International Journal of Human Movement and Sports Sciences 13(6): 1230-1237, 2025 http://www.hrpub.org
DOI: 10.13189/saj.2025.130607

A Study on Restitution of Different Cricket Balls on Different Types of Pitches

Papan Mondal[1], Neptune Ghosh[1,*], Pallab Ghosh[2], Kallol Ghosh[1], Sumanta Kumar Mondal[3]

[1]Department of Physical Education, Jadavpur University, India
[2]Department of Physical Education, Chandipur Manoranjan High School, West Bengal, India
[3]Department of Physical Education and Sports Science, Visva-Bharati University, India

Received June 29, 2025; Revised October 13, 2025; Accepted November 19, 2025

Cite This Paper in the Following Citation Styles

(a): *[1] Papan Mondal, Neptune Ghosh, Pallab Ghosh, Kallol Ghosh, Sumanta Kumar Mondal , "A Study on Restitution of Different Cricket Balls on Different Types of Pitches," International Journal of Human Movement and Sports Sciences, Vol. 13, No. 6, pp. 1230 - 1237, 2025. DOI: 10.13189/saj.2025.130607.*

(b): *Papan Mondal, Neptune Ghosh, Pallab Ghosh, Kallol Ghosh, Sumanta Kumar Mondal (2025). A Study on Restitution of Different Cricket Balls on Different Types of Pitches. International Journal of Human Movement and Sports Sciences, 13(6), 1230 - 1237. DOI: 10.13189/saj.2025.130607.*

Abstract Cricket performance is influenced not only by player skill but also by the interaction between the ball and the playing surface. The purpose of this study was to examine how different types of cricket balls behave on varied pitch surfaces in terms of their coefficient of restitution (COR). This study investigated the coefficient of restitution (COR) of five types of cricket balls—soft tennis (Cosco and Wilson), hard tennis (Headly), synthetic (SS), and leather (SG)—when dropped from four heights (120 cm, 150 cm, 180 cm, and 200 cm) onto three pitch types: turf, astro turf, and concrete. Bounce heights were recorded using high-speed videography, and data were analyzed using ANOVA and LSD tests. Results showed that the soft and hard tennis balls (Cosco, Wilson, and Headly) had significantly higher COR values compared to the synthetic and leather balls (SS and SG) across all pitch types. However, there was no significant difference in COR among the three tennis balls, nor between the synthetic and leather balls. Additionally, pitch type—whether turf, astro turf, or concrete—did not significantly influence the COR for any ball type. The study concludes that ball material and construction notably affect restitution, with tennis balls demonstrating higher bounce. In contrast, the pitch surface has a minimal impact on COR. These insights are useful for coaches, players, and equipment manufacturers in making evidence-based decisions for training and competitive play.

Keywords Cricket Ball, Cricket Pitch, Coefficient of Restitution, Bounce, Surface Effect

1. Introduction

The cricket ball is a central element of the game, influencing bounce, swing, spin, and overall match dynamics. Traditionally, it is manufactured from high-quality leather enclosing a cork core, with its structural design aimed at balancing durability, resilience, and performance. Depending on the playing context, different types of balls—leather, synthetic, and tennis (hard and soft)—are used, each demonstrating unique physical and mechanical properties that influence play. Leather balls dominate professional cricket due to their durability and consistent behavior, whereas synthetic and tennis balls are widely employed in recreational formats because of their lower hardness, affordability, and suitability for informal settings [1], [2].

Parallel to ball type, the playing surface significantly affects cricket performance. Pitches are commonly prepared from natural turf, synthetic/astro turf, or concrete. Turf pitches, though authentic, are highly variable due to maintenance, weather, and wear, thus affecting bounce and spin [3]. Synthetic surfaces provide consistency and durability, but often fail to replicate the nuanced variations of turf [4]. Concrete pitches, frequently used in training and

recreational games, deliver high bounce and uniformity, though they may exaggerate rebound and alter ball–bat interaction. The combined influence of ball material and pitch characteristics therefore plays a decisive role in game performance.

In sports physics, the coefficient of restitution (COR) offers a useful measure for evaluating ball–surface interactions. COR is defined as the ratio of rebound to incident velocity and reflects the energy retained after impact. A higher COR indicates a more elastic collision, while a lower COR represents greater energy loss, manifested as reduced bounce height [5], [6]. Sports engineering research has widely applied COR in contexts such as tennis, baseball, and cricket, providing insights into how material composition and impact surfaces shape performance [7], [8]. However, cricket-specific literature remains relatively sparse, particularly in systematically comparing restitution characteristics across different ball types and pitch surfaces [9]. This gap underlines the need for controlled experimental studies that quantify and contrast the restitution behavior of cricket balls on varied playing surfaces.

