Analysis of wheelchair sprint biomechanics on two elite athletes on an instrumented drum ergometer

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Introduction. Wheelchair athletics requires the maximization of pushing technique throughout the full length of the race, with particular attention to the transition from start to full speed. The use of dynamometric handrims, introduced for complete propulsion analysis has only recently made available with lightweight portable solutions for athletics [1]. Drum ergometers have also showed to be effective for the study several disciplines in the analysis of propulsion techniques [2]. The use of force plates under the wheels only accounts for the first start push; the use of IMU can instead follow the action along the full race in both simulated or track measurements [3]. In the present work, the combination of a validated drum ergometer, IMU sensors and EMG analysis was adopted to study and compare the sprint biomechanics of two elite athletes on a simulated 100m sprint.
Methods. A drum ergometer [2] was adapted to host the athletics wheelchairs restrained at the front wheels. Inertial disks were applied to the drums to match the equivalent linear inertia of each subject (Figure 1.a). A set of Inertial sensors was placed on the hands and wheels of the athletes. Eight EMG sensors were placed on *trapezius descendens (TD)* right, *deltoideus anterior (DA)* right, *latissimus dorsi (LD)* right, *pectoralis major (PM)* right, *biceps brachii (BB)* left & right and *triceps brachii (TB)* left & right. IMU and EMG were captured with a MuscleLab system from Ergomotion. Two elite wheelchair athletes of Italian National Team, D.G. (T 53, 77kg, 100m P.B. 15.92s) and G.S. (T54, 56kg, 100m P.B. 14.93s) volunteered for the study and performed 5 repetitions of a simulated 100m sprint. As previous researchers, two events related to hand-to-rim contact were evaluated using hand acceleration profiles: *Hand contact (HC)* and *Hand Release (HR)*. As a result, the *Push Phase (PP)*, and the *Recovery Phase (RP)*, were calculated, together with the *Total Push Angle (TPA).* Similarly to other experiences [4], athletes were asked to perform static maximal voluntary pushes against the blocked drum resistance at three hand positions on the rim: HC, HR and an intermediate position. Isometric tangential push forces at the rim were calculated from the peak torque recorded at the drum and normalized to body weight BW as in Figure 1.b. EMG moving 50 ms window RMS signals were normalized to the trial maximum value: a threshold of 20% was chosen to consider the muscle activation pattern in a polar graph as in Figure 1.c.

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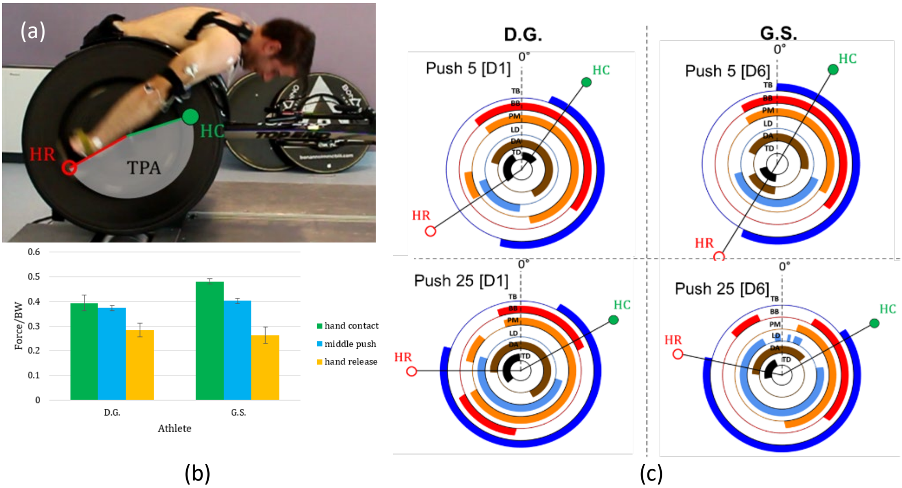

Fig. 1: (a) drum inertial bench, with indication of push cycle contact; (b) comparison of isometric strength; (c) muscle activation patterns of two athletes at 5th and 25th push.

Results. Simulated best sprint time on the drum ergometer resulted 15.25s for D.G. and 14.72s for G.S., very close to their personal best, thus confirming the validity of the equivalent intertial drum ergometer. Highest isometric forces were obtained at the HC position as shown in Figure 1.b. EMG results presented in Figure 1.c showed how the two athletes adopted different pushing techniques at 5th and 25th push. Both athletes shift forward the HC and HR position at higher speed and widen their TPA, but G.S. TPA increase is more evident. Clock polar diagram allow to capture the differences in muscle coordination among athletes and the change of activation from slow to high speed.

Discussion. The use of wireless sensors for IMU and EMG analysis allows for the extension of the method to track tests, in combination with the collection of loads from instrumented handrims that are under development.

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