Proceedings

Effect of the Grip Angle on Off-Spin Bowling Performance Parameters, Analysed with a Smart Cricket Ball †

Franz Konstantin Fuss [1,*], Batdelger Doljin [1] and René E. D. Ferdinands [2]

[1] Smart Equipment Engineering and Wearable Technologies Research Program, Centre for Design Innovation, Swinburne University of Technology, Melbourne, VIC 3122, Australia; bdoljm@swin.edu.au
[2] Discipline of Exercise and Sports Science, University of Sydney, Sydney, NSW 2141, Australia; edouard.ferdinands@sydney.edu.au
* Correspondence: fkfuss@swin.edu.au; Tel.: +61-3-9214-6882
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Abstract: In the off-spin bowling grip, the ball is clamped between index and middle fingers. Spin bowlers attempt to select a spread angle between these two fingers that achieves comfort and optimises performance. The aim of this paper was to investigate whether the standard grip is superior to narrow and wide grips. The bowling performance parameters were obtained from a smart cricket ball. Smart ball data revealed that the performance parameters varied with grip type. The following parameters were optimum at the standard grip: spin rate, resultant torque, spin torque, peak angular acceleration, and peak power. The following parameters were optimum at standard and wide grips: efficiency. The following parameters were optimum at standard and narrow grips: pitch angle of spin axis. The following parameters were optimum at the wide grip: precession and the precession torque. In general, the data tended to show that the standard grip is most effective for spin bowling. However, more research is needed to confirm this result, because the precession and precession torque were optimum at the wide grip, suggesting that this may have a superior performance over the standard and narrow grips.

Keywords: cricket; smart cricket ball; spin rate; torque; acceleration; precession; efficiency; performance; finger spread angle; spin bowling

1. Introduction

In spin bowling, the fingers of the bowler are distributed around the seam of the ball in order to impart spin about an axis perpendicular to the seam. In off-spin bowling (fingerspin with a sidespin component), this is achieved by (i) combining the movement of forearm joints and wrist joint (supination + ulnar abduction); (ii) rotating the fingers that grip the ball (finger flexion and ulnar abduction; thumb reposition); and most importantly, (iii) ensuring that the last contact is between middle finger and ball immediately before release [1]. The angle between index and middle fingers varies with bowlers, the size of the angle depending on hand size, perception (which grip width is comfortable for the bowler), and coaching (which grip style the bowler was taught by the coach). For investigating whether there is an optimum grip width or finger spread angle (between index and middle fingers), the different grip-types have to be compared with hand dynamics and performance (such as, accuracy of hitting a spot on the pitch and the number of wickets taken in a season). A smart cricket ball [1–7] can be used to measure multiple parameters of hand dynamics during the period when the fingers apply spin to the ball.

The aim of this study is to use the smart ball to determine whether there is an optimal grip width for spin bowling based on hand dynamics.

2. Material and Methods

2.1. Smart Cricket Ball

The smart cricket ball used in this study [1,2,7] samples the angular velocity data about the three axes of the ball's coordinate system at 815 Hz with three high-speed digital gyroscopes, which have a maximum measurement range of 50 rps. The data are transferred wirelessly to a Smartphone or computer via Bluetooth. The battery of the ball is charged wirelessly.

2.2. Participants

A male off-spinner (amateur cricket club level) participated in the study. The participant bowled the ball 10 times each for three different grip widths. The seam sector angle between the fingertips of index and middle fingers was between 90 and 120 degrees for the standard grip, >130° for the wide grip, and <80° in the narrow grip (Figure 1). The Smart Cricket Ball study was approved by the RMIT University Human Ethics Committee (approval No. BSEHAPP 13-12).

