

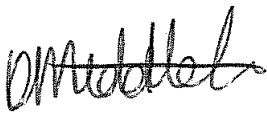
Re: Biomechanical Analysis of Lawn Bowls

Dear Mr Vellapandian Ponnusamy,

In response to a request from Bowls WA, the following report has been generated by Biomechanical Sports Services. Within this report, key kinematic variables are measured as well as motion data. The purpose of this analysis was to quantify the techniques used by elite male and female lawn bowlers. We hope that this report provides fruitful information that will be of assistance to Bowls WA.

If you require any further information feel free to contact us at any time.

Yours sincerely,



Kane J. Middleton, BSc. (Hons)
Biomechanics / Performance Analyst

Research Assistant: Gillian Weir

Beth

Draw

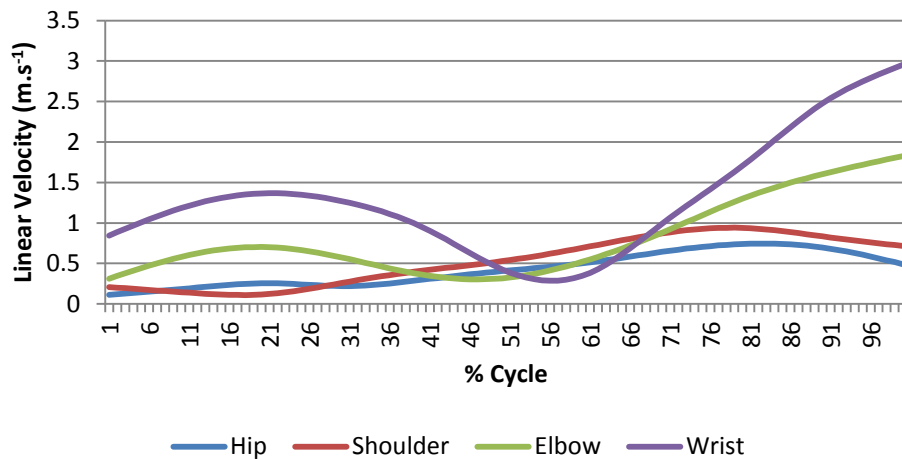


Event	Unit	Result
Front Foot Contact		
Stride length	Dist between feet	0.55
CG position	% stride length	10
Head position	% stride length	100
Back knee angle	deg	75
Front knee angle	deg	30
Front ankle angle	deg	90
Back ankle angle	deg	115
Upper arm angle	deg	-55
Elbow angle	deg	15

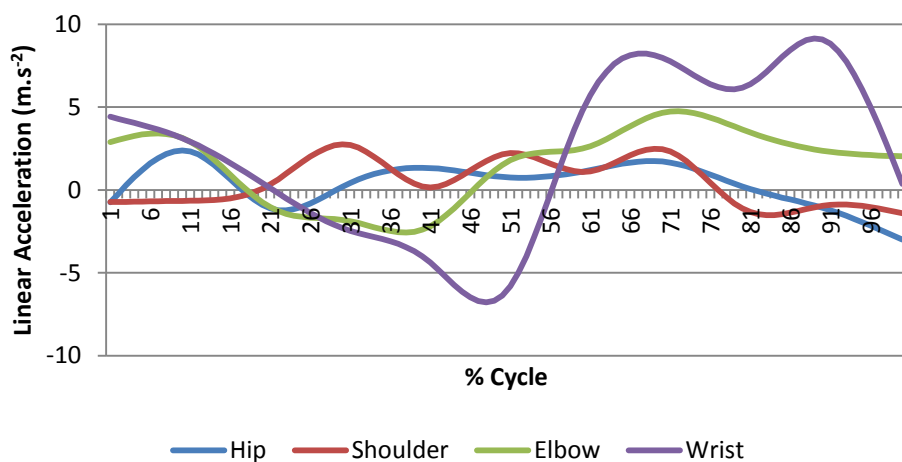
Event	Unit	Result
Release		
CG position	% stride length	50
Head position	% stride length	130
Back knee angle	deg	75
Front knee angle	deg	60
Front ankle angle	deg	100
Back ankle angle	deg	105
Upper arm angle	deg	6
Elbow angle	deg	15
Ball position	% stride length	150



