Comparative biomechanical analysis of knee injuries in skiing and snowboarding using Artificial Intelligence 3D modelling

Abstract
The cost of knee-injury treatment and recovery is skyrocketing, alongside an increasing number of injuries caused by skiing and snowboarding worldwide. Previous research (1) showed that there are very different forces exerted and angles on the knee joint in skiing as opposed to snowboarding. In addition, our initial analysis of athletes’ movements shows that we could capture and in the future suggest angles and movements that should be avoided while performing these sports. This poster presents a preliminary proof of concept, drawing from a literature review and initial testing to demonstrate that this technique could capture the movements within snowsports.

Introduction
People are becoming more conscious of the value of sporting activities such as snowsports as sedentary lifestyles and human well-being concerns become more prevalent. This project provides a foundation of information for anybody considering competing in or pursuing a career in winter sports, or just doing it as a recreational sport. The aim of this short study was to do a literature review and proof of concept pose estimation for snowsports. From a scientific standpoint, this will be another complement to the considerable biomechanics study that is now underway.

Methods
Knee joints are one of the most important research fields in sports biomechanics. This area has had difficulty in pinpointing forces and angles that are exerted on the knee joint during dynamic exercises like snow sports due to different loading scenarios in particular how people fall and what they impact. Additionally, athletes wear significantly heavy clothing which makes it harder to capture the exact joint movement. For this reason, we recorded the movement on the “endless slope”. This is a sloping treadmill that helps skiers and snowboarders improve their form and muscular strength. A snow simulator allows the rider to get the same muscular exercise as on the mountain while honing the abilities needed to move seamlessly on snow. It is a device with a driven belt of around 5m in width, that has artificial material mimicking snow resistance when applied with some lubricant, in this case, water. This simulator was used to record exercises for further initial analysis.

OpenPose was the pose estimator used by Simms lab at Trinity College Dublin to extract 2D anatomical points known as body key points and then lift them to 3D spatial coordinates to create estimations of joint positions for this exercise.

Results
According to the comparative literature review(2,3,4), snowboarders are statistically younger (20 years; range, 4-44 years) and have a considerably lower Injury Severity Score than skiers (25 in snowboarders vs. 27 in skiers). According to injury data, skiing and snowboarding injuries primarily affect the lower extremities, namely the knee (in skiing 81.8%–36.7% in snowboarding 6.4-17%) and ankle joint (in skiing 6-12.2% and in snowboarding 4.9-10%). The median total cost of care per injury was 665,4 with a visit costing $73. The median length of treatment was 25 days and the number of visits was 8. Tom ligaments, particularly the anterior cruciate ligament (ACL) and medial collateral ligaments (MCL) are the most common knee injuries sustained with snowsports. Therefore that the focus when positioning cameras which captured movement for these tests.

There are multiple forces involved in a steady-state turn in snowsports: gravity force acting towards the ground, friction between the snow/material on the slope and the board/skies, reaction forces and centripetal force. In order for both skiers and snowboarders to perform this activity, they need to stay in balance which means that all of the mentioned forces have to come to equilibrium. The main difference between forces that were observed on videos that act upon the knee in skiing and snowboarding is that there is significantly less knee-to-the-side bending in snowboarding. Therefore this preliminary proof of concept shows that we could capture and mark bending points of the movement of athletes as shown above and in future research use this data to analyse their state of the potential for future injury. Continuing this research will enable the precise analysis of the exact implications of certain angles of a repeated movement.

Conclusion
Both snowboarders and skiers are at high risk of injury. According to reviewed literature, snowboarding accidents are often less severe and have different injury patterns than skiing accidents. Research conducted using modern technologies like skiing simulators is needed to understand better forces acting on knee joints. This successful proof of concept shows that it can be used to enhance learning methodologies to avoid injuries that are connected with poor technique, in the case of a novice, or extreme techniques in the case of professional athletes.

References