ILLEGAL BOWLING ACTIONS LAWS, DO THEY REALLY MATTER?

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The purpose of this study was to compare performance variables and upper body kinematics between cohorts of pathway (illegal and legal action) and elite level (legal) finger-spin (FS) bowlers. Results indicated that pathway illegal bowlers created significantly more ball angular velocity compared with bowlers of the same level, reaching levels of elite level bowlers. These differences are driven by various upper body kinematic differences at the trunk, elbow and wrist. This research highlights that when bowling with an illegal action, a possible performance benefit exists, reinforcing the current illegal action laws (this rule of the sport does matter).

KEYWORDS: cricket, finger-spin, elbow, ball-release, illegal action.

INTRODUCTION: The laws of cricket state, for a delivery to be legal, the amount of elbow extension used between upper-arm horizontal (UAH) and ball release (BR) during the swing phase must be less than 15º (ICC, 2013). Over history, this threshold has ranged from 0º or no straightening, to a tired system dependant on bowling type (5º for spin bowlers, 7.5º for medium pace bowlers and 10º for fast bowlers) to the current 15º threshold (Portus, Rosemond, & Rath, 2006). This evolution has been driven with advancements of technology that now allow scientists to more accurately measure human movement and the realisation that a majority of bowler's deliver the ball with some amount of elbow extension. While maintaining a non-throw like motion during the bowling action is undoubtedly important to protect the nature of the game, little evidence exists linking increases in elbow extension values to that of increases in performance for finger-spin (FS) bowlers. Previous literature has shown that BR resultant velocity and ball angular velocity can distinguish between elite and non-elite FS bowlers (Chin, Elliott, Alderson, Lloyd, & Foster, 2009; Spratford & Davison, 2010; Spratford et al., 2017). Therefore, the purpose of this study was to compare BR velocity, ball revolutions, bowling arm and trunk kinematics for a cohort of pathway bowlers, who delivered the ball with a bowling action that exhibited >15° of elbow extension UAH to BR, with pathway and elite bowlers that used a legal action. Results will may indicate if elbow extension values above the 15° threshold impact on performance and give greater insight into how mechanics differ from bowlers who employ a legal action.

METHODS: Forty-eight male FS bowlers participated in this study. Participants were assigned to one of 3 groups based on their playing level and legality of their bowling actions; pathway legal (up to and including list A cricket, n=24, 19.4±2.7 yrs, 181.9±6.9 cm, 74.0±8.2 kg), elite legal (1st class and above, n=12, 24.9±6.5 yrs, 179.6±6.9 cm, 76.0±12.2 kg), and pathway illegal bowlers (n=12, 19.4±2.7 yrs, 173.3.9±9.8 cm, 66.9±8.2 kg). Bowling data collection took place in an indoor motion capture laboratory purpose built for cricket analysis and contained a permanent artificial pitch. 63 retro-reflective markers were affixed to each participant's upper-body and the ball according to a customized marker set. Trajectory data were captured using a 22-camera (MX 13 and 40) Vicon MX motion analysis system (Oxford Metrics, Oxford, UK) operating at 250 Hz. Participants warmed up as per their normal pre-game routine and bowled 6 overs (36 deliveries) with a 2-minute break between each to replicate match conditions. (Spratford, Kenneally-Dabrowski, Byrne, Hicks, & Portus, 2016). Trajectories were filtered using a quintic spline Woltring filter at a mean square error (MSE) of 20 after a residual analysis (Winter, 2005). Data were then modelled using previously published custom upper-body and ball models (Campbell, Lloyd, Alderson, & Elliott, 2009; Chin, Lloyd, Alderson, Elliott, & Mills, 2010; Lloyd, Alderson, & Elliott, 2000; Whiteside, Chin, & Middleton, 2012). Mean resultant ball velocity and angular velocity after release were computed using the data collected from the first 30 frames post-BR. All kinematic data were

