Pressure Distribution in Selected Curling Brush Heads

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Introduction

In curling, athletes brush in front of an ~18 kg curling stone to influence both the carry and trajectory of the stone as it travels down a sheet of ice (~40 m).

- One effect of brushing is to slightly raise the ice temperature (+0.5C to +1.7C)
- A complete understanding of the effects of brushing remains a research problem
- A high-performance athlete will generate vertical forces equivalent to ~95% of their body mass, or 932 N for a 100 kg athlete (Figure 1) [1,2]
- Vertical and horizontal force outputs during a brush stroke are oscillatory (Figure 2) [1]
- In competitive play, the World Curling Federation (WCF) regulates brush head dimensions, fabric type, and foam compression

Figure 1 - Forces achieved during a single stroke

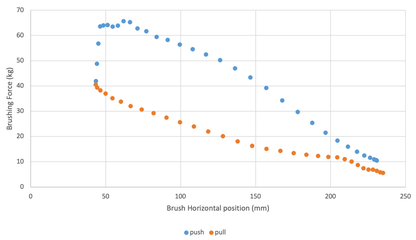
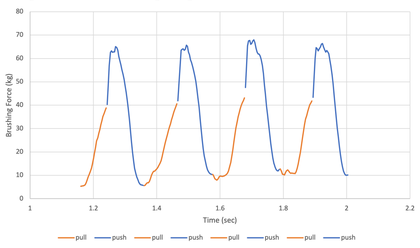


Figure 2 - Push and pull portions of a stroke over time



The WCF specifies that a compliant brush pad must:

- spread vertical force evenly across the area of the brush head in contact with the ice;
- prevent significant deflection of the faceplate, leading to non-uniform pressure;
- disallow force applied by the brusher to be focused on a significantly small area of the brush head.

Method

Our aim: determine if different commercial brush head designs reflect the WCF specification.

Equipment:

- Forces and pressures were recorded using two 3200E Tekscan (Tekscan Inc., Boston, MA) pressure sensors affixed to the top of an AMTI BP400600 force plate (AMTI Inc., Watertown MA), with the sensel areas abutted (Figure 3). CONFORMat Research software (version 7.1: Tekscan Inc.) was used to collect the pressure sensor data.
- Three-dimensional kinematics (rigid-body marker configurations) of the broom head and handle were recorded using an OptiTrack (Natural Point Inc., Corvallis OR) motion-analysis system.
- All data were recorded at a frequency of 100Hz, and data acquisition was synchronized using TTL signals (eSync2, Natural Point Inc., Corvallis OR).
- Each of seven WCF-approved brush heads were tested (Figure 4) under four static loading conditions (200, 400, 600, 800N) and three broom handle angles (50, 70, and 90 degrees) (Figure 5).

Figure 3 - Setup

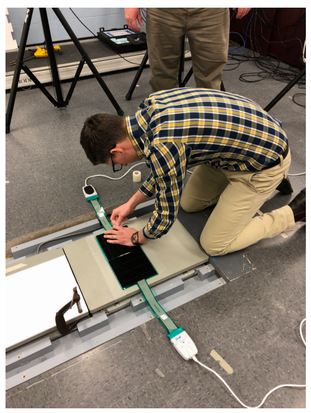


Figure 4 - Brush heads under test

Figure 5 - Load testing

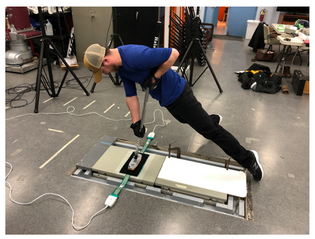
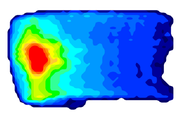


Figure 6 - Dynamic pressure map



Results

Figures 7-9: Pressure distributions of commercial brush "A" when held at a 70-degree handle angle from horizontal, with varying vertical forces.

Figure 7 - Brush "A" - 200 N

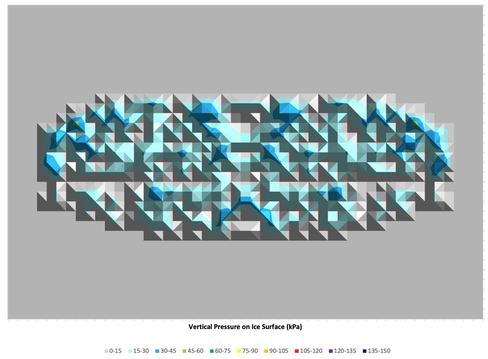


Figure 8 - Brush "A" - 600N

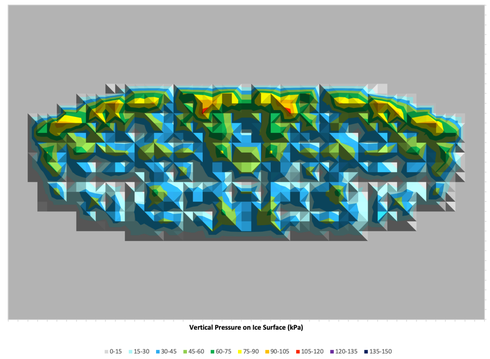
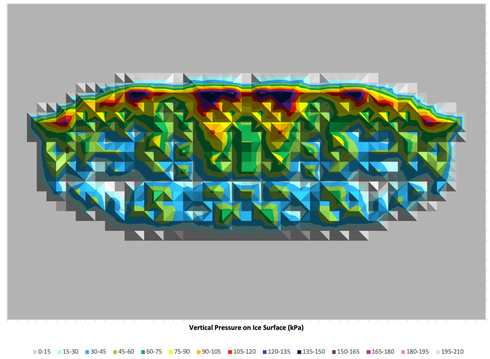


