Kinematics of Anterior Cruciate Ligament Injury Incidents in World Cup Alpine Skiing

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I. INTRODUCTION

Based on visual video analyses of 20 injury situations we have identified the main mechanism of anterior cruciate ligament (ACL) injury in World Cup (WC) alpine skiing, termed the "slip-catch" mechanism [1]. This situation is characterized by a common pattern where the inside edge of the outer ski catches the snow surface while turning, forcing the knee into valgus and tibia internal rotation. To describe the exact joint kinematics at the time of injury, a more sophisticated approach is needed. The aim of the present study is to describe the knee and hip kinematics in two slip-catch situations utilizing a model-based image-matching (MBIM) technique [2].

II. METHODS

Two typical slip-catch situations in WC alpine skiing reported through the FIS Injury Surveillance System were captured on video with high definition cameras from more than one angle of view. In case 1, a male alpine skier suffered an ACL tear of the right knee in a slalom WC race in Alta Badia, Italy 2007. Prior to the injury situation, the racer was late in line after a change of rhythm in the set course. He skied too directly into the entrance of a hairpin while leaning backwards and tried to manage the next gate with an inner ski turn [3]. In case 2, a female alpine skier suffered an ACL tear of her left knee in a parallel slalom WC race in Schladming Austria 2012. Prior to the injury situation, the racer was late on the ideal line, thus she had a more direct approach into the next gate in a right hand turn. In the steering phase out of the fall line, she was leaning backwards and inwards, losing pressure on the outer ski.

The injury situations were analyzed using the MBIM technique to produce continuous measurements of knee and hip joint kinematics. The matching process was performed using the commercially available program Poser 4 and the Poser Pro Pack (Curious Labs Inc, Santa Cruz, California, USA). A model of the surroundings was built and manually matched to the background video picture for each frame in all camera views. A skeleton computer model from Zygote Media Group Inc (Provo, Utah, USA) was used for the skier matching.

III. INITIAL FINDINGS

We observed sudden changes in knee and hip joint angles, in both cases, when the inside edge of the outer ski caught the snow surface. Within 60 ms, the knee flexion angle increased rapidly from 26° to 63° in Case 1 and 39° to 69° in Case 2. In the same period, we observed a rapid increase in internal rotation of the tibia with a peak of 12° and 9°, respectively. The knee valgus angle changed less markedly in both cases. We also observed a rapid increase of hip flexion, as well as substantial hip internal rotation.

IV. DISCUSSION

The leg was abruptly and forcefully compressed from a relatively straight position in both cases. This motion pattern indicates that there is likely a high knee joint compression force involved. Combining the observation on the joint kinematics, knee compression and knee internal rotation and abduction torques are important components of the injury mechanism in a slip-catch situation. From the view of clinical relevance, prevention efforts should focus on avoiding a forceful tibia internal rotation in combination with knee valgus.

V. REFERENCES

[1] Bere T et al., Am J Sports Med, 2011. [2] Krosshaug T & Bahr R, J Biomech, 2005. [3] Bere T et al., Br J Sports Med, 2011

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