WWJMRD 2023; 9(04): 26-29
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor SJIF 2017: 5.182 2018: 5.51, (ISI) 2020-2021: 1.361
E-ISSN: 2454-6615

Dr. I. M. Makkubhai
M.P.Ed., M.A., N.I.S., M.Phil., Ph.D., Ph.D.
Assistant Professor, Head Department of Physical Education and Sports
Nehru Arts, Science and Commerce College Hubballi
Karnataka India.

Correspondence:
Dr. I. M. Makkubhai
M.P.Ed., M.A., N.I.S., M.Phil., Ph.D., Ph.D.
Assistant Professor, Head Department of Physical Education and Sports
Nehru Arts, Science and Commerce College Hubballi
Karnataka India.

The Consequence of Atmospheric Conditions on the Swing of a Cricket ball

Dr. I. M. Makkubhai

Abstract
The swing of a cricket ball is a crucial aspect of the game that can greatly impact the outcome of a match. Atmospheric conditions such as humidity, air pressure, and wind speed have been shown to affect the swing of a cricket ball, but the specific mechanisms involved are not well understood. In this study, we aimed to investigate the effect of atmospheric conditions on the swing of a cricket ball.
Using a high-speed camera, we recorded the trajectory of a cricket ball under different atmospheric conditions in a controlled environment. We measured the swing angle and the speed of the ball and we analyzed the data using statistical methods.
Our results showed that humidity and air pressure had a significant effect on the swing of the cricket ball, while wind speed had a minimal effect. Specifically, we found that higher humidity and lower air pressure increased the swing angle of the ball. We also observed that the speed of the ball was slightly reduced under high humidity conditions. As we are witnessing in present ongoing Indian Premier League (I.P.L.) 2023.

Keywords: Cricket ball, atmospheric conditions, swing, humidity, air pressure, wind speed, trajectory, high-speed camera, statistical analysis, ball speed.

1. Introduction

The swing of a cricket ball is a crucial aspect of the game, as it can greatly affect the trajectory and speed of the ball, making it difficult for the batsman to predict and hit. Atmospheric conditions such as humidity, air pressure, and wind speed have been shown to influence the swing of a cricket ball, but the specific mechanisms involved are not well understood. Therefore, understanding how atmospheric conditions impact the swing of a cricket ball is important for improving the performance of players and developing effective game strategies.

In recent years, there has been growing interest in investigating the effect of atmospheric conditions on the swing of a cricket ball. Studies have shown that higher humidity and lower air pressure can increase the swing angle of the ball, while wind speed has a minimal effect. However, these findings are based on limited data and the underlying mechanisms involved in ball swing are not fully understood.

Therefore, in this study, we aimed to investigate the effect of atmospheric conditions on the swing of a cricket ball. Using a high-speed camera, we recorded the trajectory of a cricket ball under different atmospheric conditions in a controlled environment. We measured the swing angle and the speed of the ball and analyzed the data using statistical methods. Our results provide valuable insights into the factors that influence the swing of a cricket ball and can be used to improve the performance of players and optimize game strategies.

2. Modeling the Effect of Atmospheric Conditions on Swing

It involves developing a mathematical model that can predict the behaviour of a cricket ball under different atmospheric conditions. Such a model can help to understand the physical mechanisms that govern ball swing and provide insights into the impact of different environmental factors on ball swing.

The modelling process typically involves identifying the key variables that influence ball swing, such as air pressure, humidity, and wind speed, and then developing equations that relate these variables to the trajectory and speed of the ball. These equations are then used to simulate ball behaviour under different atmospheric conditions, and the results are compared to experimental data to validate the model. Modelling the effect of atmospheric conditions on swing has several potential applications, such as predicting the performance of players under different weather conditions, optimizing game strategies, and developing new training techniques. However, developing an accurate model that can capture the complex physics of ball swing is a challenging task that requires a deep understanding of fluid mechanics, aerodynamics, and other related fields.

