

Ergonomic optimization as a basis of performance enhancement in cerebral palsy athletes

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Introduction

This paper intends to clarify the importance of optimizing the man-machine interface in order to enhance performance in cerebral palsy (CP) athletes. Petra RaceRunning (PRR) – as an alternative for wheelchair driving, hand biking, or tri-cycling for persons with more severe CP - is used as an example in this paper. Rather than using a pedalling system, the users sit on the saddle and propel themselves forward by contact of their feet on the ground. The purpose of this research project is to investigate how persons with CP respond to the activity of PRR. More specifically; what is the physiological response of trained persons with CP to sustained PRR over 12 minutes? What is the effect of fatigue on the movement patterns used in Petra-running?

Methods

Eight persons with CP (table 1), familiar with PRR during training and competition, participated with their own Petra-bike in a 12 min Cooper test on a track. The personal coach was present during the testing session to assist in appropriately adjusting the Petra-bike to the functional potential of the athlete (saddle height, position of chest support). A Polar Heart Rate Monitor was worn by participants during their exercise test (Polar Heart Rate Monitors, Finland). Blood lactate samples were taken immediately before starting the test, after 4 minutes, after 8 minutes, and at the end of the test, using a LactatePro testing kit (Samcon, Belgium). Two-D kinematic analysis (stride frequency, step length, symmetry of propulsion) was performed using a video Hi8 camera (50Hz) perpendicular to the direction of propulsion.

Results

Performance, expressed as distance covered in 12 min, ranged from 206 m to 1867 m (table 1). Minimal variation in relative pace over the 12 min course was demonstrated. Maximum heart rates recorded ranged from 171 to 203 beats per minute, representing 96.5% of the maximal HR predicted by age. Blood lactate concentration evolved curvilinear from 0.78 mmol/l in rest, to 2.82, 4.06, 5.4 mmol/l after 4, 8 and 12 min respectively. No changes in stride-cycle frequency or symmetry of movement were demonstrated.

| Participant | Descriptor | CP-ISRA Class | Age (years) | Gender | Performance (m) | HRmax (beats/min) | Lmax (mmol/l) |
|-------------|------------------|---------------|-------------|--------|-----------------|-------------------|---------------|
| A | Spastic Quad. | CP1 | 14 | Female | 797 | 200 | 2,8 |
| B | Spastic Quad. | CP1 | 14 | Female | 463 | 203 | 1,9 |
| C | Spastic Quad. | CP2 | 16 | Male | 206 | 180 | 2,8 |
| D | Athetoid Quad. | CP2 | 33 | Male | 1867 | 204 | 10,5 |
| E | Spastic Quad. | CP2 | 17 | Male | 324 | 190 | 5,1 |
| F | Spastic Diplegia | CP4 | 19 | Female | 620 | 171 | 1,9 |
| G | Spastic Diplegia | CP5 | 29 | Female | 1130 | 175 | 8,6 |
| H | Dystonic Quad. | CP6 | 34 | Female | 1266 | 203 | 9,9 |
| AVERAGE | | | 22,0 | | 834,1 | 190,8 | 5,4 |
| SD | | | 8,6 | | 558,1 | 13,7 | 3,7 |

Table 1: Characteristics of the participants and results (CP-ISRA = Cerebral Palsy International Sports and Recreation Association classification system; Lmax = Maximal lactate; Quad. = Quadriplegia).

Discussion/Conclusion

In most of the participants with more severe CP, the economy of movement in PRR is rather low. Minimal performance elicited maximal metabolic responses, however, without any repercussions on the timing parameters of the movement pattern. However, movement analysis was limited to the lower extremities. At the end of the 12 min stage, fatigue might induce important changes in postural control and quality of movement of the head, trunk, and upper extremities. A qualitative movement analysis, performed by clinicians with extensive experience in working with persons with CP in a therapeutic environment, is worth considering. Finally, the (dis-)advantages of PRR over tri-cycling, where the legs are generating force in a closed chain, should be discussed. Especially the ergonomic advantage of a tri-cycle in using different gears facing different environmental conditions should not be underestimated.