reported at BR, as well as peak values between back foot impact (BFI)—BR for the pelvis and thorax and UAH-BR for the bowling limb. Elbow extension values were calculated as per the existing ICC regulations. A one-way analyses of variance (ANOVA) with a Bonferroni correction was performed to determine ball kinematic differences between the 3 groups (p=0.05). Independent group post-hoc t tests were then performed between pathway illegal and elite groups to establish differences between all other kinematic variables. Due to the multiple comparisons being made, an amended alpha level of p=0.01 was adopted. Effect sizes (ES) were also reported to functionally differentiate between variables, with levels of 0.2, 0.5, and 0.8 representing small, medium, and large effect sizes.

RESULTS: Results of the ANOVA showed that elite legal bowlers displayed significantly greater ball velocity and angular velocity than pathway legal bowlers, while pathway Illegal bowlers had significantly greater angular velocity than pathway legal bowlers (Table 1).

Table 1. Group means (SD) for resultant ball velocity and angular velocity for pathway legal, elite legal and pathway illegal FS bowlers.

Variable	Pathway legal	Elite legal	Pathway illegal
Ball velocity ($°\cdot s^{-1}$)	19.2 (0.9)*[a]	20.4(1.4)*[a]	19.7 (1.4)
Ball ω ($rev\cdot s^{-1}$)	26.4 (2.7)*[†ac]	30.0 (2.8)*[a]	30.1 (3.1)[†c]
Velocity/ω index	59.7 (3.0)*[ac]	64.5 (3.7)*[a]	62.9 (4.4)[c]

*Significant *p* <0.05 Elite legal to pathway legal, [†]*p* <0.05 Pathway illegal to Pathway legal, [a]Large ES ≥0.80, Elite legal to pathway legal, [b]Large ES ≥0.80 Elite legal to Pathway illegal, [c]Large ES ≥0.80 Pathway illegal to Pathway legal

Performance characteristics of the lower level pathway illegal bowlers approximated that of the elite legal bowlers. For this reason, selected biomechanical variables are now presented to further explore differences between elite legal and pathway illegal bowlers. Significant and large ES differences were observed at the pelvis, thorax, elbow, and wrist between elite legal and pathway illegal bowlers (Table 2).

Table 2. Group means (SD) for selected angular displacement parameters for elite and illegal pathway FS bowlers.

Variable (°)	Pathway illegal	Elite legal	p-value & ES
Pelvis forward rotation peak (BFI-BR)	161.2 (9.2)	171.9 (10.0)	0.017-1.11[#]
Thorax forward rotation (BR)	81.3 (9.1)	89.8 (8.2)	0.029-0.98[#]
Thorax forward rotation peak (BFI -BR)	166.5 (10.7)	176.2 (8.1)	0.024-1.02[#]
Elbow flexion (UAH)	47.0 (8.8)	24.0 (8.29)	≤0.000*-2.70[#]
Elbow flexion peak (UAH-BR)	51.3 (7.8)	29.3 (6.2)	≤0.000*-3.12[#]
Elbow flexion (BR)	15.8 (7.7)	24.0 (6.9)	≤0.000*-1.12[#]
Elbow extension range (UAH-BR)	35.9 (9.0)	5.5 (3.5)	≤0.000*-4.45[#]
Elbow supination (BR)	-100.3 (21.1)	-89.3 (21.7)	0.197-0.51[#]
Elbow supination peak (UAH-BR)	-130.4 (24.9)	-106.8 (33.5)	0.070-0.80[#]
Wrist extension (BR)	-47.5 (12.2)	-34.2 (10.5)	0.010*-1.17[#]

*Significant *p* ≤0.010 and [#]Large ES ≥0.80

Significant and large ES for angular velocity differences were found at the thorax, elbow, and wrist (Table 3).

Table 3. Means (SD) for selected angular velocity parameters between elite and illegal pathway FS bowlers.