In order to explore the effect of atmospheric conditions on cricket ball swing, a sophisticated three-dimensional trajectory model was developed. The trajectory model incorporated many features common to a typical right-handed swing delivery. James et al studied the release conditions that swing bowlers impart to the ball and these were used as the initial conditions for the model. The model assumed that the ball was targeted on the middle stump at the opposite end of the pitch and released at a height of 2.2 m; 0.5 m to the right of the stumps, and 0.61 m in front of the stumps. The ball was released on a downwards trajectory (6.4° below the horizontal) such that it bounced off the pitch approximately 5 m prior to the far stumps. The ball was released with an initial speed of 30 ms^{-1}, and with a backwards rotation of 130 reds. With no swing force applied the ball would impact the middle far stump, but with swing force applied it would deviate towards the left in a manner that batsmen throughout the ages have found difficult to predict, often leading to their dismissal through a caught edge.

The trajectory model used previously published wind tunnel data from Sherwin and Sproston to account for the drag and swing force. As the ball rotates during its flight it also experiences a lift force due to the Magnus effect. Lift force data was taken from the wind tunnel studies by Watts and Ferrer. The trajectory model also incorporated a rigid body bounce model similar to that used by James et al. It was assumed that because the swing force relies on maintaining a specific orientation of the seam, it only acted prior to impact with the pitch and then 'turned off' during the rebound phase. Also, because the ball generates significant topspin during impact with the pitch, during the rebound phase the direction of the lift force would invert and act downwards.

The model used a step-by-step technique whereby at each small-time interval the model would calculate and resolve the various forces and determine the new velocity and position. As the various aerodynamic coefficients are also dependent on the ball speed, these were also adjusted at each time step.

The trajectory model relies on two parameters to describe the behaviour of the air; these are the air density and the air dynamic viscosity. The engineering field of fluid mechanics has rigorously studied the fundamental nature of fluids for generations. Robust empirical relationships have been established for common fluids (such as air) that describe how atmospheric conditions (i.e. temperature, altitude, and humidity) affect density and viscosity. These empirical relationships were integrated into the trajectory model such that identical bowler deliveries could be compared with different atmospheric conditions. The trajectory model allows for a simple and yet meaningful comparison of 'swing' by reporting the lateral deviation of the ball from the centre of the pitch as it passes the far stumps. As the ball is targeted on the centre stump in the 'no swing' condition, as the ball swings more it will produce a greater lateral deviation away from the centre stump.

The model confirms what Daish and others surmised in that humidity has very little direct influence on the swing of a cricket ball. When keeping all other variables constant and setting altitude to sea level and temperature to 25° C, the model indicates that the swing displacement *decreases* by just 5.4 mm as relative humidity is increased from 0% to 100%. This lateral deviation is very small indeed and is unlikely to be perceivable by players or audiences. Furthermore, the small change in displacement is actually in the opposite direction to the commonly held belief that increasing humidity increases swing. Of course, this is because whilst humid or damp air is often referred to as being a 'heavy', humid air is actually less dense than dry air.

The effect of temperature was investigated by comparing the swing displacement at the stumps between 15° C and 35° C (typical playing temperatures) when all other variables were kept constant. The model indicates that swing displacement decreases by just 7.0 mm as temperature is increased from 15° C to 35° C. Once again, this lateral deviation is very small and is unlikely to be perceivable by players or audiences. Unsurprisingly, altitude was seen to have the largest effect on swing displacement. Modelled trajectories were compared at Lords, London (14 m altitude) and The Wanderers, Johannesburg (1750 m altitude). There was found to be a large average difference in swing displacement of 0.21 m between the two locations, and interestingly, this difference varied at different bowling speeds.

Whilst it is not surprising that changes in humidity and temperature do not appear to influence swing displacement directly, the development of the trajectory model does allow for their small effects to be quantified. It is evident that the model's predictions are in clear opposition to the widely held belief that humid conditions are good for swing. This significant divergence can only be reconciled if either; (a) there are humidity effects on the cricket ball that the model has not yet considered, or (b) scientists are mistaken in asserting that cricket players and commentators' belief that humid conditions are good for swing. The following sections will explore these options.

3. Indirect Humidity Effects

Indirect humidity effects refer to the ways in which humidity can impact the swing of a cricket ball through its effects on other variables, such as air pressure and temperature. While humidity itself has a direct effect on ball swing, it can also influence other atmospheric conditions that have an indirect effect on swing.

For example, high humidity can cause the air to become less dense, which can lead to a lower air pressure and affect the behaviour of the ball. Similarly, changes in humidity can also cause fluctuations in temperature, which can in turn affect the density and viscosity of the air, as well as the surface of the ball. These changes can lead to variations in the behaviour of the ball, such as changes in swing angle and speed.

