SWEEP LENGTH VS SWEEP RATE ANALYSIS IN COMPETITIVE MALE AND FEMALE CURLERS

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The purpose of this study was to examine sweep length and sweep rate in competitive male and female curlers. Sixteen curlers (8 males, 8 females) completed a 25-second bout of maximal effort sweeping which was video recorded and analyzed using Dartfish. Sweep length and sweep rate were determined for each 5-second interval (0-5s, 5-10s, 10-15s, 15-20s, 20-25s). Comparisons were made among time intervals and between genders. Sweep length was found to be similar between genders ($p = 0.922$), with significant differences seen between the 0-5s and 5-10s time intervals ($p < 0.05$). Sweep rate was significantly faster for males across all time intervals ($p < 0.001$), with males and females showing differences in the rate at which sweep rate decreased over time. This information may help curlers improve their sweeping strategy during competitive play.

KEYWORDS: curling, sweeping, sweep rate, sweep length.

INTRODUCTION: In the sport of curling, sweeping is used to increase the distance a stone travels and reduce the amount it deflects laterally or ‘curls’. Sweeping is one of the most physically demanding skills in the sport, requiring balance, coordination, strength, and endurance. Effective sweeping is characterized by a large downwards force on the broom and a rapid back-and-forth movement of the broom head (Marmo et al., 2006). Players may be required to sweep for up to 26 seconds per shot, which is then followed by a brief rest period while the other team is delivering their stone (Arnold et al., 2007). Sweeping produces frictional heat between the nylon brush head and the ice. This increases the ice temperature, melting it briefly and thereby reducing the coefficient of friction (Marmo & Blackford, 2004). Thus, sweeping provides a certain degree of control for the curlers in determining the exact position in which the stone will stop. To maximize the effect of sweeping, curlers must sweep as close to the on-coming stone as possible without coming into contact with it (Marmo et al., 2006).

Sweeping velocity is dependent on two factors: sweep length and sweep rate. Sweep length is the displacement of the broom from one end of the stroke to the other, whereas sweep rate is the number of sweeping strokes completed per second. Limited data on sweep length and sweep rate have been published. Bradley (2009) reported average sweep lengths of 0.1071±0.013m in competitive male and 0.1071±0.024m in competitive female curlers. Bradley (2009) also reported sweep rates of 4.32±0.66 strokes per second and 3.81±0.37 strokes per second in competitive male and female curlers, respectively. This data, however, was an average over a 20-second bout of hard sweeping, and did not take into consideration the potential changes that would be seen in these variables during prolonged sweeping as the curler begins to fatigue. Bradley (2009) suggested that sweep length remains constant throughout the sweeping period and that there is a decrease in sweeping rate over time, however, no empirical data was provided to support this. An analysis of sweep length and sweep rate throughout a maximal effort bout of sweeping would provide a better understanding of these mechanical factors that determine sweep velocity. Therefore, the purpose of this study was to examine sweep length and sweep rate in competitive curlers. Comparisons were also made between males and females.

METHODS: Sixteen participants were recruited for this study, 8 males and 8 females. Mean age and years of curling experience for the males was (age: = 25 ± 3 years; curling = 15 ± 4 years) and for the females (age = 23 ± 4 years; curling = 12 ± 3 years). All participants were members of teams who competed at regional, provincial, or national curling events, and played on any of the four positions on the team (lead, second, third, skip). Ethical approval was received from the Lakehead University Research Ethics Board prior to data collection.

Prior to testing, each participant warmed up as he/she would prior to competitive play, which involved static and dynamic stretching and simulated sweeping. Testing required the participants to complete one maximum effort sweeping bout for 25 seconds. In order to simulate actual sweeping conditions and to ensure consistency for all participants, the curling stone was pushed by one of the investigators using a curling broom. The stone was pushed starting from the t-line at one end of the ice sheet and was directed along the centre line towards the camera which was located at the other end, with the participant sweeping in front. The stone was pushed with a velocity of approximately 1.5 ms^{-1} to ensure that it travelled from one end to the other in 25 seconds.

Video for each trial was recorded on a miniDV tape using a Canon ZR950 camcorder. The camera was located on a tripod at a height of 30 centimetres above the ice surface. The camera was positioned at the opposite end of the testing ice sheet near the house and on the centre line. The camera was focused on the stone, zooming in such that the width of the stone was approximately two-thirds of the width of the camera field of view. As the pushed stone moved towards the camera, the camera was slowly zoomed out to accommodate for the changing perspective (Figure 1).