Joint Centre Linear Velocities



Joint Centre Linear Accelerations

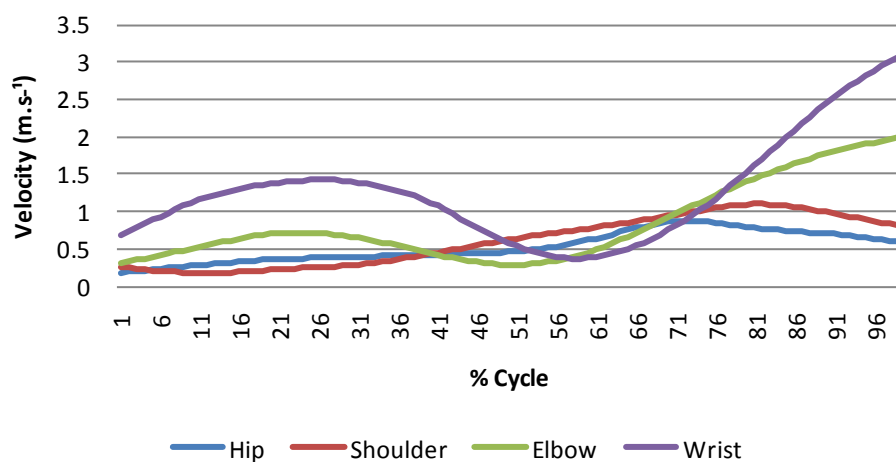


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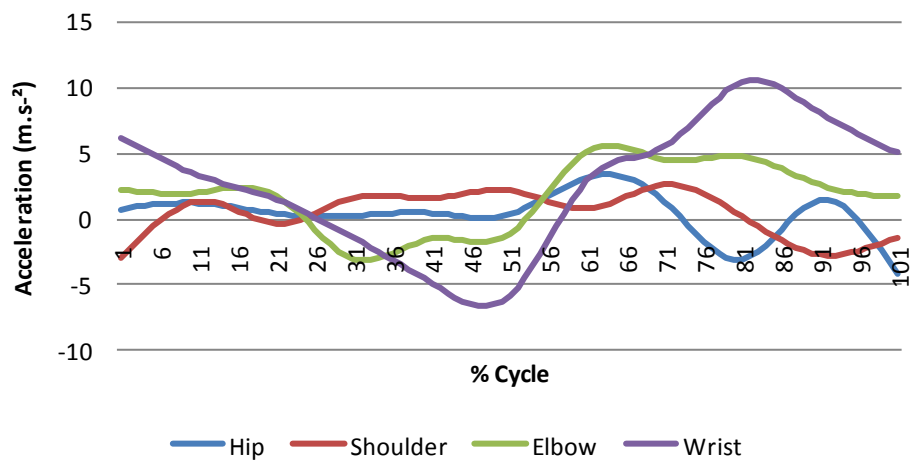




Joint Centre Linear Velocities



Joint Centre Linear Accelerations



Therese

Draw

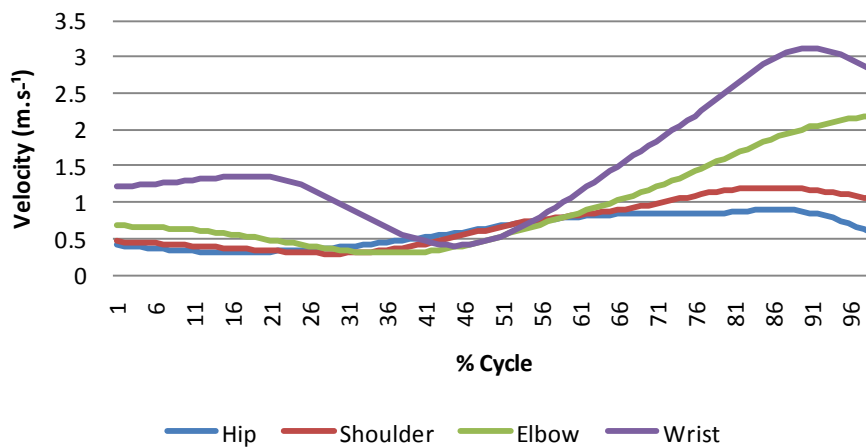


Event	Unit	Result
Front Foot Contact		
Stride length	Dist between feet	0.63
CG position	% stride length	14
Head position	% stride length	74
Back knee angle	deg	92
Front knee angle	deg	35
Front ankle angle	deg	96
Back ankle angle	deg	122
Upper arm angle (s)	deg	-72
Elbow angle	deg	27

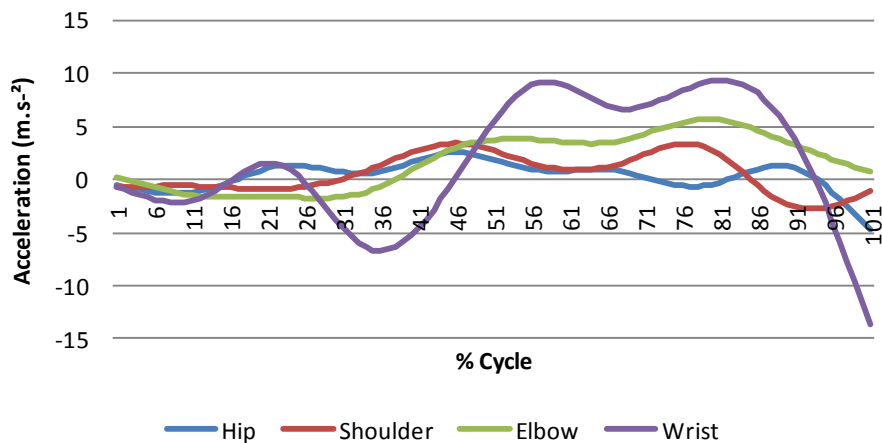
Event	Unit	Result
Release		
CG position	% stride length	33
Head position	% stride length	92
Back knee angle	deg	113
Front knee angle	deg	96
Front ankle angle	deg	97
Back ankle angle	deg	119
Upper arm angle (s)	deg	5
Elbow angle	deg	19
Ball position	% stride length	101