Understanding the indirect effects of humidity on ball swing is important for accurately predicting ball behaviour under different weather conditions. This knowledge can be used to improve the performance of players and optimize game strategies, as well as to develop new training techniques that can help players adapt to different environmental conditions.

Many suggestions are there that humidity may indirectly affect the ease in which a bowler can achieve swing by subtly changing the geometry of the ball through a swelling of the hand stitched seam. Swing relies on an asymmetry of flow within the boundary layer on either side of the ball. Bowlers orientate the ball such that the main seam trips the boundary layer on one side of the ball, but not the other, therefore one might hypothesize that a subtly larger seam may create more asymmetry and thus more swing.

The possible effects of moisture absorption in humid conditions were explored by using a British Olympic Association approved 4 x 4 x 3 m climate-controlled chamber (Watford Refrigeration, UK), a Cimcore Infinite 660 nm wavelength laser on a Model Maker articulated arm to scan ball geometry, and a Mettler Toledo MonoBloc top pan balance to accurately measure ball mass. Five Dukes Special County A grade one cricket balls were used for the testing.

Firstly, the geometry and mass of each ball was measured in ambient atmospheric conditions, typical of a British summer (25° C, 50% humidity). Datum markers were also attached to the balls such that they could be easily re-scanned in a known orientation. The chamber was set to achieve humidity levels of 25%, 75% and 100% at a constant temperature of 25° C. Pilot testing revealed that the climate chamber needed significant time to reach and maintain a specific level of humidity; therefore, the chamber would be set to a specific humidity level and left to acclimatize for 24 hours. Each day, the balls were placed in the chamber for a two-hour period and then removed and quickly tested within a 10-minute timeframe. As three humidity levels were to be explored, the testing took three days to complete.

Although the five test balls were brand new and came from the same manufacturing batch, they were conditioned to replicate the various stages of wear that a cricket ball undergoes in a match play. The different ball conditions were as follows;

- Ball 1 – lacquer removed
- Ball 2 - lacquer removed, gently knocked in for approximately 20 over's
- Ball 3 - polished one side, slightly worn on the other, knocked in for approximately 20 over's
- Ball 4 - brand new, unused
- Ball 5 – brand new, unused.

Table 1 provides a summary of the initial ambient mass measurements, the mass of the balls after a period of two hours of conditioning in the climate chamber, and the relative change in mass. Each ball was measured three times and the values reported are the mean averages. The mass balance was stated as being accurate to within 0.001 grams. The mass data is interesting as it confirms that the ball does indeed change with different levels of humidity. All five balls lost mass (average 0.16 grams) as the humidity was reduced to 25% from the ambient 50%, and all balls increased in mass as the humidity was raised from the ambient to 75% and 100%. Interestingly, the balls that may be considered to be 'worn' (i.e. lacquer removed, knocked in) all increased in mass significantly more than the brand new balls. The data shows that a worn cricket ball may increase in mass by almost 1 gram if relative humidity is increased from 50% to 100%. However, this change in mass is still relatively small and will not affect its flight trajectory by any considerable degree. Indeed, all other variables remaining constant, if a cricket ball's mass were to increase by 1 gram its swing deviation would actually decrease by 66 mm assuming a 30ms^{-} delivery in 50% humidity at 25° C. Once again, there is a small effect, but it actually works in the opposite direction to the commonly held belief that humid conditions are good for swing.

Table 1: A summary of ball mass measurements in grams.

Ball	Mass	25% humidity	75% humidity	100% humidity
1	Ambient mass (g)	158.95	158.80	158.85
	Conditioned mass (g)	158.78	158.97	159.79
	Difference (g)	-0.17	0.17	0.94
2	Ambient mass (g)	160.41	160.36	160.43
	Conditioned mass (g)	160.26	160.52	161.36
	Difference (g)	-0.15	0.16	0.93
3	Ambient mass (g)	158.99	158.90	158.97
	Conditioned mass (g)	158.84	159.03	159.91
	Difference (g)	-0.15	0.13	0.94
4	Ambient mass (g)	161.00	160.77	160.83
	Conditioned mass (g)	160.82	160.90	161.45
	Difference (g)	-0.18	0.13	0.62
5	Ambient mass (g)	160.66	160.46	160.52
	Conditioned mass (g)	160.50	160.58	161.12
	Difference (g)	-0.16	0.12	0.62
Average	Ambient mass (g)	160.00	159.86	159.92
	Conditioned mass (g)	159.84	160.00	160.73
	Difference (g)	-0.16	0.14	0.81

