FRONTAL PLANE ALIGNMENT DURING FOREHAND AND BACKHAND LAWN BOWLS DELIVERIES

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There is very little research on the biomechancis of the lawn bowls delivery. Bowls are commonly delivered using either a forehand or backhand technique. The purpose of this study was to compare the pelvis, trunk and upper limb kinematics of the forehand and backhand lawn bowls delivery. Elite lawn bowlers (n=18) who were competing at international level performed a series of forehand and backhand lawn bowls deliveries on a simulated indoor bowling rink. Differences were found between the delivery types for pelvis and trunk segment angles but there were no differences in upper limb frontal plane joint angles at the shoulder, elbow or wrist. It was concluded that the backhand delivery is executed with a more upright technique, possibly affecting weight transfer during the delivery stride. The similarity in upper limb kinematics suggests coaching drills that focus on the upper limb can benefit deliveries on both the forehand and backhand.

KEYWORDS: upper limb, bowling, coaching.

INTRODUCTION: Lawn bowls' popularity is due to its accessibility. People of varying ages, backgrounds and abilities can participate across a range of formats. There were 671,316 bowls participants in Australia in 2017 with the largest sector being social (62%), followed by pennant/competition (31%) and 'jack attack'/school programs (7%) (Bowls Australia, 2019). Although social participation increased 15.6% from 2010 to 2017, there was a 7.2% decrease in regular pennant/competition participation over the same time period. A report commissioned by Bowls Australia on participation in the sport found that there was some dissatisfaction with the coaching provided to players at their respective clubs (Hoye, Brown, Nicholson, Sherry, & Clement, 2013). This may not be surprising given most of the coaching literature is based on personal experience (e.g. Judson, 2002), with little scientific research having been conducted on the mechanics of the lawn bowls delivery.
Lawn bowls are shaped asymmetrically, creating a rolling bias on one side and influences its trajectory (Cross, 1998) and has implications for game-play strategy. Bowls are typically delivered with either a forehand or backhand delivery style. The forehand is delivered with the bowl released so that the apex of the bowl's trajectory is on the same side as the delivery arm, whereas the backhand is delivered with the bowl released so that the apex of the bowl's trajectory is on the opposite side of the delivery arm. Most interceptive sports such as tennis (Elliott, 2005), table tennis (Bankosz & Winiarski, 2018; Huang et al., 2013), and squash (Ariff, Osman, & Usman, 2012) feature a forehand and backhand that requires a change in technique due to task constraints. It is currently unknown whether lawn bowlers adapt their technique from the forehand to backhand delivery. Knowing this will advance coaching practices so that relevant technical feedback can be provided to players.
The aim of this study was to compare the pelvis, trunk and upper limb kinematics of the forehand and backhand lawn bowls delivery, with a focus on the frontal plane. The null hypothesis was that there would be no difference in pelvis, trunk, nor upper limb kinematics between the forehand and backhand lawn bowls delivery.

METHODS: Eighteen male and female lawn bowlers (12 males, 6 females; age 27.8 ± 7.1 years, height 1.76 ± 0.10 m and mass 83.1 ± 21.4 kg) who were international representatives at the time of data collection volunteered to participate in this study. Ethics approval was granted and written informed consent was obtained from each participant prior to the commencement of the study, in accordance with the requirements of the La Trobe University Human Research Ethics Committee.

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. Participants bowled to a 'jack' that was placed 27 m away on both the forehand and backhand. Participants bowled in pairs with the order of delivery hand randomised for each pair. Participants were instructed to deliver each bowl to stop 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. The first four deliveries of each condition were considered familiarisation trials. Participants were required to deliver five bowls within a 60 cm radius around the jack, as per standard training drills.