In cricket, research on ball performance has examined both the aerodynamics and the impact behavior of different ball types. Studies highlight that ball material composition (e.g., leather, synthetic, or rubber cores) and structural features such as seam orientation significantly influence bounce and post-impact motion [1], [10]. Leather cricket balls, with stitched seams and layered cork cores, are designed for longevity and controlled performance in competitive cricket. By contrast, tennis and synthetic cricket balls, though widely used in recreational formats, exhibit markedly different restitution behavior due to their softer material properties [2].

The playing surface is another factor that affects impact dynamics. Turf pitches, which are traditional in professional cricket, introduce variability in bounce depending on grass coverage, soil composition, and moisture levels [3]. Synthetic or astro turf pitches offer more consistent performance, though they may not fully replicate the nuanced interactions observed on natural turf [4]. Concrete pitches, common in informal play, generally yield the highest bounce because of their rigidity, though they lack the variability needed to simulate match conditions.

Beyond cricket, comparative studies in sports like tennis and baseball have shown that ball restitution is sensitive to both surface hardness and ball design [7], [8]. These findings support the idea that cricket balls will also vary significantly in restitution depending on their material and the pitch used. For instance, Haron and Ismail [9] specifically measured cricket ball COR across different surfaces and reported values ranging between 0.35 and 0.61, demonstrating how environmental and material factors interact to determine performance.

The behavior of cricket balls on different playing surfaces is a critical factor influencing bounce, pace, and overall game dynamics. While cricket is played at multiple levels using various types of balls (tennis, leather, synthetic) and on diverse pitches (turf, astro turf, concrete), there is limited scientific research quantifying how these combinations affect performance. Most existing studies in sports engineering and biomechanics focus on other sports (e.g., baseball, tennis), leaving a gap in applied cricket research. Understanding the restitution of cricket balls is important for coaches and players (for training strategies), administrators (for facility and equipment selection), and manufacturers (for ball design and standardization). This study addresses that gap by systematically comparing the coefficient of restitution (COR) of different cricket balls across common pitch types, providing both theoretical insights into ball-surface interactions and practical guidance for cricket stakeholders.

2. Materials and Methods

2.1. Study Participants

Ball 1: soft tennis cricket ball (Cosco), Ball 2: soft tennis cricket ball (Willson), Ball 3: hard tennis cricket ball (Headly), Ball 4: synthetic cricket ball (SS) and Ball 5: leather cricket ball (SG) were selected as the different sample balls; and Pitch 1: turf pitch, Pitch 2: astro turf Pitch and Pitch 3: concrete (cemented) pitch were selected as different sample pitches for measuring the restitutions of five different balls on three different pitches. All these three pitches were the practice pitches of Jadavpur University (second campus), which were maintained by Cricket Association of Bengal (CAB).

The instruments and tools which were used for the collection and the analysis of the data were: stadiometer, steel tape, camera with tripod stand, computer system, motion analysis software (Kinovea-0.8.25), standard cricket balls of three kinds (three different tennis cricket balls, synthetic cricket ball & leather cricket ball) and cricket pitches of three kinds (turf, astro turf & concrete).

2.2. Study Organization

In order to calculate the coefficient of restitution of any object, the velocity before collision and the velocity after collision of both the object and the surface should be measured. But there is an easy and alternative way to measure the coefficient of restitution for free-falling objects on a stationary horizontal surface. As the cricket pitch is a stationary surface facing upward, the ball can be used as a free-falling object to apply the method. To measure the coefficient of restitution of the ball using this method, it is necessary to measure the bounce height and drop height of the ball. Though it is easy to measure the drop height of any object manually, it is very difficult to

measure the bounce height of the object accurately without the help of video analysis. Hence, the video analysis method was used as illustrated in Figure 1.

