Aerodynamics simulation of ski-jumping take-off considering dynamic postural change

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Introduction

In ski-jumping, the take-off and flight posture are considered to have strong influence on the flight distance of the jump. Ski jumper changes his/her posture from a crouching posture to a flight posture in a short period from take-off to the initial flight phase. In order to understand the aerodynamic characteristics of this motion, it is indispensable to analyze in consideration of unsteady flow. The purpose of this study was to investigate the unsteady aerodynamic characteristics during dynamic postural change with computational fluid dynamics (CFD).

Methods

The kinematic data in three actual ski-jumping trials of a ski-jumper were obtained with 19 inertial motion unit sensors. Using both motion data and body surface scanned data, the 3D computer graphic animation was generated. An aerodynamic simulation was performed for the motion from 0.3s before take-off to 0.7s after take-off. Aerodynamic simulation was enabled through the numerical framework developed by Jansson et al. (2019), which enables local adaptive mesh refinement, and it incorporates immersed boundary methods that can model complex geometries undergoing complex motions such as dynamic postural change in ski-jumping.

Results

It was found that the lift and lift-to-drag ratio increased greatly during take-off and flight. Drag and lift showed a difference between trials immediately after take-off, but it was confirmed that they approached a certain value as ski jumper reached a stable flight posture. The key flow structures during the motion were identified and correlated with the aerodynamic forces acted on the jumper.

Conclusion

The unsteady aerodynamic characteristics and the aerodynamic forces during dynamic postural change were unveiled with wearable motion capture sensors and a CFD analysis.