DIFFERENCES IN ACCURACY AND CONSISTENCY IN ELITE LAWN BOWLERS

Samantha Birse[1], Kate Webster[1], Jodie McClelland[1], Kane Middleton[1]

[1]School of Allied Health, La Trobe University, Melbourne, Victoria, Australia

The purpose of this study was to compare the accuracy and consistency of repeated lawn bowls deliveries across four different bowling conditions, as well as the bias in displacement of bowls that did not hit the target. Twenty-seven national and international representative lawn bowls athletes completed 16 forehand and backhand deliveries at two different bowling lengths. The resting position of each bowl in relation to the target was used to calculate width, length and absolute displacement of bowls from the target for each participant in each condition. Accuracy was not different between conditions, but athletes were less consistent in delivering forehand bowls. Athletes also had greater displacement in bowling width during forehand deliveries. The results of this study can be used as a guide for targeting training strategies that improve lawn bowling performance.

KEYWORDS: lawn bowls, error, precision, performance

INTRODUCTION: Lawn bowls is a complex target-based sport that requires participants to roll an asymmetrical ball (bowl) down a grass or synthetic bowling rink towards a target bowl known as the Jack. The objective of the most common bowls delivery (draw shot) is for each bowl to come to rest as close to the Jack as possible (Hamdan, Suwarganda, Malik, & Wilson, 2011). An added complexity of lawn bowls that may not be present in most target-based sports, is that the bowl rolls with a curved trajectory. The curvature of the trajectory is dictated by characteristics of the bowl itself (Cross, 1998), though this may possibly be influenced by the technique of the bowler and the speed of the delivery, however this is yet to be determined.

A typical game of lawn bowls requires athletes to deliver draw shots using either a forehand (FH) or backhand (BH) that are aimed at a target of distances between 23m and 36m away from the athlete. Superior bowling performance relies on an athlete being able to deliver accurate bowls consistently across these changing conditions. Understanding how the accuracy and consistency of deliveries changes across conditions will allow for more specific training, and aid in tactical decision making to improve bowling performance. Therefore, the aim of this study was to determine whether there were differences in accuracy and consistency between the type of delivery (forehand or backhand) and the length of the delivery (short or long distance to Jack); and to describe the bias in the position of the bowls that missed the target in terms of length and width for each condition.

METHODS: Twenty-seven male and female national and international representative lawn bowlers were recruited through Bowls Australia. Seven indoor bowls carpets (Indoor Lifestyle Carpets, Henselite, Melbourne, Australia) were laid sequentially on an indoor synthetic running track to simulate a lawn bowls rink. Eight hemispherical retroreflective markers were placed on the non-running surface of the bowl (Fihure 1) to enable the bowl to be tracked by a 20-camera (T40) motion capture system (Vicon Motion Systems Ltd, Oxford, UK; 100 Hz) for all marker trajectories to be reconstructed in Vicon Nexus 2.5 (Oxford Metrics, Oxford, UK).

Athletes were assessed during four different bowling conditions: (i) FH draw over 23m (FH short), (ii) FH draw over 27m (FH long), (iii) BH draw over 23m (BH short) (iii), and BH draw over 27m (BH long). During a FH delivery the athlete releases the bowl so that the apex of the curvature of the bowl's trajectory is on the same side as the delivery arm, and the trajectory is on the opposite side of the delivery arm in BH delivery.

Athletes were tested in pairs and each pair were randomly allocated the order of the four testing conditions. Athletes were instructed to deliver their bowl to result as close to the Jack as possible and each bowl was removed from the playing surface once it had come to rest before the next bowl was delivered. For each condition, the first four deliveries were

considered familiarisation trials, which is typical of a game situation and were not included in analyses. Before proceeding to the next condition, athletes were required to deliver ten bowls within a 60cm radius around the Jack, as per standard training drills.

The resting position of each bowl relative to the Jack was recorded using the x (length) and y (width) distances. Participant means were calculated for each condition in terms of (i) absolute displacement of the bowl from the Jack, (ii) displacement in the x direction from the Jack (length of the rink), and (iii) displacement in the y direction from the Jack (width of the rink). Negative length displacement indicated that the bowl did not reach the distance of the Jack and negative width displacement indicated that the bowl did not return to the midline from the apex of the curved trajectory. As a measure of accuracy, for each participant and each condition, the mean of the absolute displacement was calculated (commonly known as radial error) (Hancock, Butler, & Fischman, 1995; Phillips, Portus, Davids, & Renshaw, 2012). As a measure of consistency, the bivariate error was calculated where the difference between the x and y components of each bowl and the participant mean was averaged across all trials within a condition for each participant (Hancock, et al, 1995; Phillips, et al, 2012). The bias for bowls to miss the target by length (too short or too long) or by width was described in terms of the mean of the x component and y component, respectively.

