PORTABLE STRAIN MEASUREMENT SYSTEM FOR ICE HOCKEY STICKS

PM Magee[1], P Dixon[1], TJ Stidwill[1], DJ Pearsall[1], RA Turcotte[1], and K Covo[2]

[1]Department of Kinesiology and Physical Education, McGill University, Montreal, QC, Canada,
[2]Nike-Bauer Hockey Inc, Research, Design and Development, St. Jerome, QC, Canada,
URL: http://icehockeyscience.mcgill.ca/

INTRODUCTION

Bending of an ice hockey stick is commonly observed during slap and wrist shots, wherein the shaft deformation stores elastic energy that may be transferred (in part or in whole) to the puck for higher projection velocity (Villasenor-Herrara *et al,* 2006). Hence, understanding the optimal bend stiffness characteristics is important to both athletes and manufactures of these specialty products. Previous studies have used high speed video recording (Wu *et al*, 2003), or infrared motion tracking (Worobets *et al,* 2006) for successful estimates of gross deflection. Alternatively, pioneering studies by Roy *et al* (1979) used strain gauges adhered to hockey sticks to obtain greater resolution of material deformation properties. Given advances in miniaturization and data storage, it may now be feasible and practical to use this latter approach. The purpose of this study was 1) to develop a portable strain gauge measurement system for evaluation of stick dynamic deformation characteristics during puck shooting tasks and 2) to demonstrate its utility for both in lab and on ice testing conditions.

METHODS AND PROCEDURES

Four paired strain gauges measured shaft bend (B1 to B4) and two obliquely oriented gauges measured shaft torsion (T2 to T3) at 15 cm intervals. These were positioned on the lower end of the stick shaft (Fig 1). The strain gauge system consists of: 1) a half-active Wheatstone bridge composed of 350 Ω, 0.125” long strain gauges with a 5 V DC battery excitation; 2) a signal conditioning unit capable of acquiring signals in ±100 mV and amplify to a 0 to 5 V range; 3) an 8 channel DAQ (using LabVIEW 8) at 2.5 kS/s for 2 seconds. Acquired data were stored on a laptop computer. The above components could be contained within a backpack. Fine wires connecting the strain gauges to DAQ were tethered along the stick shaft and upper limb of a subject with minimal encumbrance to the swinging motion.

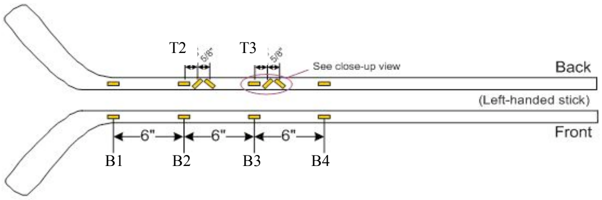

Figure 1. Strain gauge placement along hockey stick.

Calibration of the system was conducted at the ambient air temperature of the test environment (lab = 20°C, arena = 2°C) prior to testing. As a subject, a high calibre hockey player executed a several wrist and slap shots. For in lab conditions, shots were performed on top of a synthetic gliding surface (0.6 cm thick polyethylene sheets with silicon lubricant). Subsequently, the same subject repeated the skill on the ice in the hockey arena.

RESULTS

Initial inspection of the acquired strain data demonstrated both high temporal response and discrimination between strain by shaft location. Also, quantitative differences between skills were displayed. With regards to the wrist shot (Fig 2) the 6 strain-pair records corresponding to “pre-shot gathering”, shot loading, and recoil strain coincided in time (600, 100, and 200 ms in length respectively) but with different magnitudes (800 to 200 μE). Greatest deflection occurred at B4 (near lower hand position) and least at B2. Concurrent torsion measures occurred from 50 to 200 μE. For the slap shot (Fig 3), similar temporal synchronization and rank order was shown though the loading phase was shorter (~100 ms) and the magnitudes of maximal strains were greater (1000 to 3500 μE). In-lab versus on-ice strain records showed almost identical patterns (Fig 4).

