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Exploring kinematics and kinetics in elite ten-pin bowling – A field study

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Summary

In ten-pin bowling, bowlers try to knock down ten pins, with the allotted two tries. The present study investigated full-body kinematics and kinetics in the lower extremities in elite ten-pin bowling. Our study showed novel findings regarding how elite bowlers changed kinematics over time during the ball delivery, probably as a consequence of reduced friction between lane and ball over time. The results are discussed in relation to an energy perspective, discussing the linear and rotational kinetic energy of the bowling ball.

Introduction

Bowling ball release velocity (BR_{vel}) is significantly positively correlated with the average bowling score (B_{ave}) [1]. Furthermore, the ability to perform a consistent front foot slide (FFS) has significant relation to the B_{ave} [2]. Biomechanical knowledge in ten-pin bowling is limited. Therefore, the purpose of the present study was to explore full-body kinematics, and kinetics in the lower extremities and how these might change over time.

Methods

Six male elite ten-pin bowlers participated in the experimental session, all right-handed. Each participant performed six consecutive bouts, of twelve bowling trials. Bouts were separated by three minutes rest. The bowling lane was prepared with the oil profile "Winding Road" before each session. Full body kinematics were collected with Xsens MVN Link and the vertical ground reactions forces with Loadsol force sensors. Further, BR_{vel} was measured at every trial. The bowlers aimed for a strike in each trail, resetting pins after every trial. They were restricted to one bowling ball, personally chosen, throughout the session.

Results and Discussion

The results showed a significant decrease in BR_{vel} throughout bouts ($p < .001$) but no changes in vertical peak forces, centre of mass velocity (COM_{vel}) and bowling score. BR_{vel} was gradually decreasing from bout 1 (8.37 ± 0.28 m/s) to bout 6 (8.07 ± 0.38 m/s). Joint angles were compared over bouts using 1D statistical parametric mapping (SPM1D). An increased flexion of the dominant wrist ($p < .001$) and elbow ($p = .004$) were found prior to ball release (BR). An increased pronation of the dominant wrist was found during ball release ($p = .034$) (Figure 1).

Elite bowlers decreased BR_{vel} throughout bouts. Surprisingly, neither vertical ground reaction force, nor COM_{vel} changed as a consequence of reduced BR_{vel}. However, bowlers increased the flexion of both the dominant wrist and the elbow prior to BR, and pronation during BR throughout bouts. As the experimental session progressed the oil profile covering the lane, was dragged further down the lane, reducing the overall traction between ball and lane. This changing of the oil profile happens also during real bowling matches. To compensate for this loss of traction it is possible that the athletes transformed some of the linear kinetic energy, represented by the BR_{vel}, into rotational energy, represented by the increase in pronation and flexion, in order to compensate for loss of traction. The aforementioned proposition is under the assumption that the bowler exerts the same total amount of energy during each trial.

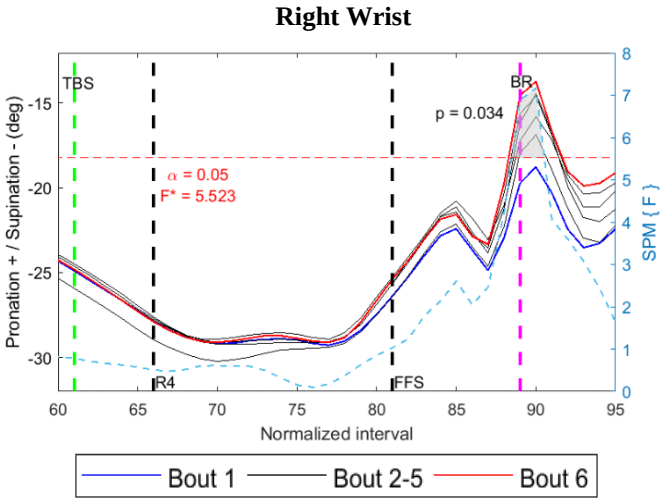

Figure 1: Shows mean pronation/supination of the right wrist angle for all participants throughout bouts. Black vertical lines are mean heel contact of right (R4) as the fourth step and FFS as the left and last step of the bowling trial. Green and pink lines represent top of backswing (TBS) and BR, respectively. SPM1D analysis is inserted onto the figure as a dashed blue line, critical threshold as a horizontal red dashed line, with a corresponding alpha and F-value. A cluster of significant difference is marked with grey and a p-value. Be aware that the statistics shows within subjects, whereas the bouts are an average of all subjects.

Conclusions

Elite bowlers need to either decrease the BR_{vel} over time or increase the rotation significantly to maintain accuracy and precision during a bowling match. The most appealing approach for bowlers would be to increase rotation significantly since B_{score} and BR_{vel} are dependent [1].

Acknowledgments

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References

[1] Razman et al. (2010). *ISBS Conference Proceedings Archive*, **1**.
[2] Razman et al. (2011). IFMBE Proceedings, **35**: 222-224.