

INSTRUMENTED CURLING BROOMS

THE TECHNICAL COACH SERIES

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NO. 2

OVERVIEW

In the first article of this series (Anatomy of a Brush Stroke), we presented an overview of the forces and motion components involved during the brushing of a curling stone, and introduced standardized terminology for describing the motion and the forces during a brushing stroke. We concentrated on two principal measurements of brushing performance: the amount of vertical force (or pressure) applied by brush head to the surface of the ice, as well as the number of brush strokes per second. The article was based on detailed and controlled measurement taken in a laboratory.



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To be an effective tool for coaching and development, we require a curling broom instrumented in such a way that an athlete can use it on the curling ice, in training or game situations, to get meaningful feedback on their performance when in motion.

In this article, we will focus on the idea of an instrumented curling broom, its requirements and the details of the CurlSmart Broom, developed at Dalhousie University, as an example.

NEED FOR AN INSTRUMENTED BROOM

For many aspects of coaching and training in the sport of curling there are several ways that athletes receive immediate and often very visual feedback on their skills and performance. For some of the early development skills such as delivery technique, the athlete will be able to easily appreciate better balance or better control of release and weight. As they work on refining their skills and improving their delivery, the outcomes at the other end of the sheet change in terms of more consistency with making draws and hits. At a higher level we can also introduce skills competitions (hot shots) and quantitatively track an athlete's progress and improvement.



For brushing, however, the immediate visual and quantitative outcomes are often not as obvious, and it is harder for the developing athletes to appreciate whether a change in footwork, hand position, open versus closed stance, or other aspect of technique are making any difference to their brushing effectiveness. It is also difficult to objectively evaluate one brusher's performance against

another. Without the aid of special devices, brushing effectiveness has to be deduced from the eventual outcome of a shot, which has many more influences than just brushing.



The instrumented brush is viewed as a tool that can provide the athlete and coach with immediate feedback on current performance, quantify the impact of changes in technique, and permit trend analysis of the gradual improvements of an athlete over time as they invest in brushing-specific training and development.

Several researchers from various countries have worked on developing an instrumented curling broom and there are currently commercial products on the market. This article will discuss some of the generic aspects of instrumented brooms, but we will also discuss the specifics of the Curl Smart Instrumented Brush developed at Dalhousie University to improve our understanding of brushing science and to help develop coaching strategies.

INSTRUMENTED BRUSH OBJECTIVES AND CRITERIA

There are several objectives for the use of the instrumented brush in developing better brushing:

1. Provide coaches and researchers with a tool to study brushing technique and increase our understanding of the science of brushing.
2. Provide athletes and coaches with training level data:
 - a. Allow them to see impact of changes in technique;
 - b. Allow them to track development and performance over a period of time.
3. Allow benchmarking and identification of skill levels and set target performance levels for various groups.
4. All teams to understand brushing performance levels of each athlete and develop team strategies for brushing.

To accomplish this, we propose several criteria for an effective instrumented brush.

It must be accurate

Above all else, the accuracy and reliability of the information provided by the instrumentation must be very high. Any coaching decision or technique adjustments must be based on both good data and a good understanding of what the data means. Furthermore, some of the issues being studied or techniques being adjusted may have only a minor effect on the brushing

forces; hence, the brush's accuracy must be sufficiently high so as to capture and quantify these small impacts.

Wireless

The instrumented must be wireless to allow easy use in both training and game scenarios.

Unobtrusive

The instrumented brush will add components to the brush head and/or handle of the broom. These components should not impact the athletes' brushing mechanics. They should be as light as possible and have minimal interference with sight lines and possible hand positions.

Provide immediate and meaningful feedback

As a training tool the device should be able to provide some level of immediate feedback to the coach and athlete about the impact of whatever changes in style or technique that are the focus of that session. The data may be looked at more rigorously after practice, but ideally the coach should be able to see the brushing results as they happen and while the coach is observing the athlete's activity in real time. It should be noted that there is a balance between capturing enough, and too much, information that must be considered.