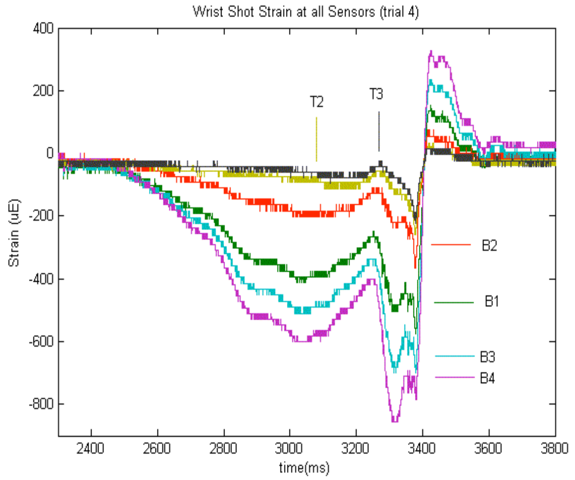

Fig 2. Wrist shot: example data for all strain gauges.

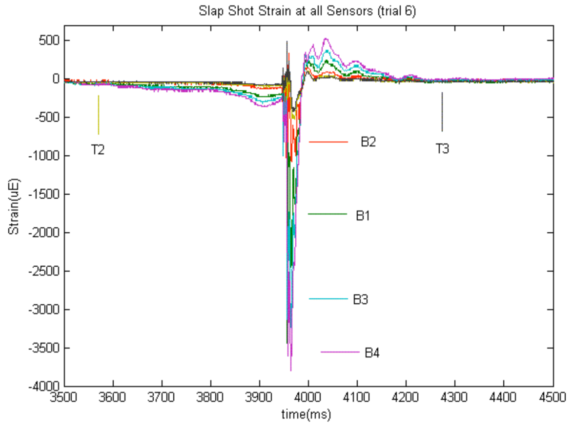

Fig 3. Slap shot: example data for all strain gauges.

DISCUSSION

The objective to create a portable system was successful. The use of several strain gauges revealed heterogeneous bending and torsional strain magnitudes along the shaft during the shooting task, similar to dynamic cantilever loading. Equally important, the testing system was sensitive enough to demonstrate different strain rate behaviours between skills. Finally, the high similarity in strain profiles between in-lab and on-ice testing gives confidence in the measurement consistency.

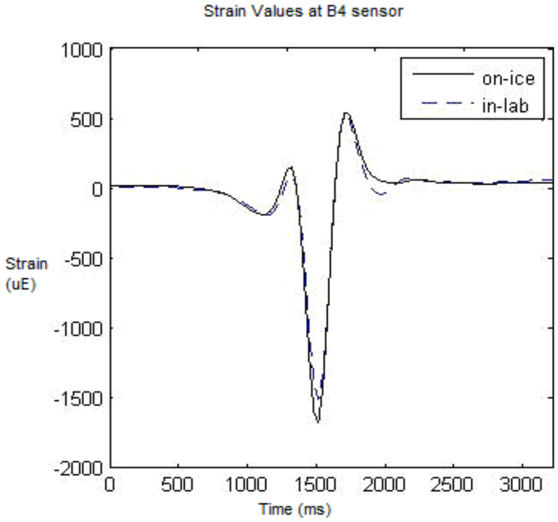

Fig 4. Wrist shot: B4 strain in lab versus on-ice

SUMMARY

The above results indicate that strain gauge technology is robust enough and portable for testing in both lab and real game cold environments. It also possesses the necessary spatial and temporal resolution to identify material behaviour responses during dynamic activities that other conventional video based technologies detect. After more extensive verification of the system's accuracy, future studies addressing material properties and construction properties will be pursued.

REFERENCES

Roy B et al. (1979) *Can J Appl Sport Sci* 4:1-7

Villasenor-Herrara A *et al* (2006) *J Appl Biomech* 22(3): 202-211

Worobets *et al* (2006) *Sports Eng* 9(4): 191-200

Wu T-C *et al* (2003) *Sports Eng* 6(1):31-39

ACKNOWLEDGEMENTS

NSERC and Nike-Bauer Hockey Inc
Dr. Lassard, R Lawand and J Lepore, Mechanical Engineering, and D Marrone, and F Medleg, Kinesiology.