ω Variable (°·s-¹)	Pathway illegal	Elite legal	p-value & ES
Thorax forward rotation (BR)	125.5 (75.2)	186.8 (63.4)	0.048-0.88#
Elbow extension (BR)	-385.6 (279.9)	-115.6 (99.5)	0.010*-1.29#
Elbow supination peak (UAH-BR)	786.0 (283.2)	553.5 (286.7)	0.065-0.82#
Wrist flexion (BR)	801.1 (366.5)	480.7 (232.3)	0.026-1.04#
Wrist flexion peak (UAH-BR)	914.0 (322.3)	642.6 (303.4)	0.050-0.87#
Ulna deviation (BR)	16.3 (242.8)	-250.0 (82.3)	0.004*-1.47#
Ulna deviation peak (UAH-BR)	-179.1 (91.0)	-289.2 (118.0)	0.023-1.04#

*Significant $p \leq 0.010$ and #Large ES ≥0.80

DISCUSSION: Bowling performance of the pathway illegal bowlers reflected that of the more experienced and higher quality elite legal cohort. Given that both pathway groups were playing at a similar level and were at a similar age, the findings highlight that when a FS bowler delivers the ball with more than 15° of elbow extension (ie, an illegal action) the illegal group exhibits greater performance in comparison to the legal cohort reinforcing the validity of the current illegal action law. While it is evident that bowling with an illegal action has performance benefits, to date, no research has explored if biomechanical differences exist between legal and illegal bowlers. Illegal bowlers displayed significantly higher absolute levels of elbow flexion at UAH and significantly reduced values at BR, subsequently recording higher extension ranges and peak extension angular velocity during the forward swing. While it is important to understand how elbow extension mechanics differ between legal and illegal bowlers, a better descriptive understanding of the contribution of other upper-body mechanics will provide coaching staff with the necessary information to help remediate bowlers with illegal actions.

At the trunk, illegal bowlers were more front-on at BFI for both the pelvis and the thorax. They also experienced less pelvic rotation between BFI-BR, exhibited lower thorax angular velocity at BR, and subsequently displayed a more front-on thorax alignment at BR. Traditional coaching literature stresses the need for a FS bowler to have a “classical side-on” position at BFI and to rotate their trunk through to the point of BR. In theory, increased angular velocities observed at the trunk will lead to increased velocities at the distal segments through the proximal to distal linkage system. Rotation of the trunk also assists in getting the bowling arm into the appropriate position to release the ball. These data suggest that both groups adopt polarizing biomechanical strategies early within the bowling phase. Attempts have been made to describe these different techniques, with authors classifying these as the “javelin” and “discus action”(Woolmer, Noakes, & Moffett, 2008). The “javelin action,” described as the traditional side-on approach at BFI, is clearly observed within the legal cohort of this study, with the “discus action” or front-on approach at BFI observed in the illegal bowlers. Aside from the elbow flexion-extension differences, pathway illegal bowlers exhibited increased peak elbow supination displacement and angular velocity, wrist extension displacement at BR, and peak wrist flexion angular velocities. However, decreased peak levels of ulna deviation, together with peak angular velocity at BR, were found in the pathway illegal cohort. By BR, the wrist joint of the pathway illegal bowlers was moving into radial deviation, like that of a wrist-spin bowler and opposite to the elite group’s ulna deviation angular velocity. It would appear that the distal segments of the bowling limb are influenced by the earlier movements of the trunk. Rather than relying on the natural rotation of the trunk to get the hand in a position to release the ball, the illegal group relied on greater flexion and rapid supination at the elbow to shorten the delivery arc and get the body into an appropriate BR position. From this position, the natural centrifugal forces that act along the long axis of the bowling arm force both the elbow joint into extension and the wrist joint into extension, naturally increasing the elbow extension range. It also forces the illegal bowlers to rely on wrist extension rather than the traditional ulna deviation observed in the elite cohort.

