SKI SKATING 3-D KINEMATICS IN ELITE CROSS-COUNTRY SKIERS AT A WORLD CUP RACE IN S.CATERINA IN 2000

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In competitive cross-country skiing (CCS) the athletes’ performances are frequently close to each other and are influenced by the complexity of the environment conditions (air and snow temperature, track, techniques, gradients, etc.). This implies that the experimental quantitative description of the CCS technique as a way to improve athletes’ performance is a notable challenge. Nevertheless, during the past 15 years the new skating technique has reached a great popularity and has received attention by biomechanical research. This has led to several studies describing the CCS skating technique, but the kinematic analysis of world best athletes during high-level competitions deserves further attention in order to better understand the factors influencing the performance. The reliable kinematics analysis of different CCS techniques aiming, for example, to the quantification of the related mechanical work, requires repeated 3D motion capture sessions in challenging environmental conditions, counting on a long working volume, because of the extended stride length (Minetti, 2000). This implies not negligible methodological issues especially when aiming to the evaluation of the kinematics associated to the two main ski skating techniques, V1 and V2, on elite CC skiers during high-level race.

The collection of data presented in this work was performed on 8.12.2000 during the men’s 15 km freestyle CC competition during the World Cup in S.Caterina (I). Two couples of digital camcorders (SONY 50 Hz) were located on two sections of the 7.5 km race track (2 laps): an uphill (6°), 20 meters long section at the 3 km mark and a flat 40 meters long section at the 6,5 km mark. Due to the technical requirement of a wide working volume, dedicated software for video analysis, with free panning, tilting and zooming TV cameras was used (Baroni et al., 1998). Calibration was performed by means DLT method. The 3-D positions of the control points for system calibration were measured by means of a geodetic theodolite and were marked out with 50 high rigid poles. The biomechanical model of the skier consisted of 17 body landmarks among which 4 points were used for the poles and for the skis identification. Joint angles were calculated as the absolute angles between different anatomical landmarks; the displacements of the body’s centre of mass (CG) were quantified on the average plane of track (horizontal plane) and on the orthogonal direction to this plane (vertical direction).

Ten skiers, including the 5 best in the ranking list, were considered in this work. Fig. 1 shows a typical stick diagram, the CG vertical displacement and the contact and flight phases of poles and skis in V1 skating technique in correspondence of the uphill section. According with previous works (Smith, 1990; Viitasalo, 1993), the mean values of the cycle time and cycle length were about 1,35 s and 5 m respectively. The mean CG velocity was about 3,7 m/s with a velocity vector inclination with respect to the horizontal of 10° and a vertical displacement of about 15-20 cm. The kinematic patterns of elbows and poles angles were found to be quite similar to literature data. Fig. 2 shows a typical stick diagram on the horizontal plane as well as the contact and flight phases of poles and feet, the CG velocity components and velocity vector angle related to the V2 skating on flat terrain. This faster technique (we found typical average CG velocity of about 6 m/s or more) has received less attention in research, but nowadays almost every skier use the V2 technique on flat terrain and moderate slope. The kinematics of additional biomechanical parameters is also discussed with reference to the potential significance for the optimisation of the overall movement performance.

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