Measures of accuracy, bias and consistency were compared between conditions using a two-way repeated measures analysis of variance with two factors (delivery hand and bowling length). Where a significant interaction was shown, Tukey's post hoc tests were conducted to identify the location of the effect. In terms of bias, the proportion of athletes with resting positions in (i) positive x and positive y coordinates, (ii) positive x and negative y coordinates, (iii) negative x and negative y coordinates, and (iv) negative x and positive y coordinates were reported to describe group trends. Significance level of $P \leq 0.05$ was set for all analyses, and all statistical analyses were completed in SPSS (IBM, SPSS Statistics, v 24).

Figure 1: Marker placement on the bowl

RESULTS: Regarding accuracy, a main effect of bowling length was statistically significant ($F_{1,26}$=4.14; P=0.05; Table 1) where athletes were more accurate at the longer length, and there was a significant interaction between delivery hand and bowling length ($F_{1,26}$=8.66; P=0.007). Post hoc tests on the interaction showed that there were significant differences in accuracy between FH short and FH long (P=0.04), as well as FH short and BH short (P=0.03). In terms of consistency, there was no significant main effects of bowling length nor delivery type (main effect for delivery type: $F_{1,26}$=0.22; P=0.65; main effect for distance of delivery: $F_{1,26}$=2.60; P=0.12). There was a significant interaction for the consistency measure ($F_{1,26}$=4.37; P=0.05). Post hoc tests showed that the FH short condition was significantly less consistent than the FH long (P=0.03), and the FH long was significantly more consistent than the BH long condition (P=0.04). When comparing the bias for bowls to be displaced in length, there were no significant differences across conditions in terms of the interaction or main effects (interaction $F_{1,26}$=2.01; P=0.17; main effect for delivery type: $F_{1,26}$=1.76; P=0.20; main effect for distance of delivery: $F_{1,26}$=0.60; P=0.44). However, when comparing the bias for

bowls to be displaced in width, there was a significant main effect of delivery type where FH deliveries came to rest with greater width displacement than BH deliveries ($F_{1,26}$=40.90; *P*<0.001; Figure 1). Fifty percent of athletes had an average displacement on the forehand that was greater than the distance of the Jack for forehand, and 51.8% had the same for the backhand (Figure 2). Conversely, 87% of athletes had an average displacement in width for forehand that did not reach the midline, compared to only 37% for backhand.

Table 1: Group means (±SD) of absolute, participant standard deviation in absolute displacement, and length, and width displacements for each bowling condition.

Bowling Condition	FH Short	FH Long	BH Short	BH Long	Interaction P-value	Main Effect (FH/BH) P-value	Main Effect (Length) P-value
Absolute Displacement (Accuracy) (cm)	80.2 ± 21.5	69.1 ± 18.1†	69.1 ± 14.6†	70.8 ± 15.0	***0.01****	0.26	***0.05****
Bivariate Error (Consistency) (cm)	75.2 ± 22.3	63.6 ± 14.6†	70.0 ± 16.4	71.7 ± 14.2††	***0.05****	0.64	0.12
Length Displacement (cm)	-3.3 ± 29.6	-0.6 ± 20.1	9.2 ± 25.9	0.4 ± 25.1	0.20	0.44	0.17
Width Displacement (cm)	-29.4 ± 30.5	-25.8 ± 31.8	-1.1 ± 23.0	3.4 ± 27.2	0.78	***<0.001****	0.16

*Significant at *P*<0.05 level
†Post Hoc test significantly different compared to FH short condition
††Post Hoc test significantly different compared to FH long condition