In contrast, the legal or traditional “javelin” technique sees bowlers use the natural rotations of the trunk created during the bowling action, rather than flexion and supination at the elbow joint to attain the appropriate release position. This may likely reduce the influence of centrifugal forces at the elbow, placing the bowling hand in a position to take advantage of ulna deviation rather that wrist extension at BR. The adduction (ulnar deviation) movement of the wrist is a common feature within the coaching literature, referred to as “opening the door” or “screwing off the top of a jar” and is seen as critical in applying revolutions to the ball and also as a natural component of FS bowling technique.

CONCLUSION: Pathway illegal bowlers can place significantly more revolutions on the ball compared with bowlers of the same level who bowl with a legal action and similar elite legal level bowlers. Pathway illegal bowlers displayed a more front-on delivery technique at BFI and BR, relying on increased flexion and supination at the elbow to get to the point of BR. Subsequently, this increased the amount of elbow extension and wrist extension angular velocity to the detriment of ulna deviation angular velocity. Indicating that illegal pathway bowlers relied on elbow extension and wrist extension to create all-important ball revolutions. These results are the first to show that a possible performance benefit may exist when FS bowlers deliver the ball with more than the allowable 15° of elbow extension, which helps to reinforce the validity of the current laws of the game.

REFERENCES

Campbell, A., Lloyd, A., Alderson, J., & Elliott, B. (2009). MRI development and validation of two new predictive methods of glenohumeral joint centre location identification and comparison with established techniques. *Journal of Biomechanics, 42*, 1527-1532.

Chin, A., Elliott, B., Alderson, J., Lloyd, D., & Foster, D. (2009). The off-break and "doosra". Kinematic variations of elite and sub-elte bowlers in creating ball spin in cricket bowling. *Sports Biomechanics, 8*(3), 187-198.

Chin, A., Lloyd, A., Alderson, J., Elliott, B., & Mills, P. (2010). A marker-based mean finite helical axis model to determine elbow rotation axes and kinematics in vivo. *Journal of Applied Biomechanics, 26*, 16.

ICC. (2013). *Standard Test Match Playing Conditions*. Retrieved from Dubai, UAE:

Lloyd, D., Alderson, J., & Elliott, B. (2000). An upper limb kinematic model for the examination of cricket bowling: A case study of Muttiah Muralitharan. *Journal of Sports Sciences, 18*, 975-982.

Portus, M., Rosemond, C., & Rath, D. (2006). Fast bowling arm action and the illegal delivery law in men's high performance cricket matches. *Sports Biomechanics, 5*(2), 215-231.

Spratford, W., & Davison, J. (2010). *Measurement of ball flight characteristics in finger-spin bowling*. Paper presented at the Conference of Science, Medicine and Coaching in Cricket, Gold Coast, Australia.

Spratford, W., Kenneally-Dabrowski, C., Byrne, S., Hicks, A., & Portus, M. (2016). Does stride length play a role in cricket fast bowling performance outcomes? An observational, cross-sectional study. *International Journal of Sports Science & Coaching, 11*, 655-661.

Spratford, W., Whiteside, D., Elliott, B., Portus, M., Brown, N., & Alderson, J. (2017). Does performance level affect initial ball flight kinematics in finger and wrist-spin cricket bowlers? *Journal of Sports Sciences*. doi:10.1080/02640414.2017.1329547

Whiteside, D., Chin, A., & Middleton, K. (2012). The validation of a three-dimensional ball rotation model. *Journal of Sports Engineering and Technology, 227*, 8.

Winter, D. (2005). *Biomechanics and motor control of human movement (3rd ed.)*. New Jersey: John Wiley & Sons.

Woolmer, B., Noakes, T., & Moffett, H. (2008). *Bob Woolmer's Art and Science of Cricket* (First ed.). Sydney: New Holland Publishers Ltd.

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