Directional Accuracy of the Delivery in Competitive Curlers

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Introduction

The delivery is one of the most important skills in the sport of curling. The objective of the delivery is to release the stone so that it will eventually come to rest in a specific position at the opposite end of the sheet, or so that it will contact and remove an opponent's stone from play. Curlers attempt to deliver the stone with the appropriate combination of direction and speed. The stone must be delivered in the appropriate direction to allow for the proper amount of curl to complete the required shot. In addition, the stone must be released with the speed necessary for the type of shot being played, whether it is a draw or take-out (Bradley, 2009; Buckingham, Marmo & Blackford, 2006). It is the curling delivery which has the appropriate combination of direction and speed which will be most successful.

The line of delivery is the imaginary line between the hack, which is the rubber foot pad from which the curler imparts force during the delivery, and the skip's broom head (Ontario Curling Association, 2012). Based on the specific situation seen during the competitive play, curlers may be required to deliver the stone to virtually any position in or around the house. Ideally, the curler delivering the stone will position him/herself in the same manner regardless of where the line of delivery is located. To date, there has been no quantitative assessment of the ability of competitive curlers to deliver the stone on the line of delivery, whether it is positioned to the right, centre, or left of the house, with an in-turn or out-turn rotation, or delivered at a draw or a take-out speed. The purpose of this study was to assess the directional accuracy of the delivery during curling.

Methods

Sixteen curlers were recruited for this study, eight males and and eight females (mean age = 27.0 yrs; mean years of curling experience = 17.3 yrs). All participants had competed at regional, provincial, national curling events, and were right handed throwers. Ethical approval was received from the Lakehead University Research Ethics Board prior to data collection.

The participants were required to deliver eight curling stones, which represented a variety of frequently played shots seen during competitive play. They included the following targets, rotations, and speeds: target on right side of the house (out-turn draw, out-turn take-out), target on centre line (in-turn draw, in-turn take-out,

out-turn draw, out-turn take-out), target on left side of the house (in-turn draw, in-turn take-out). The deliveries were performed random order. The participants were instructed to aim at a laser level device which was located 5 centimetres above and parallel to the ice surface, and was pointed towards the centre of the hack. This device represented the skip's broom (line of delivery). A JVC ZR-950 camcorder, mounted on a mini tripod, was positioned directly above the laser device and was used to record each delivery (Figure 1).

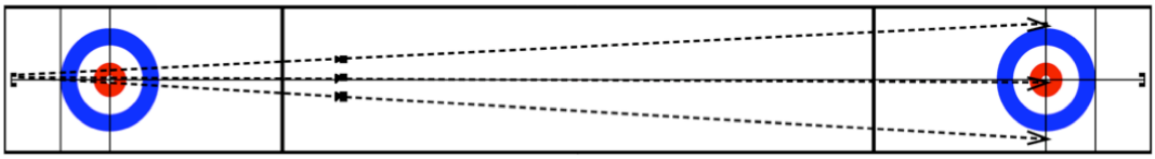

Figure 1: Set up for testing protocol, including the lines of delivery (right side of house, centre line, left side of house), and the location of the laser device and video camera for each.

The camera was zoomed in to ensure that the stone filled most of the the field of view, and then was zoomed out slowly as the stone was delivered towards the camera. The video was captured on a miniDV tape for subsequent analysis using Dartfish (software version 4.0.9). Using the diameter of the stone as the known distance, the location of the laser dot relative to the stone diameter was measured and used to determine the position of the stone relative to the line of delivery. A measurement directly on the line of delivery was represented by a value of zero. Positive numbers represented distances measured in which the stone was located to the right of the line of delivery, negative values indicated the stone was positioned to the left (Figure 2).