Joint Centre Linear Velocities



Joint Centre Linear Accelerations

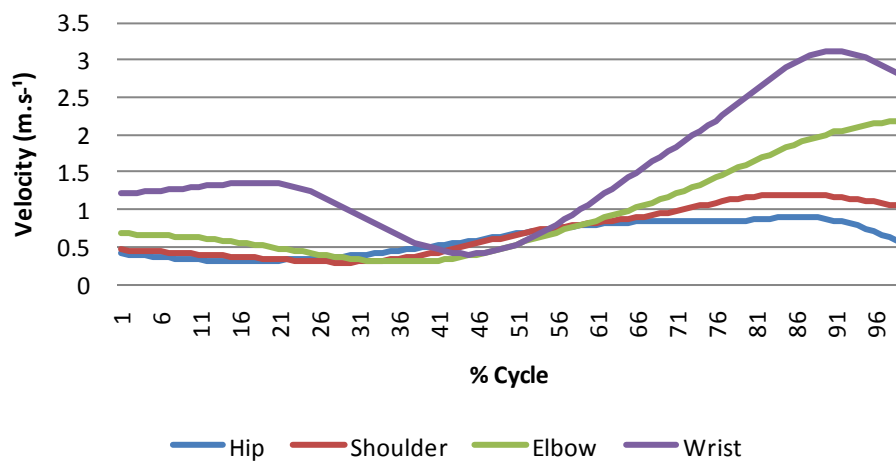


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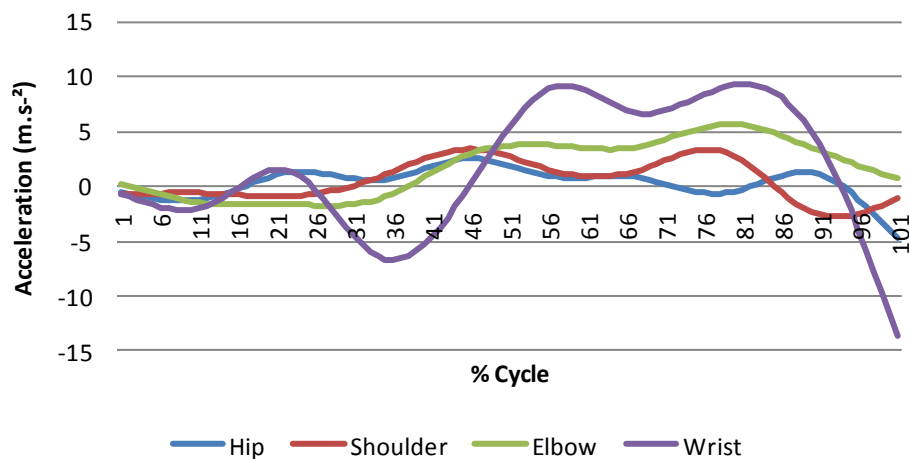




Joint Centre Linear Velocities



Joint Centre Linear Accelerations



Pam

Draw

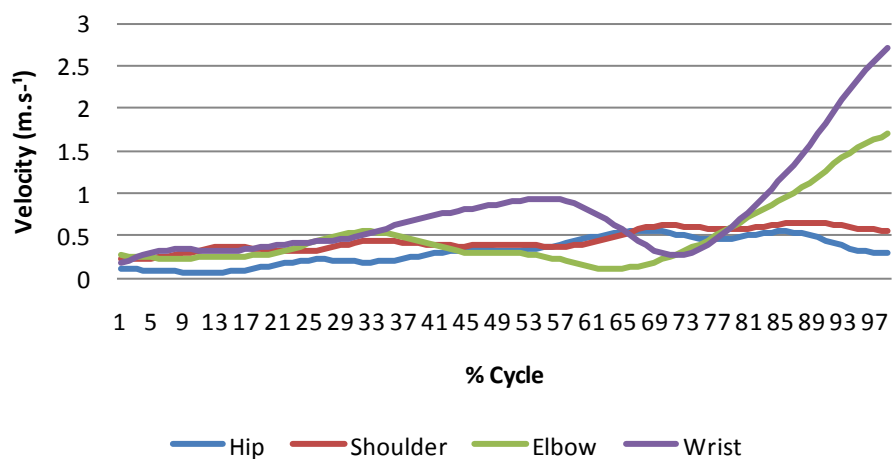


Event	Unit	Result
Front Foot Contact		
Stride length	Dist between feet	.49
CG position	% stride length	14
Head position	% stride length	120
Back knee angle	deg	106
Front knee angle	deg	21
Front ankle angle	deg	92
Back ankle angle	deg	113
Upper arm angle (s)	deg	-29
Elbow angle	deg	21

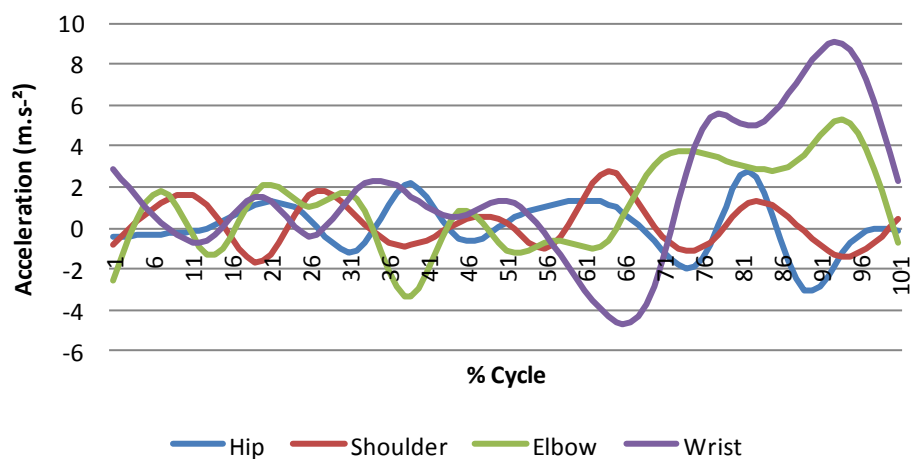
Event	Unit	Result
Release		
CG position	% stride length	16
Head position	% stride length	132
Back knee angle	deg	94
Front knee angle	deg	109
Front ankle angle	deg	101
Back ankle angle	deg	103
Upper arm angle (s)	deg	5
Elbow angle	deg	19
Ball position	% stride length	167



