Biomechanics of all-out handcycling exercise
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Introduction

Handcycling is a Paralympic endurance sport for people with a spinal cord injury (SCI) or amputation of the lower extremities. The athletes make use of a three wheeled vehicle - called handcycle - that is propelled with synchronous cranks driven by their upper extremities. At the London Paralympic Games in 2012, the most commonly injured regions appear to be the shoulder (17.7%), wrist/hand (11.4%) and elbow (8.8%) [1]. To improve performance and reduce the risk for overuse injuries in handcycling, a profound understanding of the movement and muscular coordination is needed. Biomechanical knowledge of the kinematics, kinetics and muscular activity underlying handcycling propulsion is primarily based on single case studies and rather moderate intensities [2, 3]. Hence, the aim of this study was to assess the biomechanics of all-out handcycling exercise in several participants.

Methods

Twelve able-bodied competitive triathletes performed a 15-s all-out sprint test in a recumbent racing handcycle that was attached to an ergometer. During the sprint test, tangential crank kinematics and 3D joint kinematics were analysed using motion capturing (Vicon Nexus 2.3, Vicon Motion Systems Ltd., Oxford, UK) according to previous research [4]. The joint angles of shoulder flexion (SB), shoulder abduction (SA), shoulder rotation (SR), elbow flexion (EF), palm flexion (PF), radial abduction (RD) and trunk flexion (TF) were considered.

Muscular activity of ten muscles (M. trapézius, Pars descendens (TD); M. pectoralis major, Pars sternalis (PM); M. deltoideus, Pars clavicularis (DA); M. deltoideus, Pars spinalis (DP); M. biceps brachii, Caput breve (BB); M. triceps brachii, Caput laterale (TB); M. flexor carpi radialis (FC); M. extensor carpi ulnaris (EC); M. latissimus dorsi (LD) and M. rectus abdominis (RA)) was measured unilaterally on the dominant (right) side of the participants using surface electromyography (sEMG) (DTSEMG Sensor®, 1000 Hz, Noraxon Scottsdale, Arizona, USA). Muscular activity was expressed as a percentage of maximal voluntary isometric contraction (MVIC) attained in four fixed crank positions (0°, 90°, 180° and 270°). Parameters were compared between revolution one (R1), revolution two (R2), the average of revolution three to thirteen (R3) and the average of the remaining revolutions (R4) using a one-way analysis of variance (ANOVA) and post-hoc comparisons using Bonferroni’s correction.

Conclusions

The results of this study indicate that all-out handcycling exercise comes along with a high load of the shoulder region. Due to the fact that the shoulder provides the most degrees of freedom at the expense of reduced stability [6] and wheelchair athletes hardly rely on the functionality of their upper extremities in daily living and exercise, there seems to be a high risk for overuse injuries in the shoulder and wrist. Since muscular activity was primarily altered in the muscles that are associated with the push phase of handcycling propulsion (DA, PM and TB), force generation during this phase could be a limiting factor for all-out exercise performance.

Strength exercises that lead to an adaptation of this complex (e.g. bench press) might be a useful addition in the training of elite athletes. However, additional load should be applied with caution and preceded by exercises that increase the stability of the shoulder and focus on the muscles surrounding the scapula (rotator cuff) [6].

References