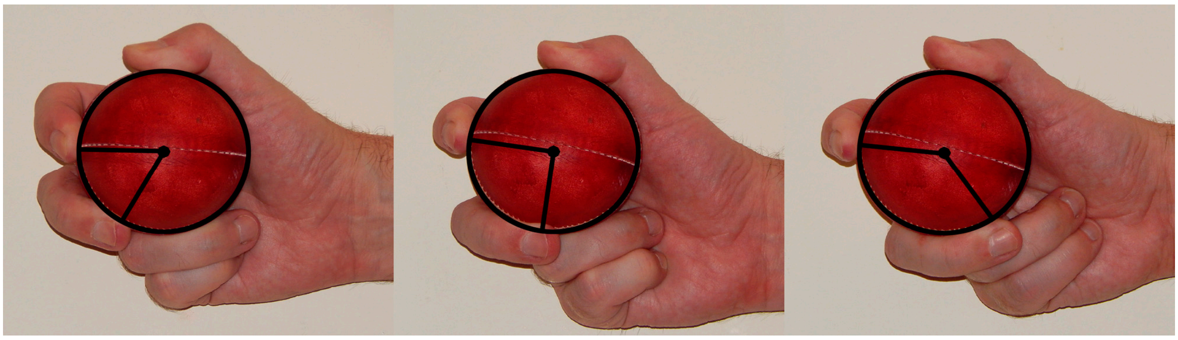

Figure 1. Three different grip width (angle between index and middle finger tips) investigated in this study: from left to right: narrow grip; standard grip; wide grip.

2.3. Performance Parameters

A total of nine different performance parameters (Table 1) were calculated from the raw data: spin rate (ω), pitch of the spin axis (angular deviation of the spin axis from the pole of the ball, where the pitch is 90 degrees if the spin axis is exactly at the pole of the ball), angular acceleration (α), resultant torque (T_R), spin torque (T_ω), precession torque (T_p), power (P), precession (p; speed of the moving spin axis), normalised precession (p_n; angle between spin and torque vectors [2]), and efficiency (η) of bowling (ratio of actual to ideal energy expressed as a percentage).

All performance data used in this study are expressed as peak data (maxima) with the exception of efficiency (which is an energy ratio). The bowling performance is improved when spin rate, acceleration, resultant and spin torque, power, and efficiency increase significantly, with concomitant decreases in precession torque, precession, and normalized precession [2,4,5]. As the spin rate depends on the torque data, the torques were normalised to the spin rate (T_R/ω, T_ω/ω, T_p/ω). A bowling delivery is more effective the smaller the torque required per resultant spin rate.

2.4. Data Analysis and Statistics

The performance parameters as detailed above were calculated with the Smart Cricket Ball software. The raw gyro data were filtered by a Butterworth low-pass filter of the 3rd order with a cut-off frequency of 30 Hz. The vectors obtained from the software are aligned to the coordinate system of the ball.

The numeric performance data were correlated with grip width, which was treated as an ordinal variable (narrow = 1, standard = 2, wide = 3). The data were subjected to a non-linear regression analysis with a 2nd order polynomial for trend analysis. This analysis was used to verify whether the data showed a real trend for a *p*-value of the regression ($p < 0.05$). The 2nd order polynomial fit is able to detect a bidirectional trend, required for defining an optimum point. The distribution of the performance parameters within the 3 different grip widths was assumed to be Gaussian in theory. The performance parameters of the 3 different grip widths were compared with an ANOVA test followed by 4 posthoc tests (Tukey, Scheffe, Bonferroni and Holm). The ANOVA test strengthened the case for detecting a trend in the regression analysis. A significant difference was established if the *p*-value was smaller than 0.05 for the ANOVA test and the posthoc tests.

3. Results

The participant generated the following smart ball data: spin rate of 18.3 rps on average for his standard grip; 0.2 Nm resultant torque; 12.3 W peak power; and 53.7° pitch on average (the angle between the spin axis at release and the perpendicular to the plane of the seam was 36.3°). These data were below average for off-spinners [8]. However, the following data were above average [8]: bowling efficiency was 60.6%, precession 34 rad/s, and normalised precession 58.2° on average.