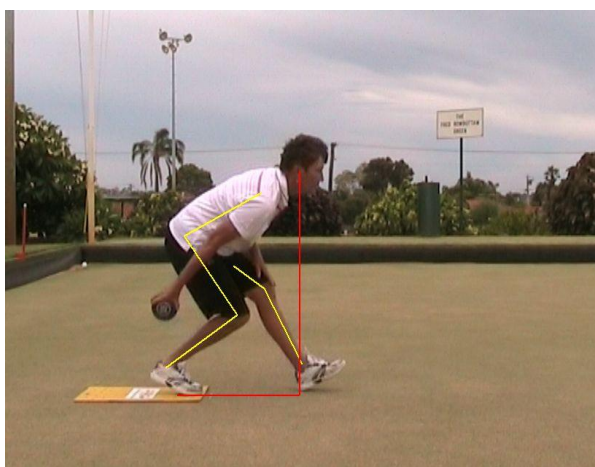
Joint Centre Linear Velocities



Joint Centre Linear Accelerations

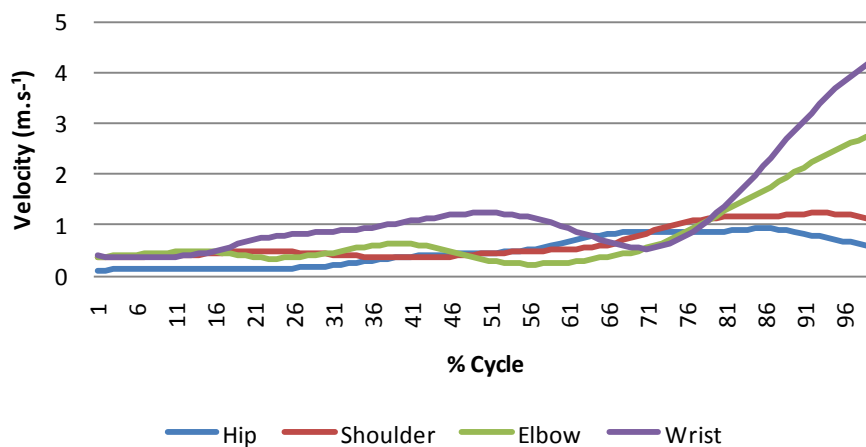


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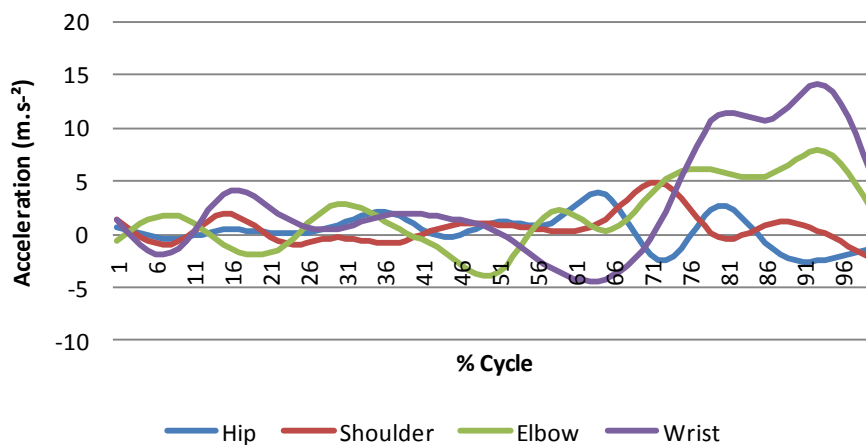




Joint Centre Linear Velocities



Joint Centre Linear Accelerations



John

Draw

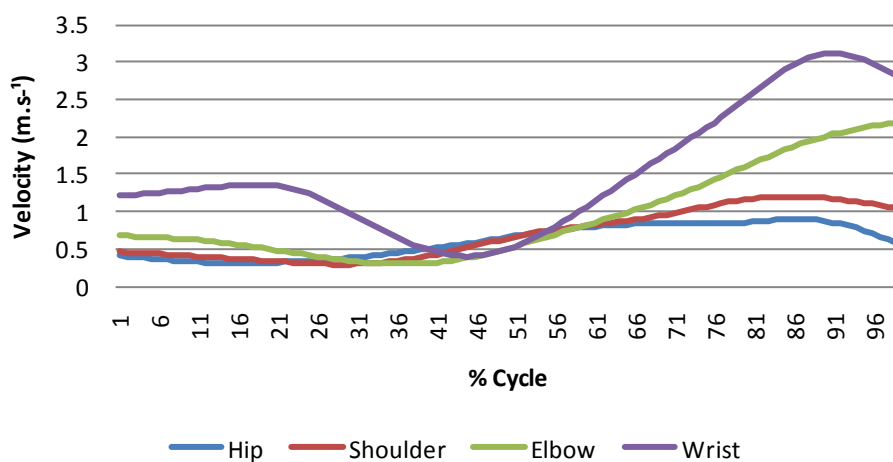


Event	Unit	Result
Front Foot Contact		
Stride length	Dist between feet	0.84
CG position	% stride length	27
Head position	% stride length	67
Back knee angle	deg	94
Front knee angle	deg	23
Front ankle angle	deg	89
Back ankle angle	deg	123
Upper arm angle (s)	deg	-51
Elbow angle	deg	22

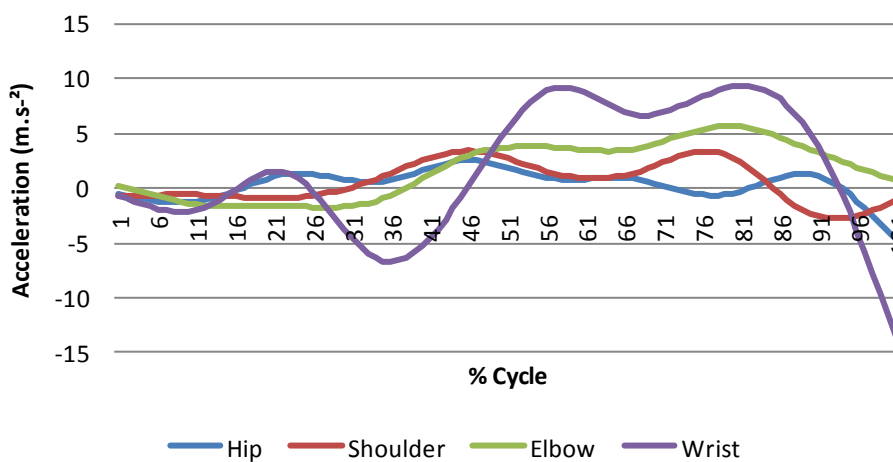
Event	Unit	Result
Release		
CG position	% stride length	55
Head position	% stride length	87
Back knee angle	deg	111
Front knee angle	deg	112
Front ankle angle	deg	121
Back ankle angle	deg	92
Upper arm angle (s)	deg	13
Elbow angle	deg	15
Ball position	% stride length	114