CURLSMART INSTRUMENTED BROOM

The CurlSmart Instrumented Broom was developed based on the criteria presented above. A



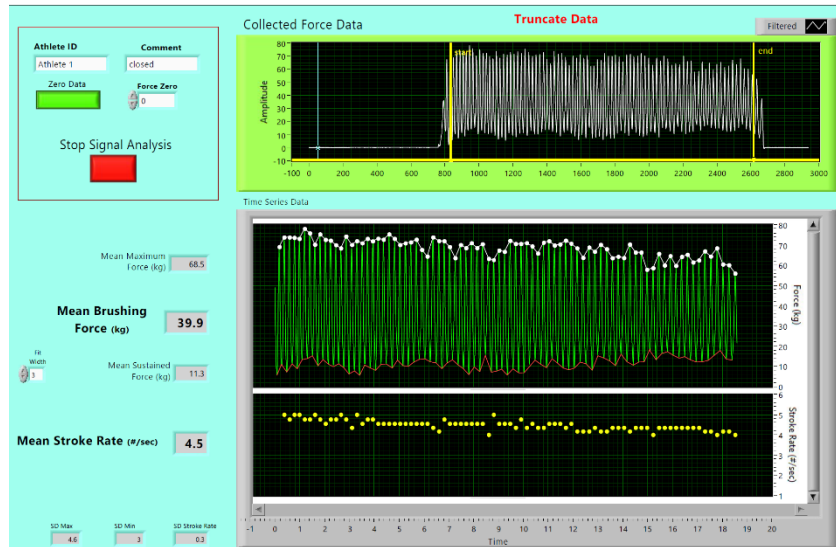
instrumented aluminum plate was placed in a custom-made brush pad to act as a bending load cell and measure the vertical contact force between the brush pad and the ice. The data is streamed wirelessly, in real time, to a laptop close by and operated by the coach. The broom measures and transmits the force readings at a rate of 100 readings per second such that each full stroke (a combination of the push portion and the pull portion) will have

at least 20 data points to reconstruct a detailed brushing profile as shown in article No. 1 and the data below.

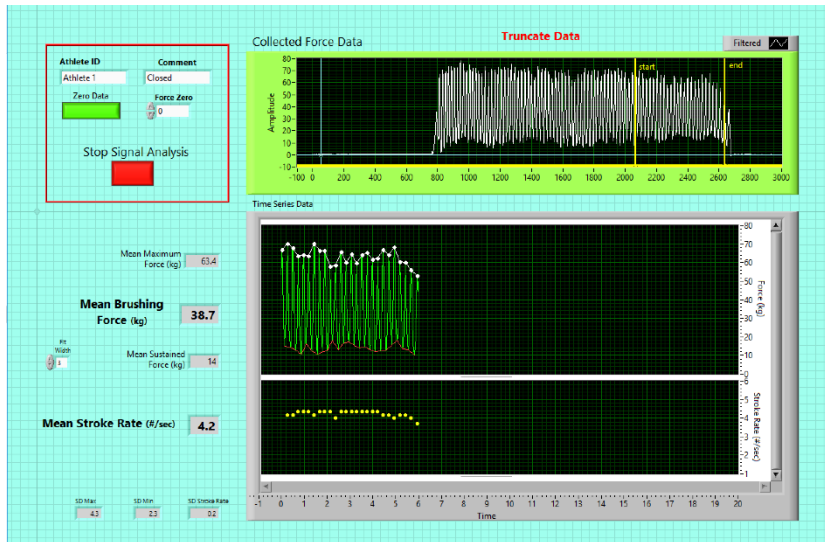
The remainder of the work to produce the necessary values defined in article No.1 of this series, and discussed in article No. 4. This is achieved through the development of signal processing algorithms that execute on the laptop.

A typical set of processed data would very similar to the screen output shown here for a high-performance athlete, brushing a draw shot for approximately 19 seconds.

The software applies a calibration factor, discussed later in this article, to the measurement data as it is being collected and displayed in real time. This is to convert the measurement values to accurate force data seen in



the collected force data window on the screen. The plotting algorithm also digitally zeroes the data to correct for any data offsets caused by temperature differences or broom head tightening between bouts. The coach can adjust the yellow vertical bars on the screen to select a portion of the recorded data file for more detailed analysis. For illustration, the first screen shot on the previous page shows the data analyzed for the entire meaningful data set, while the second screen shot below shows the same data analyzed for the last six seconds of the bout. This permits the coach to focus on the brushing values at the end of the bout when conditioning, fatigue, and alternate energy systems can significantly influence performance.



Once the yellow selection bars have been used to identify the relevant data range, the software isolates the data set (shown in the Time Series Data window) and conducts a peak detection process to identify maximum force (white line/dots) and sustained force (red line/dots) values for each individual stroke. In addition, the timing of each stroke is

determined and converted into equivalent strokes per second. This is plotted in the 'stroke rate' portion of the Time Series Data window. As can be seen in the analysis of the complete bout on page 4, note the decrease in stroke rate over time, from an initial value of 5 strokes per second to a final value of 4 strokes per second. The data windows on the left display each brushing bout's summary values: Mean Maximum Force, Mean Brushing Force, Mean Sustained Force and Mean Stroke Rate values. As will be discussed in future articles, the summary values and the detailed force profile plots are both important in the study and coaching of brushing.

