FORCE MEASUREMENT DURING ICE HOCKEY FORWARD SKATING

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INTRODUCTION

Given the technical challenges of measuring force during ice skating, not much is known of the dynamics involved with this unique form of locomotion. Previously, the group of Lamontagne, Gagnon, and Doré completed the only known studies attempting to directly determine forces on-ice specifically for ice hockey skating [1,2]. In addition to sophisticated 3D measures to determine skate orientation, they demonstrated the feasibility of using strain gauge transducers attached to the blade of a hockey skate to estimate forces while performing a parallel stop. No information of this kind has been obtained using modern skate designs. Thus, the aim of this study was to build an accurate, practical, and portable instrumented system to enable the measurement of forces during ice hockey skating while maintaining the integrity of the skate’s construction.

METHODS

The system consisted of three strain gauge sets affixed to an ice hockey skate’s blade holder with wire leads connected to a microprocessor controlled data acquisition device carried in a backpack worn by the skater (<1 kg). The recorded signals indicated the compressive and/or tensile deformation of the skate blade holder between the skate boot and skate blade (Figure 1).

One gauge was used to measure the vertical strain (V), and was oriented along the longitudinal axis (transverse plane) of the blade holder’s beam element. Two pairs of gauges were used to measure medial-lateral (ML) strain and were oriented parallel to the vertical axis of the blade holder along the front and back posts. Given the complex geometric configuration of the nylon blade holder as well as varied junctions with different materials (i.e. metal blade below, epoxy foot plate above), an extensive dynamic validation process was conducted of both the V and ML strain to force relationships by loading in three orthogonal directions against a force plate.

RESULTS AND DISCUSSION

The configuration of the strain gauges simultaneously determined the V and ML force components experienced by the blade holder, up
to a theoretical maximum of 7440 N, with a resolution accuracy of 1.9 N and an RMS error of ±68 N (coefficient of variation = 9.2). The V loading tests yielded correlations of the voltage reading (strain gauge) to force (measured on the force plate) for slow, medium and fast loading rates ranging from r = 0.94 to 0.99. V loadings showed a minimal (less than 40 N) response in the ML gauges (i.e. minimal false or cross-talk signals). Correlations for ML loading tests ranged from r = 0.95 to 0.99. ML loading tests showed a small response in the V gauge (less than 40 N).

The current configuration of strain gauges has also been shown to be able to determine simultaneously and independently the V and/or ML force components experienced by the blade holder. In order to demonstrate the functional usefulness of the measurement system, a subject performed a forward skating task on ice with the right skate instrumented.

Figure 3 shows force-time curves of the total force (summation of V and ML), as well as V and ML component forces for a representative skating trial on-ice of the right skate (note: for conceptual display the left skate forces were approximated by replicating the right skate’s data, offset temporally by 50%). Descriptive parameters from these force-time patterns can be obtained; for examples, contact time, stride time, and force maximums. In this sample trial shown, clear dynamic differences are evident between step order, with a transition from short duration (0.31 s), single force peaks (200 % BW) in the 3rd step to longer duration (0.38 s), and bimodal force peaks (120 and 180 % BW) by the 6th step. This pattern was consistently recorded, with trial-to-trial coefficient of variation ranging between 3.9 and 12.5 for steps 2 through 6 in peak force and coefficient of variation ranging between 2.8 and 10.0 in contact time estimates for each respective step.

CONCLUSION

With conventional skate models, it is possible to use strain gauges to estimate both vertical and transverse forces in real time and on-ice. The practicality and accuracy of this testing approach has many applications, such as a quantitative tool for skating power assessment to aid athletes and coaches.

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REFERENCES