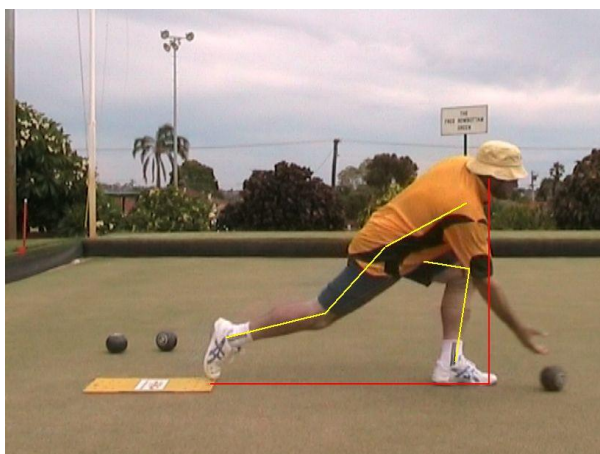
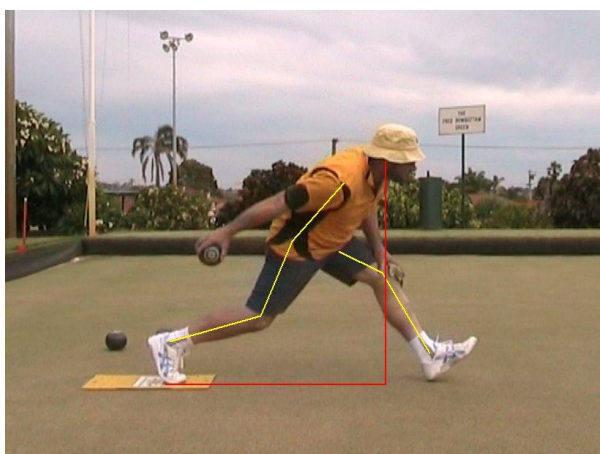
Joint Centre Linear Velocities



Joint Centre Linear Accelerations

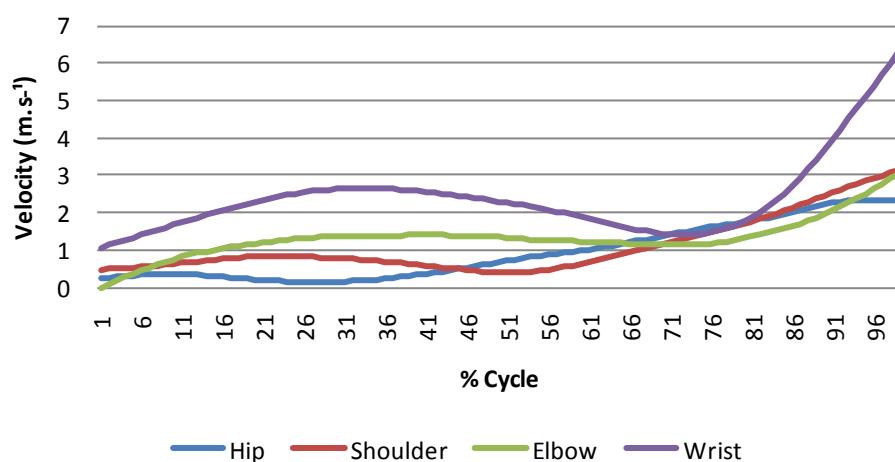


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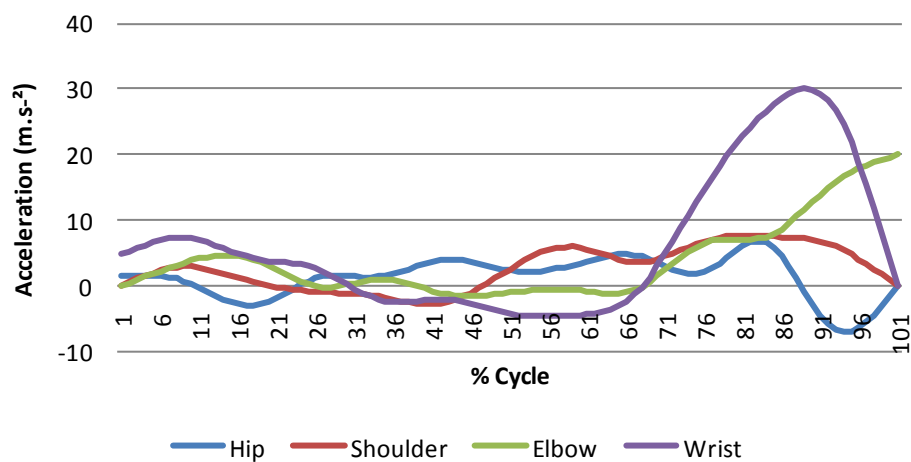