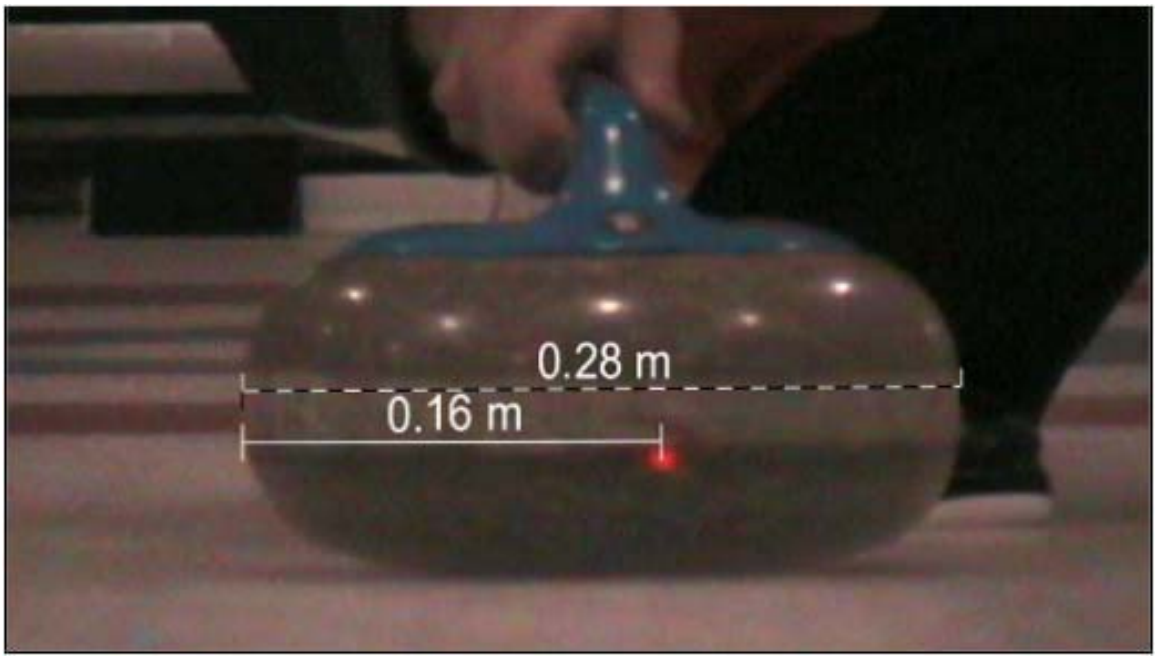

Figure 2: Screen capture outlining method used for measuring the position of stone relative to line of delivery. The diameter of the stone is 0.28m as measured from the left edge, which indicates the centre is located at 0.14m. Because the laser dot (line of delivery) is located 0.16m from the left edge, the stone is positioned 0.02m to the right of the line of delivery.

Measurements were taken in the position of the stone relative to the line of delivery at specific events during the delivery. They included the setup (the position of the curler in the hack prior to the initiation of movement), pull-back (the backward most position of the stone prior to the initiation of forward force application), release (the moment the stone left the curler's hand), and after release (a measurement taken 5 video frames (0.17 seconds) after release to represent the path of the delivered stone).

Statistical analysis was completed using SPSS 18.0. Factorial repeated measures ANOVAs were used to evaluate the position of the curling stone relative to the line of delivery for the various delivery target locations (right, centre, left), speeds (draw, take-out), and turns (in-turn, out-turn) at the different phases of the delivery (setup, pull-back, release, after release). Significant main effects were further analyzed with Bonferroni adjusted pairwise comparisons to identify the specific differences among the delivery phases. Alpha was set at $p \leq 0.05$.

Results and Discussion

The data are presented in Table 1, including the mean (± S.D) position of the stone at each phase for the deliveries released to the three targets and with different combinations of speed and turn.

Table 1: Mean (± S.D.) Position of the Stone Relative to the Line of Delivery for the Deliveries Released to the Three Targets and With Different Delivery Types

Target	Delivery Type	Delivery Phase			
		Setup	Pull-back	Release	After Release
Right	Out-turn draw	0.06 ± 0.04	0.06 ± 0.04	0.06 ± 0.04	0.06 ± 0.04
	Out-turn take-out	0.06 ± 0.05	0.06 ± 0.04	0.06 ± 0.03	0.06 ± 0.03
Centre	Out-turn draw	0.06 ± 0.04	0.06 ± 0.04	0.06 ± 0.03	0.06 ± 0.03
	Out-turn take-out	0.05 ± 0.04	0.05 ± 0.04	0.05 ± 0.04	0.05 ± 0.04
	In-turn draw	0.04 ± 0.04	0.05 ± 0.03	0.03 ± 0.03	0.02 ± 0.03
	In-turn take-out	0.05 ± 0.04	0.05 ± 0.03	0.03 ± 0.03	0.03 ± 0.03
Left	In-turn draw	0.04 ± 0.03	0.04 ± 0.03	-0.02 ± 0.03	-0.02 ± 0.03
	In-turn take-out	0.04 ± 0.04	0.04 ± 0.03	0.00 ± 0.03	0.00 ± 0.03

Significant main effects were found for turn ($p < 0.001$) and for target location ($p < 0.001$), but not for the main effect of speed ($p = 0.341$). Post-hoc analysis for turn revealed no significant differences in the out-turns among the phases of the delivery. For the in-turns, however, the setup and backswing phases were significantly different ($p < 0.001$) from the release and after release phases, with the stone being released significantly closer to the line of delivery. Post-hoc analysis for target location indicated that there were no significant differences among the deliveries to the target on the right side of the house and the out-turn deliveries to the target on the centre line. Significant differences were seen between the setup and pull-back phases and the release and after release phases for the deliveries to the target on the left side of the house, and for the in-turn deliveries to the target on the centre line ($p < p.001$).

For most of the measurements taken during this study, the stone was positioned to the right of the line of delivery. The participants were always setup with the stone situated to the right of this line, and this position did not change as they moved into the pull-back phase. It was only in the release and after release phases of the in-turn deliveries that the stone was seen to either be positioned on the line of delivery or cross over to the left side. The in-turn delivery for right handed throwers has the stone rotating clockwise. Because the stone was positioned to the right of the line of delivery during the setup and pull-back phases, this type of turn resulted in the curler changing the position of the stone towards the line of delivery as he/she approached the moment of release. This change in stone position, however, was not seen for any of the out-turn deliveries. Theoretically, the curler should be in the exact same setup position prior to the start of a delivery, regardless of the nature of the shot being played. The only difference should be in the rotational orientation of the stone for an in-turn or an out-turn release. The results of this study suggest that competitive curlers are consistent in positioning the stone in the early phases of the delivery. Similarly, curlers should also release the stone in the same manner for targets located to the right, centre, or left of the house, and for in-turn and for out-turn rotations. The results indicate that this is not the case. Further research into the kinematics of the delivery is warranted to explain this finding.

The results of this study provide insight into the ability of competitive curlers to deliver the stone on the line of delivery. Curlers must be aware of the fact that differences may be seen in the position of the stone relative to the line of delivery for various types of deliveries, and at different phases throughout the delivery.

References

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