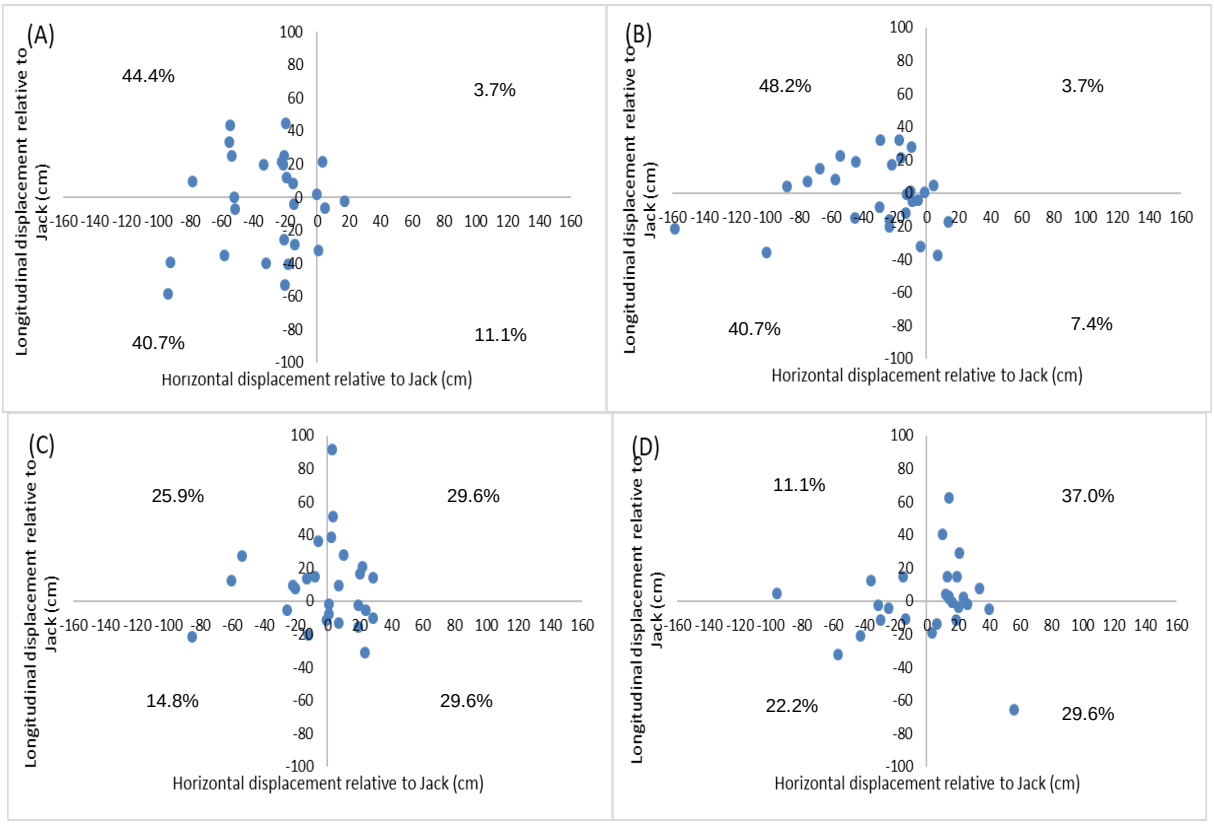

Figure 2: Average result of a bowls per athlete in (A) FH short, (B) FH long, (C) BH short, and (D) BH long conditions relative to the Jack position.

DISCUSSION: The ability to accurately deliver a bowl towards the target is paramount to success in lawn bowls. Statistically, the forehand short was the least accurate condition and were more accurate at the long bowling length. In addition, athletes were significantly more consistent at the forehand long condition than the forehand short and backhand long conditions. Being able to repetitively deliver a bowl to the same desired location is an essential skill for successful game outcomes and overall performance, and therefore, these findings suggest that elite lawn bowlers may be more successful in game situations when bowling forehand draw shots towards a Jack placed 27 metres from the bowler. This means that, when given the opportunity, athletes may seek to place the Jack at a longer distance to deliver a bowl on their forehand, or preference the use of backhand deliveries when targeting shorter distances. Training that aims to improve performance over all conditions should focus on improving consistency in short forehand deliveries in particular.

When a draw shot achieves the ideal outcome of resulting at the Jack, a bowl that overestimates the length of the target may be preferable to a delivery that falls short because of the possibility that the Jack could be propelled to a greater distance from direct contact with another bowl (Judson, 2003). However, in this study there was a bias towards overestimating the distance of the Jack by only half of the athletes. Furthermore, in terms of width, the overwhelming majority of athletes had a bias towards bowls not reaching the midline after the apex of the bowls' trajectory, and this was more pronounced in forehand deliveries. This suggests that when bowling on the forehand, athletes may aim too wide (Cross, 1998; Judson, 2003). Training techniques that aim to improve accuracy should therefore consider the interaction between the target, bowl curvature and speed.

CONCLUSION: The results of this study show that elite athletes are similarly accurate in delivering lawn bowls across forehand and backhand, and across different lengths. However, these athletes were more consistent in delivering bowls towards a target that was placed at a greater distance. There was a bias for athletes to be further from the target when delivering forehand bowls than backhand, and for the athletes to misjudge the width of the target to a greater extent than the length. This information provides specific targets for coaching techniques that aim to improve bowling accuracy and consistency. Future research may examine with-in subject accuracy and consistency to improve individual athletes' performance.

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ACKNOWLEDGEMENTS: The authors would like to thank Bowls Australia for funding this research, and the Australian Institute of Sport for use of their High Performance Centre.