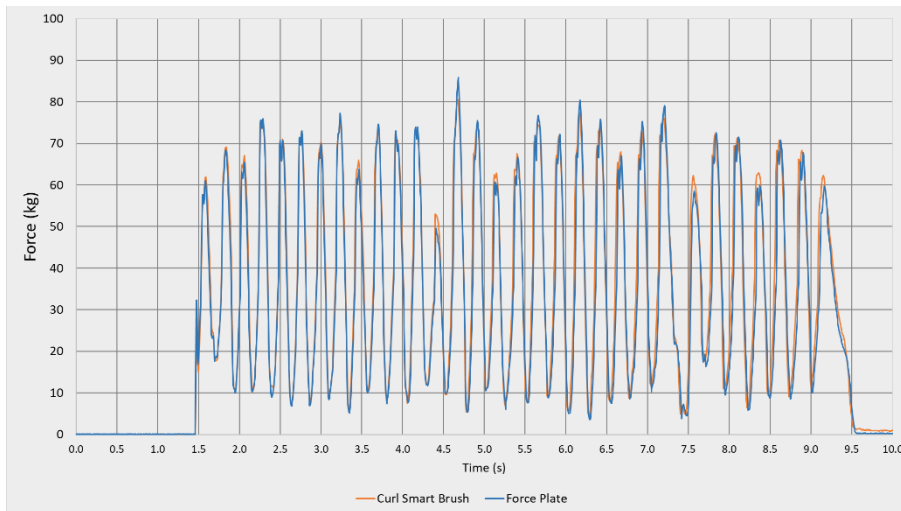
The instrumented portion of the CurlSmart Broom is contained entirely within the brush head (including the batteries and wireless transmitter). This allows any handle to be used with the brush head. However, it does mean that only this brush head can be used; no substitution of new brush pads or different head configurations are possible with this design.

The CurlSmart Broom described herein does not contain an accelerometer. Consequently, the brush's output cannot be processed to analyze stroke length, which we term displacement, or to isolate the push and pull portions of a stroke.

CALIBRATION OF INSTRUMENTED BROOMS

Calibration of an instrumented broom, or any measurement device, is a process whereby the device is tested in a controlled manner using instruments that are known to be accurate. The measurement output of the device is compared to the known values, and a factor from curve fitting determined, such that the device produces the same values as the control system. This process is essential to ensure the accuracy of the data being collected.

In Article 1, we described the professionally-calibrated force plate and measurement tracking systems in Dalhousie's Kinesiology Laboratory. This system was used as the accurate, 'known' control system. Test subjects used the CurlSmart Instrumented Broom on the force plate, and we analyzed the output to determine the calibration factor for this broom. A comparison of the force plate data and the calibrated broom data is shown in the plot below. This comparison shows very good agreement, and creates confidence that the data collected on the ice with the broom will be accurate.



SUMMARY

Instrumented curling brooms are an important tool in studying the science of brushing and in the coaching and development of athletes. Over the past two decades there have been several custom-built instrumented brooms developed for research teams and some brooms for commercial sale. The objectives of each instrumented broom are generally the same but the details of the device, its construction and its data processing can be quite different. It is very important for the user to understand as much as possible about the device, its data processing and output, and its capabilities and limitations in order to use the device and data effectively.

We presented details of the CurlSmart Instrumented Broom as an example of an instrumented broom to help athletes and coaches understand what an instrumented broom is, and to stimulate other researchers or product development teams to produce alternate versions of their own with different capabilities or improved functionality. The CurlSmart broom has the following capabilities and limitations:

- Produces calibrated vertical force data at 100 readings per second.
- Output is streamed from the device and must be collected on a wirelessly-connected laptop. The data can be viewed in real-time on a computer screen by a coach as the athlete is sweeping.
- The user can select the data range for further analysis. This can be done at any time, immediately after the bout or at a later time. Because the original, complete data file can be retained, the user can easily analyze the data multiple times and focus on different subsets of the data as necessary.
- The display screen for the analyzed data shows the complete force versus time brushing profile, as well as stroke rate versus time. It also calculates and displays summary data for the bout, including Mean Maximum Force, Mean Brushing Force, Mean Sustained Force and Mean Stroke Rate.
- While the full brush stroke is displayed, the analysis does not calculate or directly indicate the pull and push portions of the brush stroke.

The CurlSmart Broom was built as a custom device to study brushing science and to help develop coaching and athlete development ideas. IT IS NOT CURRENTLY COMMERCIALY



AVAILABLE. Individuals with interest, and access to necessary resources, are encouraged to design and develop their own devices.

REFERENCES

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QUESTIONS

We are pleased to provide whatever assistance we can to coaches and athletes. Our contact information is below.

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