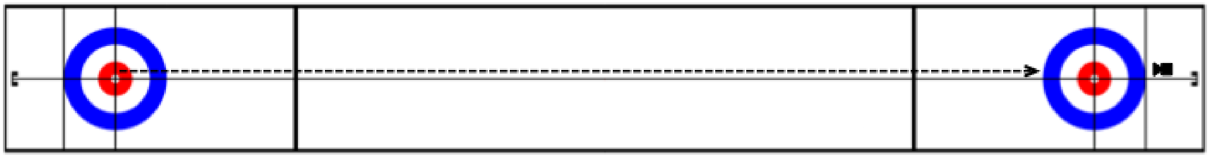
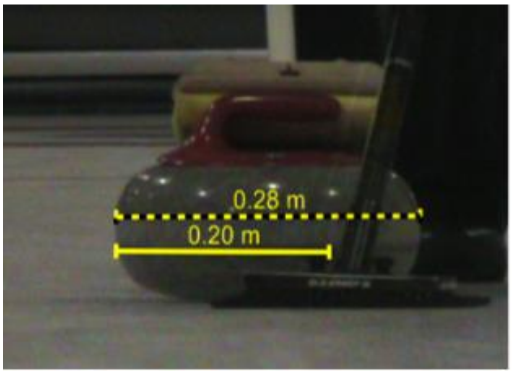
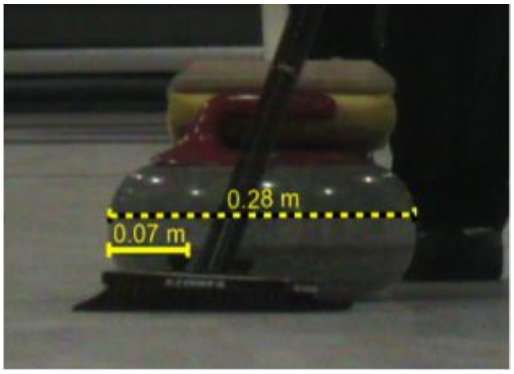


Figure 1: Set up for testing protocol. The dashed arrow shows the start and finish for the 25-second sweeping trial. The camera location is indicated.

Analysis of the sweeping performance was completed using Dartfish ProSuite (version 4.0.9). The 25-second sweeping bout was divided into 5-second intervals (0-5s, 5-10s, 10-15s, 15-20s, 20-25s). Within each 5-second interval and at approximately the midpoint of each, three successive sweeping strokes were selected for analysis. To measure sweeping rate, the time required to complete the three successive sweeping strokes was measured using the software's time clock (1 video frame = 0.0167s). One sweeping stroke was defined as the forwards and backwards movement of the broom. Sweeping rate was determined as the reciprocal of the time to complete the three strokes, and measured in strokes per second. To measure sweep length, the Analyzer function in the Dartfish software was used, which allows for distance measurements to be made based on a reference scale. Prior to testing, the diameter of the stone used for each trial was measured using a Harpenden anthropometer. Using the Dartfish Analyzer distance measurement function with the stone diameter as the reference scale, sweep length was measured (in meters) as the difference in the position of the broom from one end of the stroke to the other (Figure 2).



(a)



(b)

Figure 2: Screen captures outlining the method used to measuring sweep length. Using the diameter of the stone (0.28m) as the reference value, the change in position of the broom relative to the edge of the stone from one end of the stroke (a) to the other (b) was measured. In this example, sweep length is 0.13m.

Statistical analysis was completed using SPSS 18.0. Descriptive statistics (mean and SD) were calculated for the male and female participants for both sweep length and sweep rate during each 5-second interval of the sweep test. Factorial repeated measures ANOVAs were used to evaluate the sweep length and the sweep rate among the five time intervals and between genders. Significant main effects were further analyzed with Bonferroni adjusted pairwise comparisons. Alpha was set at $p \leq 0.05$.

RESULTS: The results for the sweep analysis are presented in Table 1, with mean (±SD) sweep length and sweep rate for both genders during each time interval.

Table 1: Sweep length and sweep rate data.