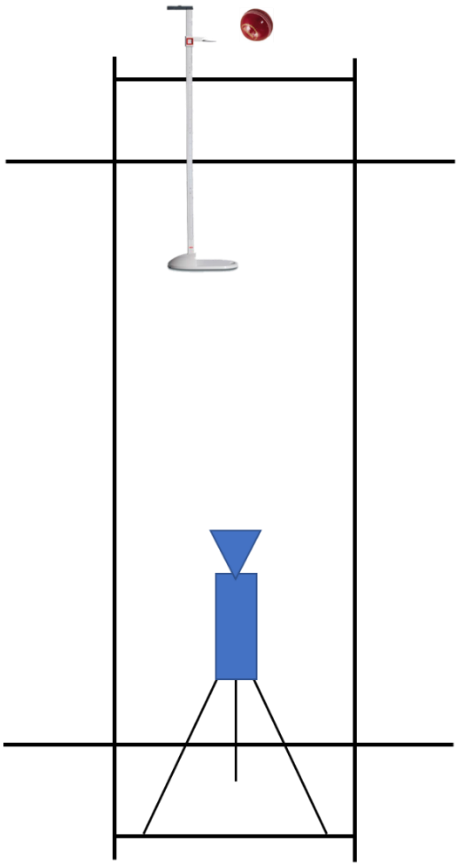

Figure 1. Filming Environment

At the beginning of the recording of the movement, the purpose of recording was briefly explained to everybody assisting the researcher for better understanding and to increase objectivity. A stadiometer was placed on the good length zone of turf pitch. The five balls were fallen freely from four different heights (120cm, 150cm, 180cm and 200cm) just beside the stadiometer [3], [9]. The camera was fixed at a certain and the same distance from the stadiometer and ball on each pitch. The camera was perpendicular to the stadiometer. The lens of the camera was parallel to the ground and the ball and stadiometer appeared at the middle of the display of the camera. After completing the recording on turf pitch, the same was conducted on astro turf and concrete pitch as shown in Figure 2.

Figure 2. Data collection

To measure the bounce height of the five different balls on the three different pitches from four different heights, the recorded film was analyzed as it is shown in Figure 3. The recorded video was transferred from the cameras to a computer, where Kinovea 0.8.25 motion analysis software was used to examine the ball's bounce height. This data was then utilized to determine the coefficient of restitution, calculated using the drop height and bounce height through the following formula [3]:

$$e = \sqrt{\frac{h}{H}}$$

Where, h= Bounce height and H= Drop height

2.3. Statistical Analysis

Descriptive statistics (mean, standard deviation, range) were computed for all conditions. A one-way analysis of variance (ANOVA) was performed to compare COR values across ball types and pitch types. All statistical analyses were conducted using SPSS software.