The trend analysis revealed 6 different parameters (Figure 2). In the first 5 trend patterns (below), the regression *p* and the ANOVA *p* were smaller than 0.05. The posthoc tests showed the same significance or non-significance levels (*p* was either larger or smaller 0.05) across all 4 posthoc tests within each trend patterns.

1. Optimum point (highest performance) at the standard grip and less performance at wide and narrow grips: standard grip performance was significantly higher compared to narrow and wide grips, with insignificant difference between wide and narrow grips. This trend was seen in the spin rate, resultant torque, spin torque, T_ω/ω, peak angular acceleration, and peak power.
2. Optimum point (highest performance) at the standard and narrow grips and less performance at the wide grip: standard and narrow grip performance was significantly higher compared to the wide grip, with insignificant difference between standard and narrow grips. This trend was seen in pitch and T_R/ω.
3. Optimum point (highest performance) at the standard and wide grips and less performance at the narrow grip: standard and wide grip performance was significantly higher compared to the narrow grip, with insignificant difference between standard and wide grips. This trend was seen in the efficiency.
4. Optimum point (highest performance) at the wide grip and less performance at standard and narrow grips: the wide grip performance was significantly higher compared to standard and narrow grips, with insignificant difference between standard and narrow grips). This trend was seen in the precession and the precession torque.
5. Optimum point (highest performance) at the wide grip and decreasing performance over standard to narrow grip: all 3 grip performances were significantly different. This trend was seen in T_p/ω.
6. No trend at all (regression $p > 0.05$; ANOVA $p > 0.05$), seen in the normalized precession.

With the exception of normalized precession, precession torque and T_p/ω, there was an optimum performance value at the standard grip in the remaining 10 performance parameters. In 4 of these 10 performance parameters, there was a further optimum, in addition to the standard grip, either at the narrow or at the wide grip. The latter two grips, however, did not achieve a consistent optimum. Precession torque and its normalized T_p/ω did not follow the overall trend and showed an optimum at the wide grip.