Figure 9 - Brush "A" - 800 N



Figures 10-13: Pressure distributions of other commercial brushes when held at a 70-degree handle angle from horizontal, with vertical force ~800 N (80 kg) .

Figure 10 - Brush "B" - 800 N

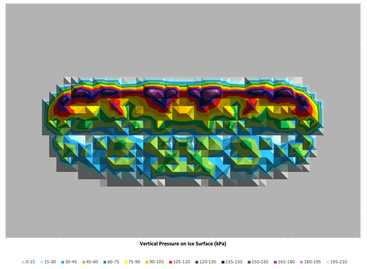


Figure 11 - Brush "C" - 800 N

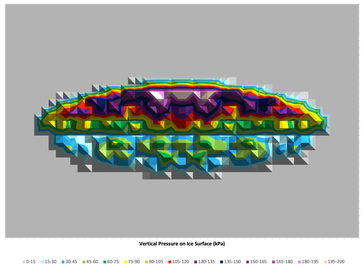


Figure 12 - Brush "D" - 800 N

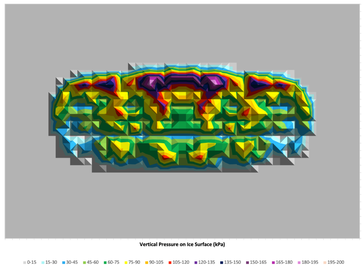
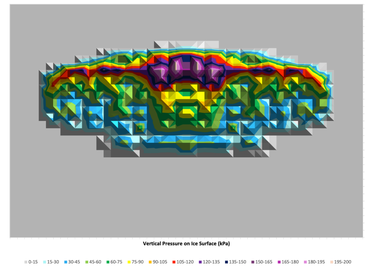


Figure 13 - Brush "E" - 800 N



Figures 14-17: Pressure distributions of other commercial brushes when held at a 50-degree handle angle from horizontal, with vertical force ~600 N (60 kg) .

Figure 14 - Brush "F" - 600 N

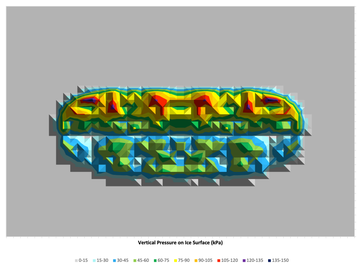


Figure 15 - Brush "G" - 600 N

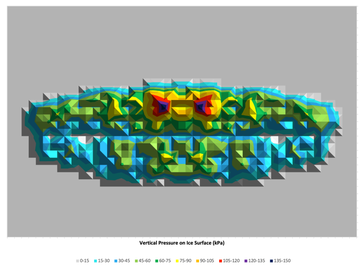


Figure 16 - Brush "C" - 600 N

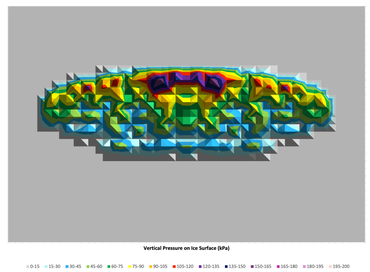
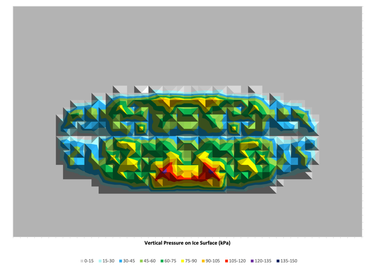


Figure 17 - Brush "D" - 600 N



Conclusions and Future Research

- All of the brush heads tested do not reflect the WCF specification for sweeping devices when under the loads achieved by competitive athletes.
- With all tested brushes, pressure distributions vary depending on the force applied and handle angle. Some heads concentrate force around the handle mount (Figures 15-17) while other heads concentrate force along the leading edge (Figures 9, 10, 12, 13).
- Different pressure distributions can be seen in the wear patterns of used, game-worn pads (Figure 18).
- These results suggest that brush designs may be customized in the future to suit an athlete's force profile.
- It is unclear how pressure distribution changes when the brush is in motion. Early results (Figure 6) indicate large variations in pressure across a pad through a complete stroke with all tested models.

Figure 18 - Used brush pad showing greater wear around the edges

References

[1] Newhook, John and Glenn Paulley. Anatomy of a Brush Stroke. Technical Coach Series #1, June 2018. Available from the authors.

[2] Newhook, John and Glenn Paulley. Brushing Definitions and Targets. Technical Coach Series #4, June 2018. Available from the authors.