Marker trajectory data were collected using a 20-camera T40 motion capture system (Vicon Motion Systems Ltd, Oxford, UK; 100 Hz). A full body marker set (Middleton, Mills, Elliott, & Alderson, 2016; Wells, Donnelly, Elliott, Middleton, & Alderson, 2018) consisting of 64, 12 mm retro-reflective markers, was affixed to the trunk, pelvis and the lower and upper limbs. Vicon Nexus software (version 2.5, Vicon Motion Systems Ltd, Oxford, UK) was used to track, label and complete marker trajectories for each trial. Marker trajectory data were filtered using a fourth order Butterworth low pass filter with a cut-off frequency of 12 Hz. Filtered data were modelled using custom static and dynamic direct kinematic models (Campbell, Lloyd, Alderson, & Elliott, 2009; Campbell, Alderson, Lloyd, & Elliott, 2009; Harrington, Zavatsky, Lawson, Yuan, & Theologis, 2007; Middleton et al., 2016; Wells et al., 2018).

Variables of interest included frontal plane segment angles of the pelvis and trunk as well as shoulder, elbow and wrist angles (Figure 1). In addition, relative trunk to pelvis angle was calculated. To investigate the kinematic differences between the forehand and backhand deliveries, a series of paired-sample t-tests were performed with an alpha level of .05. Effect sizes (Cohen, 1992) were calculated to reflect functional differences between groups. An effect size of 0.2 was considered small, 0.5 medium, and 0.8 large. All statistical analyses were completed in the IBM SPSS Statistics software package (version 25, IBM Corporation, New York, USA).

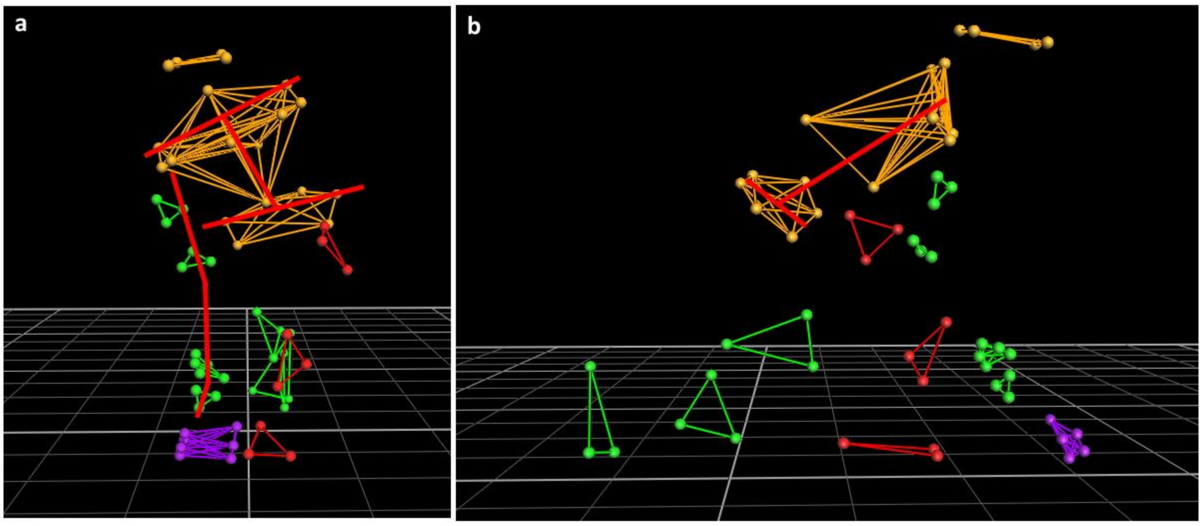

Figure 1: Graphical representation of the forehand delivery from the frontal (a) and sagittal (b) plane. The red lines indicate the segment and joint angles that were analysed.

RESULTS: The forehand was delivered with significantly higher pelvic obliquity (left hip higher than right hip; mean difference ± standard error: 7 ± 1°) and trunk right lateral flexion (left shoulder higher than right shoulder; 11 ± 1°) compared with the backhand delivery (Table1). The forehand was also delivered with significantly higher trunk flexion (9 ± 2°) but lower trunk left rotation (5 ± 2°) when expressed relative to the pelvis. Trunk lateral flexion relative to the pelvis was not different between the forehand and backhand (p = .411). There were no differences between forehand and backhand frontal plane joint angles at the shoulder, elbow nor wrist.