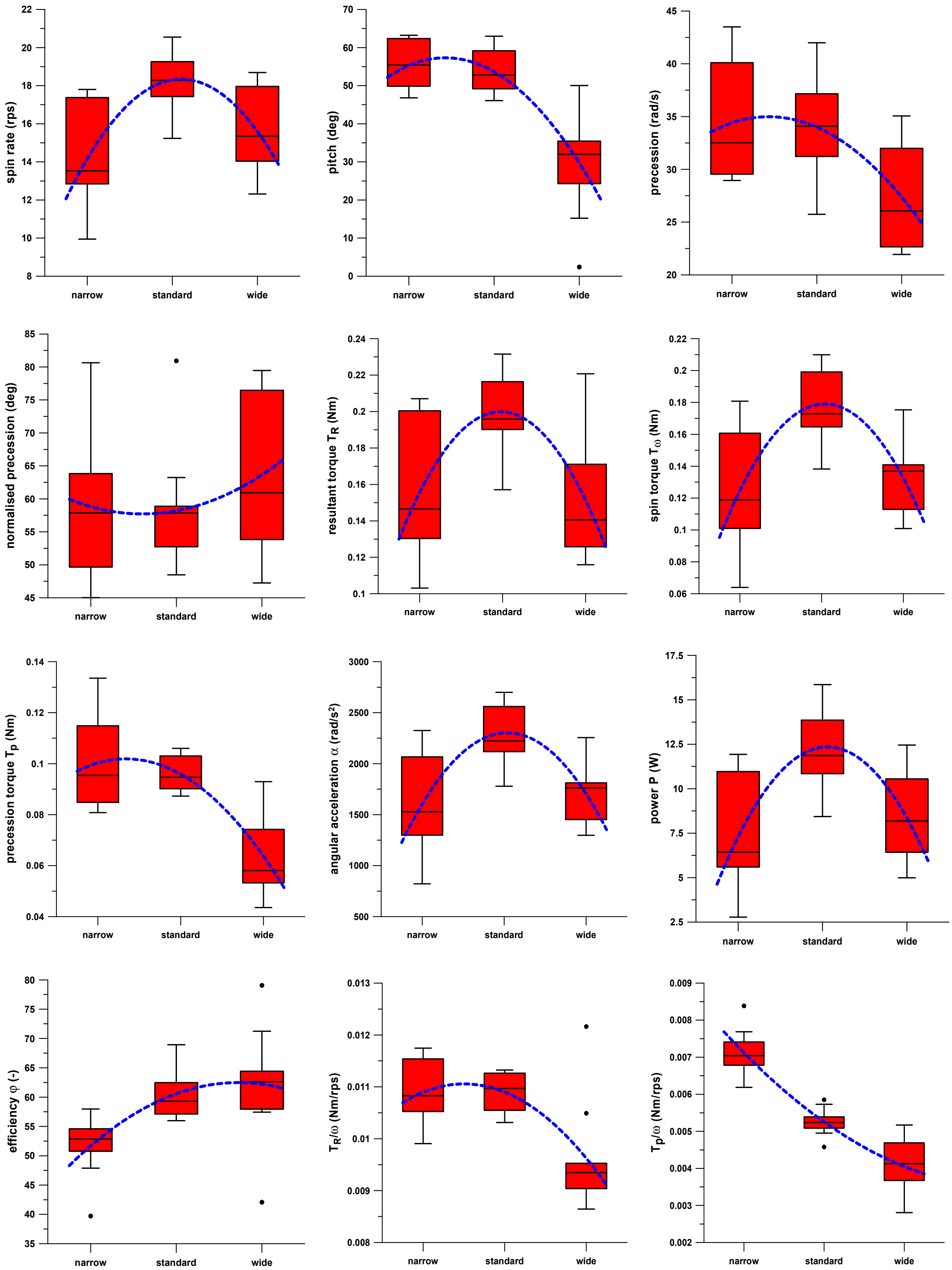

Figure 2. Box plots (red) and parabolic fit functions (blue) of performance parameters against narrow, standard and wide grips; from left to right and top to bottom: spin rate ω (rps), pitch (deg), precession (rad/s), normalized precession (deg), resultant torque T_R (Nm), spin torque $T\omega$ (Nm), precession torque T_p (Nm), acceleration α (rad/s^2), power P (W), efficiency η (−), T_R/ω (Nm/rps), T_p/ω (Nm/rps).

Table 1. Performance parameters and their statistics; **bold** font: $p < 0.05$ (significant difference); *italic* font: $p > 0.05$ (insignificant difference); ω = spin rate, p = precession; p_n = normalised precession; T_R = resultant torque; T_ω = spin torque; T_p = precession torque; α = angular acceleration; P = power; η = efficiency.