Joint Centre Linear Velocities



Joint Centre Linear Accelerations



Pieter

Draw

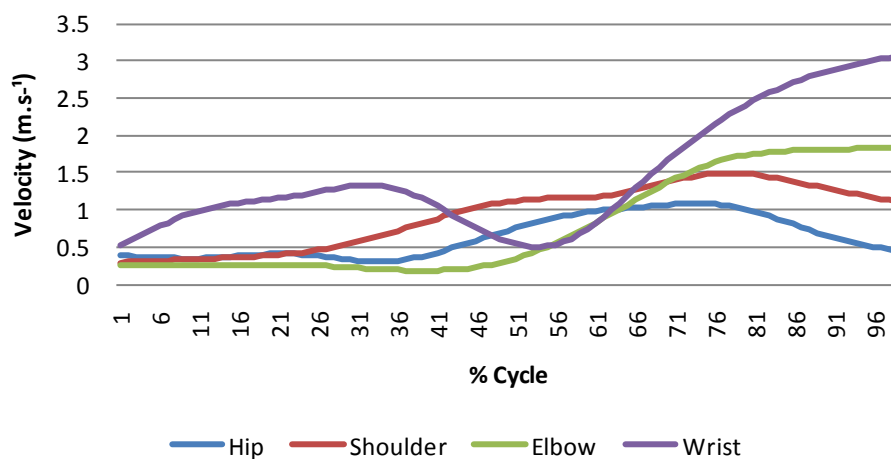


Event	Unit	Result
Front Foot Contact		
Stride length	Dist between feet	.66
CG position	% stride length	36
Head position	% stride length	104
Back knee angle	deg	68
Front knee angle	deg	24
Front ankle angle	deg	96
Back ankle angle	deg	110
Upper arm angle (s)	deg	-40
Elbow angle	deg	18

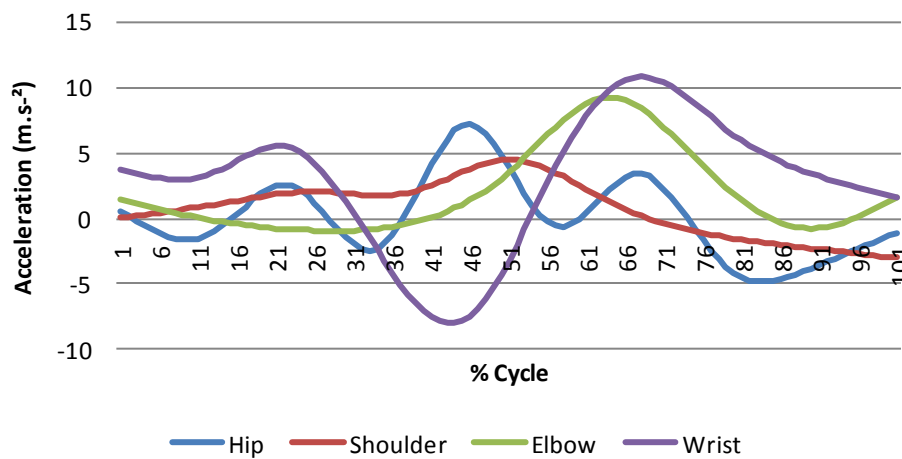
Event	Unit	Result
Release		
CG position	% stride length	45
Head position	% stride length	118
Back knee angle	deg	87
Front knee angle	deg	64
Front ankle angle	deg	106
Back ankle angle	deg	80
Upper arm angle (s)	deg	2
Elbow angle	deg	14
Ball position	% stride length	123