Table 1: Kinematic differences between the forehand and backhand lawn bowls deliveries at the instance of bowl release.

Variable (°)	Forehand	Backhand	*p*-value	Effect size (*d*)
Segment angles				
Pelvis obliquity	19 ± 8	12 ± 7	**< .001**	0.93 [0.25 – 1.61]
Trunk lateral flexion	30 ± 9	19 ± 10	**< .001**	1.16 [0.48 – 1.83]
Trunk relative to Pelvis				
Flexion/extension	36 ± 12	27 ± 9	**< .001**	0.85 [0.17 – 1.53]
Lateral flexion	11 ± 8	12 ± 7	.411	-0.13 [-0.81 – 0.54]
Rotation	6 ± 5	11 ± 7	**.015**	-0.82 [-1.50 – -0.14]
Frontal plane joint angles				
Shoulder	-42 ± 10	-42 ± 10	.412	0.00 [-0.68 – 0.68]
Elbow	-15 ± 5	-15 ± 5	1.000	0.00 [-0.68 – 0.68]
Wrist	14 ± 8	14 ± 8	.135	0.00 [-0.68 – 0.68]

DISCUSSION: The purpose of this study was to compare the pelvis, trunk and upper limb kinematics of the forehand and backhand lawn bowls delivery. The null hypothesis that there would be no difference in upper limb kinematics between the forehand and backhand lawn bowls delivery was accepted. However, the null hypothesis that there would be a significant difference in pelvis and trunk kinematics between the forehand and backhand lawn bowls delivery was rejected.

The frontal plane pelvis and trunk angles suggest that elite lawn bowls players deliver the bowl with the same angular displacement between the pelvis and trunk, but the trunk-pelvis system is laterally flexed ~10° less when bowling on the backhand compared with the forehand. Along with the decreased trunk flexion angle, it can be concluded that the backhand delivery is executed with a more upright technique when compared with the forehand. Previous research has reported that the backhand delivery of elite lawn bowlers is characterised by a larger stride length than the forehand (Birse, Webster, McClelland, Middleton, 2019), which suggests that elite lawn bowlers either ‘sit back’ on the backhand delivery or adjust their stride and/or pelvis and trunk mechanics to attain a similar release point to the forehand. This may have performance implications as it may inhibit weight transfer from the back to front foot leading up to bowl release. An investigation into the ground reaction forces during the forehand and backhand lawn bowls delivery would provide additional information about the execution of these deliveries.

The equivalent frontal plane kinematics of the shoulder, elbow and wrist in the forehand and backhand delivery, coupled with the difference in trunk and pelvis kinematics, suggests that the deliveries are executed with altered upper limb verticality. As the backhand is delivered with a less laterally flexed pelvis-trunk system but not upper limb joint kinematics, it is likely that it is delivered with a less vertical arm. It is unknown how this may affect bowl trajectory, but a bowl delivered with a more vertical arm would allow the position of the bowl to be released further towards the centre of the body’s base of support (Judson, 2002). These results provide guidance to coaches that technical drills that focus on the upper limb, but not the pelvis or trunk, may be delivery type agnostic.

CONCLUSION: This study quantified the differences between the forehand and backhand lawn bowls delivery in elite lawn bowlers. Generally, differences were limited to pelvis and trunk angles, with no difference at the shoulder, elbow, nor wrist. Backhand deliveries were delivered with less global pelvic obliquity, global trunk lateral flexion, and trunk flexion relative to the pelvis. They were also delivered with more trunk rotation relative to the pelvis. These data provide coaches and researchers with new information about the lawn bowls delivery, and more specifically, some evidence that when conducting technical coaching of forehand and backhand deliveries, differences exist at the pelvis and trunk but not upper limb joint angles in the frontal plane.

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