable system. For the ski test two different parts of the Olympic sprint track (total length 1.2 Km) were considered: part A: 120 m, slightly uphill, +5% slope, part B: the final 180 m of the track, almost flat, +1.4% slope. In the ergometer test the athletes were requested to perform a 50 second poling exercise. The ergometer load was set at the value at which the athletes exert the maximal power. The athletes were asked to do their maximal performance in all tests.

EMG data were rectified and smoothed and poling cycles were identified from the onset of triceps activation. Cycles length (T), maximum EMG (EMGmax) and integral EMG (EMGint) values were calculated from each cycles for the quantification of the activation. For this parameters, the ratio between ski and ergometer tests has been then calculated in order to compare EMG level. Ensemble average were also calculated on at least 20 poling cycles and graphicated to allow comparison between ski and ergometer muscular activation pattern.

RESULTS
Athletes reported that they feel the movement performed at the ergometer quite similar to ski action. Mean cycle was significant larger for ergometer than for both ski action (T(ergometer) = 1284±171 ms, T(ski_A) = 1021±141 ms, p<0.05 T(ski_B) = 856±81 ms, p<0.05).

For poling exercise higher muscular activity has been found in triceps and especially deltoid muscle respect to ski action for both track parts. Similar activation level has been found for biceps brachii. EMG ensemble average showed quite similar pattern of activation between the two actions. A difference can be observed for deltoid muscle, where the rise of activation after the onset is faster for ergometer.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Ratio (ski)/Ratio (ergometer)</th>
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</thead>
<tbody>
<tr>
<td>Bic brachii</td>
<td>0.55±0.33</td>
</tr>
<tr>
<td>Tric brachii</td>
<td>0.86±0.20</td>
</tr>
<tr>
<td>Deltoid</td>
<td>0.59±0.34*</td>
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</tbody>
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Table 1. Ratios between ski and ergometer values (* = p<0.05 ski vs. ergometer, t-test for paired data).

DISCUSSION AND CONCLUSIONS
Levels and patterns of EMG activation for upper body muscles show a fairly good agreement between ski and ergometer action. As the poling cycle at ergometer resulted longer than both flat and slightly uphill ski track a greater similarity between lab and specific ski action would be reached by shortening ergometer cycle. Greater activation of deltoid muscles in ergometer action could be caused by a different direction of force application. A kinematical analysis should further investigate this hypothesis and a change of the geometrical structure of the ergometer could be considered. Deltoid EMG pattern suggest that an improvement in reproducibility of sprint track action would be gained modifying the ergometer motor control parameters in order to reduce the load at the beginning of the poling action to better reproduce the rise of deltoid activation.

REFERENCES
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