Physiological responses to a simulated synchronized swimming routine in young and adult national level athletes

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Introduction
A synchronized swimming routine is a programme composed of a variety of exercises lasting in total from 2 to 5 minutes. During that time, the athletes must perform complicated and demanding combinations of movements, while holding their breath for varying lengths of time. Since the routine is performed mainly underwater (Homma 1994), many problems arise regarding the determination of the physiological demands of the sport (Yamamura et al 2000). Furthermore, little is known concerning the possible differences in physiological demands between athletes of different ages (Poole et al 1980). Thus, the purpose of the present study was to examine the physiological responses of synchronized swimmers of different ages, during the execution of a routine.

Methods
Fourteen national level female synchronized swimmers took part in the study [6 competing at the category of women and the other 8 competing at the comen (13-15 y old) category]. All the athletes performed the same routine of 2.96 (0.34) min duration, which consisted of standard elements (four competitive figures separated by the eggbeater movement). Every trial was videotaped and marked by experienced judges. Immediately after the end of the routine [delay: 7.5 (0.9) s], a mask was placed on the athletes mouth and nose and respiratory gases were measured breath-by-breath for 3 min. Oxygen uptake at the end of the routine was estimated by using a linear backward extrapolation technique on the breath-by-breath data [r²: 0.92 (0.02)]. Heart rate (HR) was monitored by telemetry and blood lactate (BLa) concentration was measured at rest and on the 3rd min of recovery. Maximal oxygen uptake (VO2max) was determined using an incremental 400 m test by the same method, and anthropometric characteristics were also determined on a separate occasion. A two-way ANOVA with repeated measures on one factor (test) was used for statistical analysis.

Results
No difference was found at the VO2 measured at the end of the routine or the VO2max between the young and adult athletes (Fig. 1). VO2 at the end of the routine corresponded to 86 (3)% and 82 (3)% of VO2max for young and adult swimmers respectively. Blood lactate was higher in women compared to the young athletes after both the routine [5.8 (0.7) vs 4.5 (0.4) mmol/l] and the VO2max test [10.6 (0.8) vs 6.8 (0.8) mmol/l]. The amplitude A and the time constant \( \tau \) were not different between young and adult athletes, but they were both higher after the routine as compared with the VO2max test (Table 1). Women athletes got better scores at the routine (78.2 vs 70.5, p < 0.05) than the athletes of comen category, but no correlation was found between scores and VO2max.

![Figure 1: Estimates of oxygen uptake at the end of the VO2max and the Routine test in young and adult athletes.](image)

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Height (m)</th>
<th>Body mass (Kg)</th>
<th>Body Fat (%)</th>
<th>BMI (Kg/m²)</th>
<th>Body Fat (%)</th>
<th>( \tau ) Routine (s)</th>
<th>( \tau ) VO2max (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young (n=8)</td>
<td>13.8 (0.2)</td>
<td>1.60 (0.1)</td>
<td>44.8 (0.2)</td>
<td>15.3 (0.8)</td>
<td>17.4 (0.5)</td>
<td>15.3 (0.8)</td>
<td>55.1 (8.6)</td>
</tr>
<tr>
<td>Adult (n=6)</td>
<td>21.2 (2.5)</td>
<td>1.66 (0.1)**</td>
<td>55.8 (0.2)**</td>
<td>15.3 (1.7)**</td>
<td>20.2 (0.5)*</td>
<td>15.3 (1.7)**</td>
<td>65.5 (9.4)</td>
</tr>
</tbody>
</table>

Table 1: Subjects characteristics and VO2 recovery curve time constant (\( \tau \)). Values are mean (SE). **: P<0.001 and *: P<0.01 from Young; †: P<0.05 from the corresponding Routine value.

Discussion/Conclusion
The main finding of the study was that at the end of a 3-min simulated synchronized swimming routine VO2 was high (82-85% VO2max) but not different between young and adult athletes. Furthermore, the combination of strenuous movements and hypoxic conditions during the routine may explain the slower VO2 kinetics compared with the VO2max test. The slower VO2 kinetics may be explained by the increased breathing frequency observed during the second half of the 3 min recovery following the routine.

References