Variable	Gender	Time Interval				
		0-5s	5-10s	10-15s	15-20s	20-25s
Sweep Length (m)	Males	0.20±0.05	0.22±0.06	0.21±0.06	0.21±0.06	0.21±0.07
	Females	0.20±0.03	0.22±0.03	0.21±0.03	0.21±0.04	0.22±0.04
Sweep Rate (strokes•s^{-1})	Males	4.55±0.35	4.42±0.28	4.19±0.31	4.03±0.35	3.87±0.33
	Females	3.94±0.19	3.85±0.18	3.67±0.10	3.54±0.11	3.46±0.11

The results of the statistical analysis revealed no significant differences in sweep length between genders ($p = 0.922$), however, a significant main effect for the time interval was found ($p < 0.05$). Post-hoc analysis revealed that the only significant difference was seen between the sweep lengths for the 0-5s and the 5-10s intervals, in which the 5-10s interval sweep length was significantly longer ($p < 0.05$). For sweep rate, a significant main effect was found for the time interval ($p < 0.001$). For the males, post-hoc analysis indicated that statistically significant differences were seen in sweep rate among all five of the time intervals ($p < 0.05$). For women, however, there were no significant differences found between the 0-5s and 5-10s intervals and the 15-20s and 20-25s intervals. Significant differences were seen for the women among the other pairwise comparisons ($p < 0.05$). Males were found to have a significantly faster sweep rates than the females across all time intervals ($p < 0.001$).

DISCUSSION: Sweeping is an important aspect of successful strategic play in curling, and requires considerable physiological effort to be effective. With 4 curlers throwing 2 stones each over 10 ends, there can be significant amount of sweeping work performed over the course of a game. The diameter of the curling stone is approximately 0.28m, however, the circular band on which the stone actually makes contact with the ice is only 0.135m in diameter (Buckingham et al., 2006). This means that curlers are only required to move the brush a short distance when sweeping. The sweep lengths in the current study averaged approximately 0.21m, which is slightly larger than needed, but is considerably larger than the sweep lengths presented by Bradley (2009). Both the male and female curlers in this study were very consistent in their sweeping throughout the 25-second test, which is in agreement with previous research (Bradley, 2009). The only significant differences in sweep length among the five time intervals were seen at the start of the sweeping bout, in which shorter sweep lengths in the 0-5s interval were followed by longer sweep lengths in the 5-10s interval. Curlers should strive to be consistent in their sweep lengths to ensure their sweeping is both efficient and effective at all times.

Both the males and females in this study showed the same general pattern of decreased sweep rate from the start to the end of the 25-second sweeping bout, which is in agreement with previous research (Bradley, 2009; Buckingham et al., 2006). There were differences, however, between the genders in the rate at which the sweep rate decreased. Male curlers started with a much faster sweep rate in the first interval (4.55±0.35 strokes•s^{-1}) as compared to the females (3.94±0.19 strokes•s^{-1}), however, the sweep rate for the males began to decrease significantly by the second interval. The females, in comparison, did not show a significant decrease in sweep rate through the second interval. Similarly, females were also consistent in their sweep rates in the final two intervals of the sweep test. This suggests that there may be two different approaches used by curlers during sweeping. In curlers who produce very high sweep rates at the beginning of a sweeping bout, a consistent decrease in sweep rate may be seen over time. For curlers who do not achieve as fast a sweep rate, decreases in sweep rate will still occur but these decreases may not be as considerable.

The results from this study have implications for both the strategies employed during sweeping and in the physical conditioning of curlers. Having a better understanding of both sweep rate and sweep length during maximal effor sweeping would allow competitive teams to develop methods of optimizing sweeping performance. For example, it is known that the sweeper closes to the stone has the greatest influence on the ice-stone friction (Bradley, 2009). Therefore, curlers could devise schemes in which players could alternate sweeping close to the stone to allow one other player to reduce his/her sweep velocity to conserve energy while still contributing by clearing away the frost and debris. In addition, this information may allow coaches, athletes, and trainers to develop more effective training programs which target the specific physiological demands of sweeping, and would reduce the effects seen as a result of fatigue.

CONCLUSIONS: The results of this study provide insight into the sweep length and sweep rate for competitive male and female curlers. Sweep length was found to be similar between genders, with significant differences seen between the 0-5s and 5-10s time intervals. Sweep rate was significantly faster for males across all time intervals. The sweep rate for males decreased significantly at each time interval, whereas there were no significant differences in sweep rate for females between the 0-5s and 5-10s intervals and the 15-20s and 20-25s intervals.

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