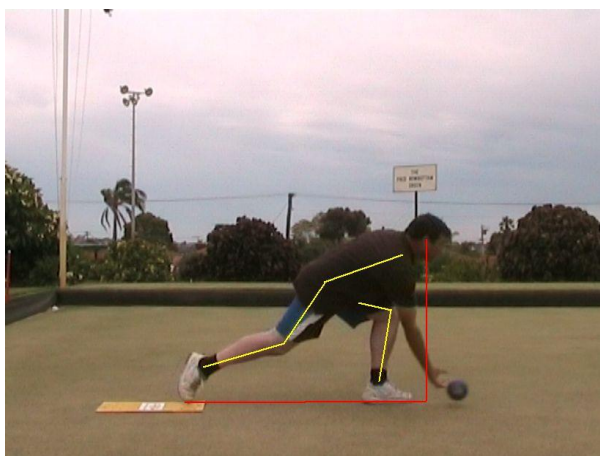
Joint Centre Linear Velocities



Joint Centre Linear Accelerations

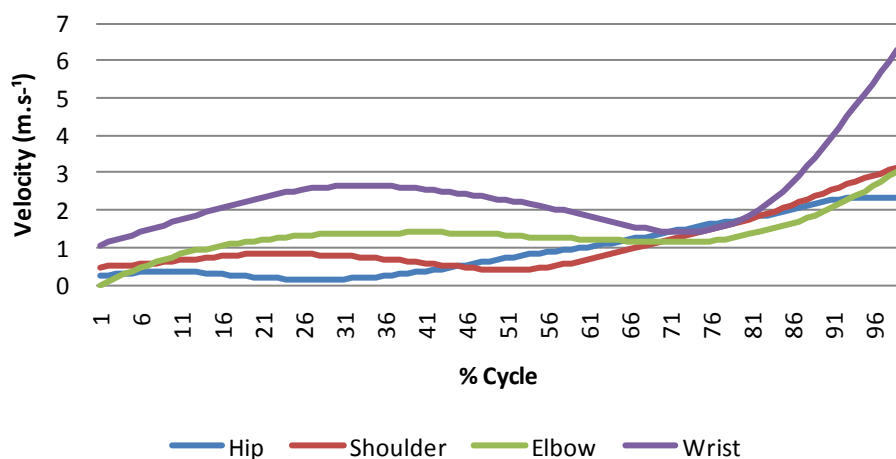


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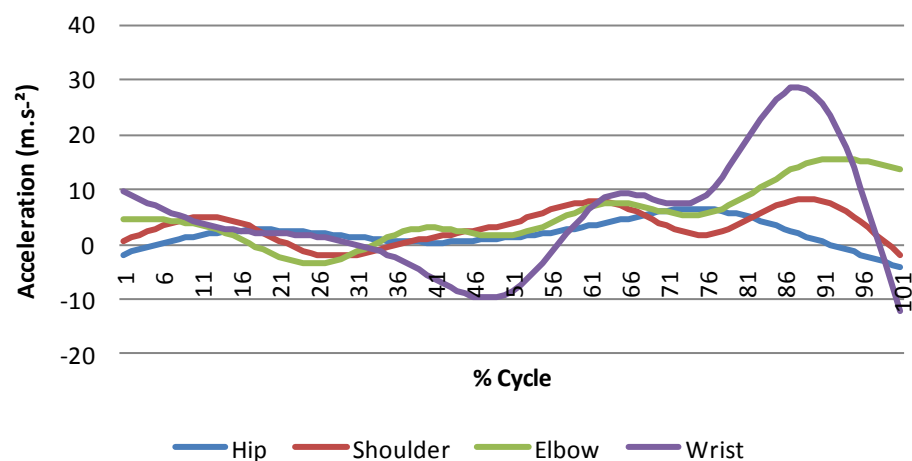




Joint Centre Linear Velocities



Joint Centre Linear Accelerations



Tristan

Draw

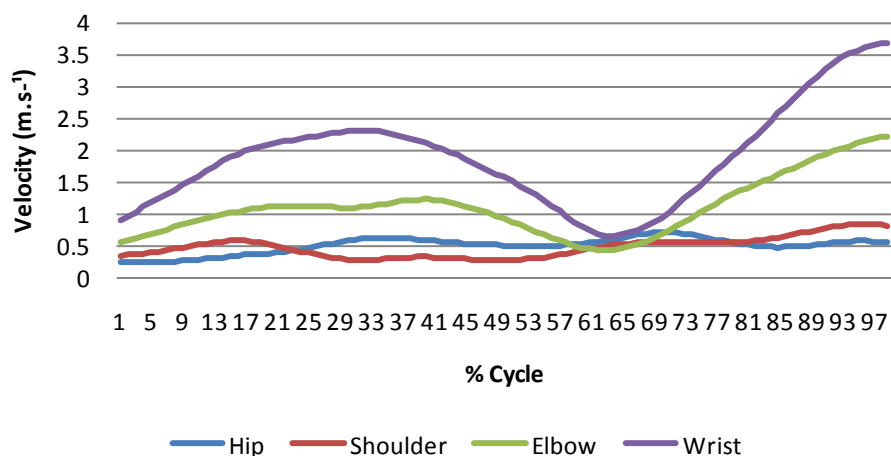


Event	Unit	Result
Front Foot Contact		
Stride length	Dist between feet	0.62
CG position	% stride length	10
Head position	% stride length	85
Back knee angle	deg	98
Front knee angle	deg	38
Front ankle angle	deg	93
Back ankle angle	deg	136
Upper arm angle (s)	deg	-69
Elbow angle	deg	19

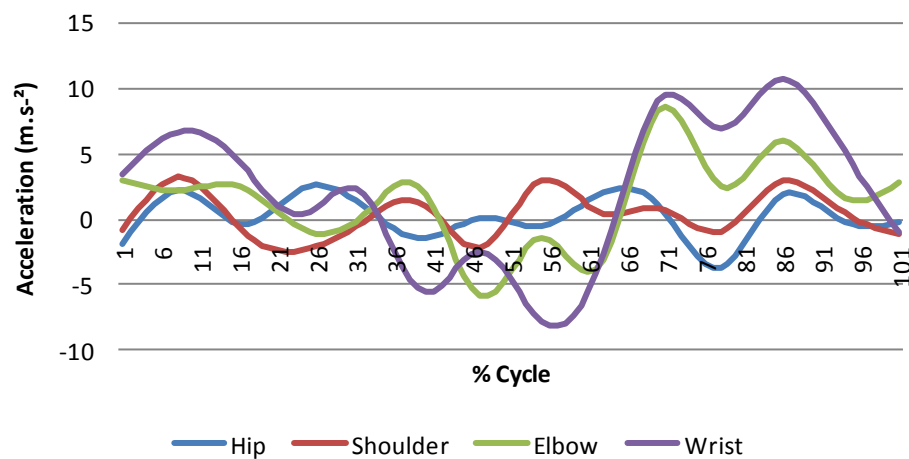
Event	Unit	Result
Release		
CG position	% stride length	32
Head position	% stride length	93
Back knee angle	deg	127
Front knee angle	deg	106
Front ankle angle	deg	116
Back ankle angle	deg	114
Upper arm angle (s)	deg	11
Elbow angle	deg	12
Ball position	% stride length	125



