Kinematic and electromyographic analysis of elite wheelchair racers during an exercise that simulated the 800 meter race

Levêque Jean-Michel¹, Quievre Jacques¹, Couturier Antoine¹, Gerges Patrice² and Miller Christian¹.

¹ : Physiology and biomechanics Laboratory, INSEP, Paris, France
² : Handisport French Federation, Paris, France

Introduction

Performance level in wheelchair track events has increased steadily in the last few decades. In order to optimise training programmes and techniques recommendations, coaches need to have information about the performance limiting factors and characteristics of wheelchair propulsion. Previous studies have focused on the underlying mechanisms of wheelchair propulsion for experienced wheelchair users (1). A combined kinematic / electromyographic approach allowed to analyse the movement and muscular activity pattern in wheelchair propulsion. However, none of these have investigated the movement pattern modifications during a specific race effort generating fatigue. The purpose of this study was to investigate the propulsion techniques of elite wheelchair racers during a 1min 30s “all out” exercise (800m duration).

Methods

Seven athletes of the French national team (VO₂peak: 3.67 ±0.51 l.min⁻¹, Maximal aerobic speed: 29 ±3 km.h⁻¹) performed 3 laboratory-based exercises: 1) a bench press exercise to determine the force-velocity relationship from an isokinetic device, 2) a continuous incremental test for the determination of VO₂peak and 3) a 1min 30s “all out” test (Perf.T). Wheelchair exercises were performed on an ergometer adapted for wheelchair racing designs. It allowed measurement of torque and velocity on each wheels (100 Hz). During the “Perf.T” exercise, two S-VHS camcorders (50 Hz) were used to obtain 3-D kinematic parameters. Muscular activity during wheelchair propulsion has been registered (1000 Hz) by surface electromyography (EMG) for six right muscles (Biceps Brachii, Deltoïdeus Anterior, Deltoïdeus Posterior, Pectoralis Major, Trapezius and Triceps Brachii). For each specific phase, 3 stroke cycles of EMG and the corresponding video recordings were analyzed. RMS normalized to the maximal voluntary contractions was used to analyze EMG activities for all muscles (nEMG). To appreciate neuromuscular fatigue between MS (approximately 30th s) and the end of exercise, we considered the evolution of the nEMG/P ratio where P is the peak power registered for each stroke cycle (2).

Results

For “perfT”, we determine specific phases : Acceleration (Acc), Maximal speed (MS), speed decrease (Dec). A positive linear relationship has been found between distance covered in 1min 30s (731 ± 65 m) and Maximal aerobic speed (r = 0.95 , P < 0.05) or Power peak (Pmax) obtained in the bench press exercise (r = 0.82 , P < 0.05). Maximal speed (9.6 m.s⁻¹) is strongly correlated (r = 0.82 ; P < 0.05) to Pmax.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acc</th>
<th>MS</th>
<th>Dec</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (Stroke.min⁻¹)</td>
<td>112 ± 9</td>
<td>113 ± 6</td>
<td>105 ± 4 a,b</td>
<td>102 ± 4 a,b</td>
</tr>
<tr>
<td>Push time (Tp) (ms)</td>
<td>203 ± 15</td>
<td>140 ± 8 a</td>
<td>139 ± 19 a</td>
<td>147 ± 16 a</td>
</tr>
<tr>
<td>Stroke time (Ts) (ms)</td>
<td>539 ± 43</td>
<td>533 ± 33</td>
<td>573 ± 23 a,b</td>
<td>590 ± 26 a,b</td>
</tr>
<tr>
<td>Wrist Amplt. Z (cm)</td>
<td>58,7 ± 11,1</td>
<td>73,3 ± 12,0 a</td>
<td>60,6 ± 9,5 b</td>
<td>52,6 ± 9,8 b,c</td>
</tr>
<tr>
<td>Wrist Vzasc (m.s⁻¹)</td>
<td>3,16 ± 0,60</td>
<td>3,61 ± 0,69 a</td>
<td>2,82 ± 0,57 a</td>
<td>2,31 ± 0,59 a,b,c</td>
</tr>
<tr>
<td>Wrist Vzdesc (m.s⁻¹)</td>
<td>-3,68 ± 0,60</td>
<td>-4,81 ± 0,64 a</td>
<td>-3,76 ± 0,46 b</td>
<td>-3,36 ± 0,31 b,c</td>
</tr>
</tbody>
</table>

Table 1 : Evolution of temporal and kinematic parameters (wrist joint).

Ampl.Z, Vzasc and Vzdesc correspond to the amplitude, ascending and descending velocities on vertical axe.

a, b, c : significant differences with the parameter obtain during Acc, MS and End phases respectively.

With the speed decrease between MS and the end of exercise (9.6 ± 0.8 to 7.4 ± 0.7 m.s⁻¹), our results highlight a slowly decrease in frequency, an increase in stroke time in spite of modifications in the push time (Table 1). The increase in ascending recovery time (300 ± 20 to 350 ± 30 ms) contributed to the increase in recovery time without modification of the descending recovery time (240 ± 20 ms). The analyse of joint trajectories (Wrist and Elbow) indicates significative reductions of amplitude, ascending and descending velocities with the speed decrease (Table 1). Simultaneously, there is a significative increase of the nEMG/P ratio only for the Deltoïdeus Posterior and Trapezius muscles.

Discussion/Conclusion

The findings of this study suggest that the speed decrease might be partly related to a lower arms elevation during the recovery time of the stroke cycle and a corresponding neuromuscular fatigue in shoulder extensor muscles. Therefore, increase endurance of these muscles through training may lead to an enhancement of performance. In addition, an increase of the maximal power for the shoulder flexor and arm extensor muscles is necessary to obtain an important speed.

Références