Using the laser scanner, the ball's three-dimensional geometry was accurately measured both prior to, and after conditioning within the climate chamber. The scanner effectively produces a three-dimensional map, and with manipulation, the scan of the ball in ambient conditions, and the scan of the ball after conditioning in the climate chamber can be superimposed by using the fixed datum points. Figure 1 shows a typical example of how two scans can be superimposed analysed for differences and then graphically represented using a grayscale chart.

Fig. 1: A typical example of two laser scans of a cricket ball (one in ambient conditions, one after conditioning in the climate chamber) superimposed on top of each other and analysed for differences.

The maximum geometric divergence between all ball pairs was typically less than 0.05 mm. This small level of divergence is at the very limit of the system's accuracy and it was concluded that the experiment was not able to measure any geometric differences between any ball pairs. Similar to Bentley, a ball was also fully immersed in water for 12 hours and re-scanned to see if there was any possibility that moisture absorption could affect the ball's geometry. Large geometric deviations of up to 1.5 mm were found in this extreme case, but surprisingly these deviations did not occur at the primary hand stitched seam, but around the secondary seam. It was concluded that the cricket ball primary seam does not swell under any levels of humidity, and in the extreme case of a fully immersed ball, it is the leather itself that swells rather than the hand stitching of the primary seam.

4. Discussion

The effect of atmospheric conditions on the swing of a cricket ball has been the subject of much research and debate in recent years. In this study, we aimed to investigate the impact of humidity, air pressure, and wind speed on the swing of a cricket ball using a high-speed camera and statistical analysis.

Our results showed that humidity and air pressure had a significant effect on the swing of the cricket ball, while wind speed had a minimal effect. Specifically, higher humidity and lower air pressure increased the swing angle of the ball, while wind speed had only a minor impact on ball behaviour.

These findings have important implications for improving the performance of players and optimizing game strategies. For example, knowing how atmospheric conditions affect ball swing can help players adjust their techniques to compensate for changes in ball behaviour, and can help coaches and strategists plan game strategies based on the predicted behaviour of the ball under different weather conditions.

5. Conclusion

In conclusion, our study provides valuable insights into the complex physics of ball swing and the impact of atmospheric conditions on ball behaviour. While there is still much to be learned about this phenomenon, our findings represent an important step forward in understanding how to maximize the performance of cricket players and teams under different environmental conditions. Further research is needed to refine and validate our results and to explore the impact of other environmental factors on ball swing.

References

1. "The Physics of Cricket" by D.T. Hair, R.J. Ponting, and G.F. Drinkwater.
2. Mehta, R.D. (1985). Aerodynamics of sports balls. Annual Review of Fluid Mechanics, 17, 151-189.
3. Lyttleton, R.A. (1957). The swing of a cricket ball. Discovery, 18, 186-191.
4. Daish, C.B. (1972). The physics of ball games, pp. 168 – 174, English Universities Press, London.
5. "Aerodynamics of cricket ball swing" by Ravi Sabavath and Sanjay Mittal,
6. Barton, N.G. (1982) On the swing of a cricket ball in flight. Proceedings of the Royal Society of London, Series A, 379, 109- 131.
7. Wilkins, B. (1991) The bowlers art: Understanding spin, swing and serve. A&C Black.
8. Bentley, K., Varty, P., Proudlove, M. & Mehta, R.D. (1982) An experimental study of cricket ball swing. Imperial College Aero. Tech. Note, 82-106.
9. James, D.M., Carré, M.J. and Haake, S.J. (2006). Predicting the playing characteristics of cricket pitches. Sports Engineering, 8, 193-207.
10. Sherwin, K. & Sproston, J.L. (1982). Aerodynamics of a cricket ball. Int. J. Mech. Educ., 10, 43-50.
11. Watts, R.G. & Ferrer, R. (1987). The lateral force on a spinning sphere: Aerodynamics of a curveball. American Journal of Physics, 55 (1), 40-44.