Statistics	**Regression R^2**	**Regression *p***	**ANOVA *p***	**Max Posthoc *p*: Narrow vs. Standard**	**Max Posthoc *p*: Narrow vs. Wide**	**Max Posthoc *p*: Standard vs. Wide**	**Narrow Grip (Mean ± Stdev)**	**Standard Grip (Mean ± Stdev)**	**Wide Grip (Mean ± Stdev)**
ω (rps)	0.4162	**0.0001**	**0.0007**	**0.0010**	*0.4373*	**0.0305**	14.16 ± 2.66	18.30 ± 1.53	15.60 ± 2.08
pitch (°)	0.6450	**<0.0001**	**<0.0001**	*1.0000*	**0.0010**	**0.0010**	55.26 ± 6.12	53.66 ± 5.97	29.73 ± 13.31
max p (rad/s)	0.2999	**0.0017**	**0.0081**	*1.0000*	**0.0193**	**0.0284**	34.39 ± 5.41	33.99 ± 5.02	27.37 ± 5.12
p_n (°)	0.0536	*0.2182*	*0.4751*	*1.0000*	*0.9775*	*0.8051*	58.82 ± 11.37	58.20 ± 9.21	63.645 ± 11.54
max T_R (Nm)	0.3462	**0.0006**	**0.0032**	**0.0157**	*1.0000*	**0.0079**	0.156 ± 0.037	0.200 ± 0.022	0.151 ± 0.034
max $T\omega_\omega$ (Nm)	0.4445	**0.0001**	**0.0004**	**0.0010**	*1.0000*	**0.0042**	0.125 ± 0.038	0.179 ± 0.022	0.133 ± 0.021
max T_p (Nm)	0.5628	**<0.0001**	**<0.0001**	*1.0000*	**0.0010**	**0.0010**	0.100 ± 0.018	0.096 ± 0.007	0.064 ± 0.018
max α (rad/s^2)	0.4445	**0.0001**	**0.0004**	**0.0010**	*1.0000*	**0.0042**	1602.9 ± 489.7	2301.0 ± 284.5	1704.1 ± 273.0
max P (W)	0.4352	**0.0001**	**0.0004**	**0.0010**	*1.0000*	**0.0078**	7.30 ± 3.14	12.33 ± 2.22	8.36 ± 2.35
η (%)	0.3468	**0.0006**	**0.0032**	**0.0220**	**0.0061**	*1.0000*	51.67 ± 5.04	60.57 ± 4.29	62.21 ± 9.53
T_R/ω (Nm/rps)	0.4424	**0.0001**	**0.0004**	*1.0000*	**0.0019**	**0.0018**	0.0109 ± 0.0006	0.0109 ± 0.0004	0.0096 ± 0.0010
T_ω/ω (Nm/rps)	0.3745	**0.0003**	**0.0018**	**0.0115**	*1.0000*	**0.0042**	0.0086 ± 0.0011	0.0098 ± 0.0005	0.0085 ± 0.0005
T_p/ω (Nm/rps)	0.8222	**<0.0001**	**<0.0001**	**0.0010**	**0.0010**	**0.0010**	0.0071 ± 0.0006	0.0053 ± 0.0004	0.0041 ± 0.0008

4. Discussion

The smart ball data showed that the performance parameters of the standard grip generally outweighed the parameters of the two other grips. This suggests that experienced spin bowlers had over time adopted a grip with a finger spread that they could perform effectively. The ideal finger spread angle, according to the general coaches' recommendation, is as wide as comfortably possible. However, this experimental protocol cannot determine conclusively that the finger-spread (grip-width) used by the bowler was biomechanically optimal, since the bowler had less experience using the narrow and wide grips.

The problem here is the training effect. It is possible that the bowler chose a non-optimal finger spread angle, but just got used to it over time. When increasing his finger-spread to a more optimal angle, he was unable to execute it, because he simply did not develop the motor pattern to do so. This effect is more pronounced in amateur athletes, but also occurs elite athletes, who could be performing better with more efficient techniques. An immediate change to the technique, even if demonstrably better, would initially lead to a diminished performance. Sometimes, the diminished performance is permanent if the motion pattern is too hard-wired to accept the technical change and perform effectively.

While there was no optimum in the normalized precession, the best performance in the wide grip was seen in the precession, precession torque and its normalized T_P/ω. It is feasible that these parameters are influenced by the forcing apart of the two fingers in the wide grip, which stabilizes the wrist and finger movements. Consequently, the T_R-vector is close to the ω-vector which keeps the precession torque and thus the precession to a minimum. This would support the general coaches' recommendation that the ideal finger spread angle is as wide as comfortably possible. Precession and the associated precession torque are technical skill parameters. The smaller the precession torque, the higher is the expected spin rate. Consequently, the wider grip may result in a higher spin rate after a significant training period with the wide grip.

Conflicts of Interest: The authors declare no conflict of interest.

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