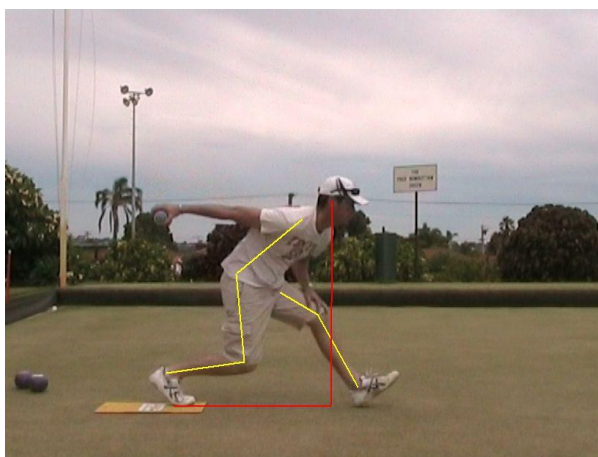
Joint Centre Linear Velocities



Joint Centre Linear Accelerations

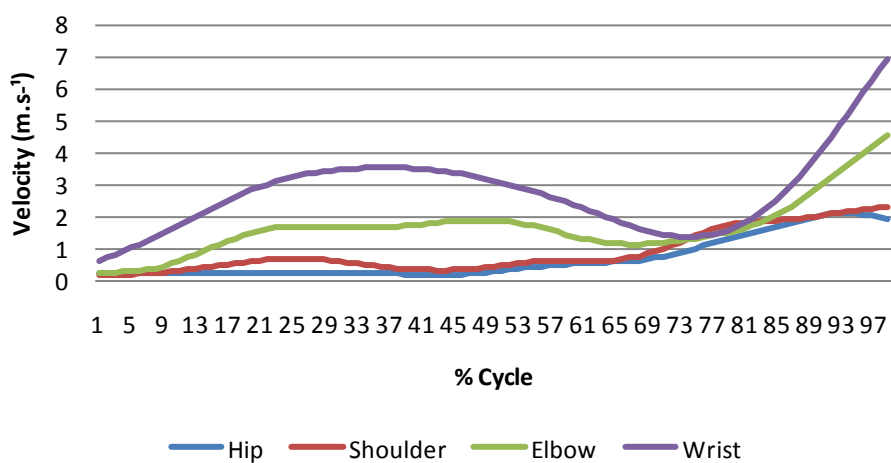


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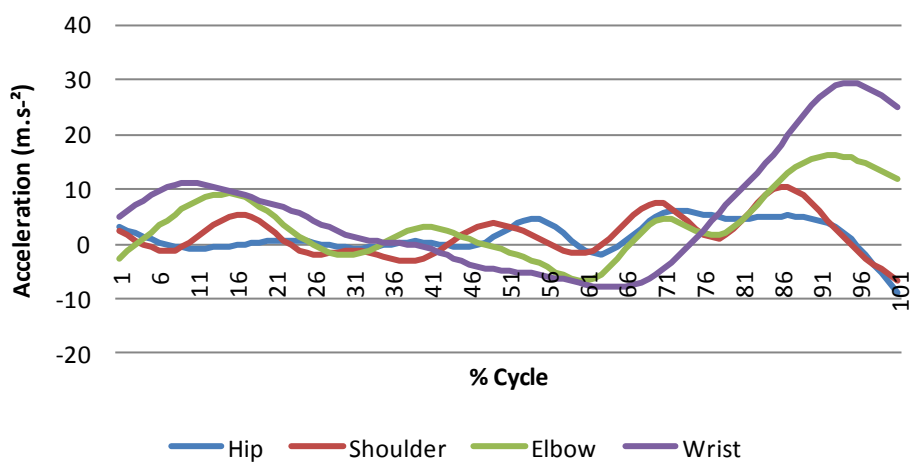




Joint Centre Linear Velocities



Joint Centre Linear Accelerations



Lawn Bowls Analysis - Summary

Event		Unit		Result			
Front Foot Contact		Beth	Therese	Pam	John	Peter	Tristan
Stride length	Dist between feet	0.55	0.63	0.49	0.84	0.66	0.62
CG position	% stride length	10	14	14	27	36	10
Head position	% stride length	100	74	120	67	104	85
Stride width	meters	0.07	0.18	0.12	0	0	0
Back knee angle	deg	75	92	106	94	68	98
Front knee angle	deg	30	35	21	23	24	38
Front ankle angle	deg	90	96	92	89	96	93
Back ankle angle	deg	115	122	113	123	110	136
Upper arm angle (s)	deg	-55	-72	-29	-51	-40	-69
Elbow angle	deg	15	27	21	22	18	19
Release							
CG position	% stride length	50	33	16	55	45	32
Head position	% stride length	130	92	132	87	118	93
Back knee angle	deg	75	113	94	111	87	127
Front knee angle	deg	60	96	109	112	64	106
Front ankle angle	deg	100	97	101	121	106	116
Back ankle angle	deg	105	119	103	92	80	114
Upper arm angle (s)	deg	6	5	5	13	2	11
Upper arm angle (f)	deg	20	17	6	16	13	17
Trunk lean	deg	15	21	29	24	23	20
Elbow angle	deg	15	19	19	15	14	12
Ball position	% stride length	150	101	167	114	123	125

Summary and conclusions

At front foot contact:

- The horizontal position of the centre of gravity position (approximately the hip) should be 10-30% of the stride length
- Horizontal head position should be 75-100% of the stride length
- Back knee is flexed between 90-110°
- Front knee is slightly flexed up to 45°
- Backswing between 45-70° and is aligned with maximum backswing

At ball release:

- The horizontal position of the centre of gravity position (approximately the hip) should be 40-60% of the stride length
- Horizontal head position should be 90-110% of the stride length
- Back knee is flexed between 90-120°
- Front knee is flexed up to 90-120°
- Upper arm is slightly past the vertical (5-20°)
- Upper arm is abducted from the body 10-20° in the frontal plane
- Ball release position should be 100-130% of the stride length

Miscellaneous:

- Trunk should remain fairly upright without excessive forward flexion
 - This is achieved by flexing the front knee and extending the back hip
- The head should follow a smooth path from the start of the downswing to ball release
- The linear velocities of the joint centres from the hip to the hand should remain constant through ball release
- The linear velocities of the joint centres from the hip to the hand should increase through ball release for the drive shot with emphasis on the elbow and wrist
- Trunk lateral flexion and upper arm abduction will be unique depending on the player, with the player's height and limb lengths determining these
- Player's may not be able to correctly bowl on their intended bowling line