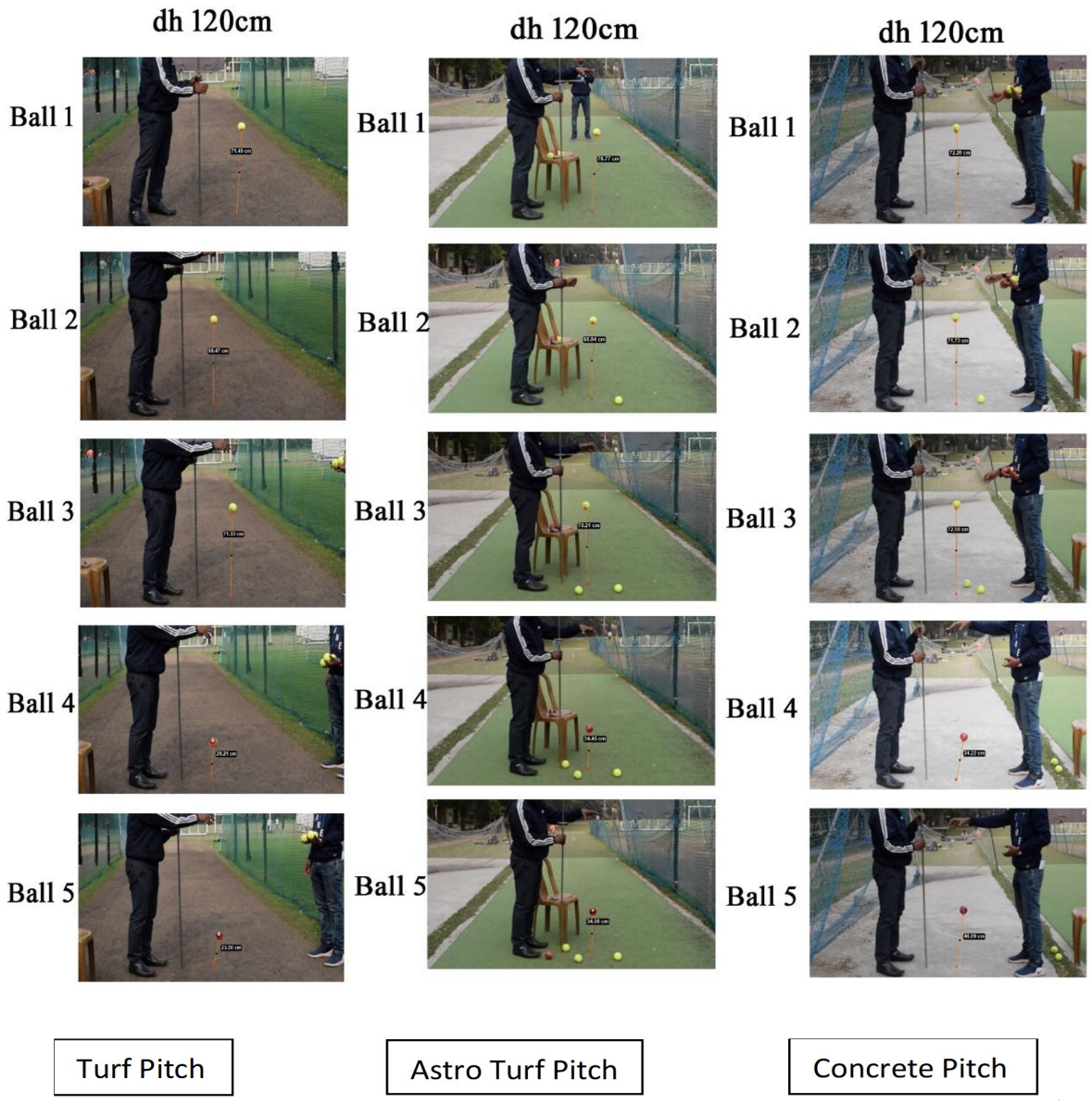

Figure 3. Video analysis of five different balls on Turf, Synthetic & Concrete pitches

2.4. Limitations

This study design has inherent limitations that must be acknowledged. First, the sample size was small and confined to a single testing environment, which may reduce generalizability. Environmental variables such as temperature, humidity, and pitch moisture, as well as the progressive wear of balls, were not controlled. The analysis was restricted to bounce height, without assessing other mechanical properties such as spin response, seam behavior, or surface deformation.

To improve technical rigor, care was taken to ensure consistency in video analysis, but no formal assessment of inter-rater or intra-rater reliability was conducted. Future studies should report measurement error margins and establish observer reliability. Moreover, while the present study compared restitution across ball types, it did not systematically evaluate material composition variables such as core hardness, seam stitching, or leather quality, all of which may influence impact dynamics. These limitations should be considered when interpreting the findings.

3. Results

Five types of cricket balls were dropped from four different heights (120 cm, 150 cm, 180 cm, and 200 cm) onto three pitches (turf, astro turf, concrete).

3.1. Descriptive Statistics of COR Across Ball and Pitch Types

From Table 1, it was clear that Ball 3 – hard tennis

cricket ball (Headly) on Pitch 3 – concrete (cemented) pitch had the maximum restitution, and Ball 5 – leather cricket ball (SG) on Pitch 1 – turf pitch had the minimum. In the case of every ball, except Ball 4 – synthetic cricket ball (SS), it was seen that Pitch 3 – concrete (cemented) pitch had the maximum restitution. On the other hand, for Ball 1 – soft tennis cricket ball (Cosco), Ball 2 – soft tennis cricket ball (Willson), and Ball 3 – hard tennis cricket ball (Headly), Pitch 2 – astro turf pitch showed minimum restitution. In contrast, for Ball 4 – synthetic cricket ball (SS) and Ball 5 – leather cricket ball (SG), Pitch 1 – turf pitch exhibited minimum restitution. In 2012 Haron, A. and Ismail, K.A. [9] found coefficient of restitution of cricket ball, 0.615, 0.610, 0.609, 0.606 and 0.606 from the height of 1.3m, 1.4m, 1.5m, 1.6m and 1.7m, respectively on the steel surface. And from these same heights, on the wooden surface, coefficients of restitution of the same ball were 0.356, 0.351, 0.351, 0.343 and 0.350, respectively.

Figure 4 represented the restitution of different balls on different pitches graphically. It showed that Ball 1 – soft tennis cricket ball (Cosco), Ball 2 – soft tennis cricket ball (Willson), and Ball 3 – hard tennis cricket ball (Headly) had almost the same coefficient of restitution even on three different types of pitches – Pitch 1 – turf pitch, Pitch 2 – astro turf pitch, and Pitch 3 – concrete (cemented) pitch. Whereas Ball 4 – synthetic cricket ball (SS) and Ball 5 – leather cricket ball (SG) had a much lower coefficient of restitution than Ball 1 – soft tennis cricket ball (Cosco), Ball 2 – soft tennis cricket ball (Willson), and Ball 3 – hard tennis cricket ball (Headly), it also showed nearly the same values across the three different types of pitches. Ball 5 – leather cricket ball (SG), which is commonly used for traditional cricket matches, displayed distinctly different behavior across the three types of pitches.

3.2. Effect of Drop Height

To determine whether drop height influenced the coefficient of restitution (COR), a one-way ANOVA was conducted across the four heights (Table 2). No significant effect was observed, $F(3,56) = 0.005$, $p = .999$, indicating that restitution values for the same ball on the same pitch were consistent across repeated trials. Accordingly, subsequent analyses were conducted using mean values across heights.

3.3. Effect of Ball Type

Table 3 represents a one-way ANOVA test performed to examine whether there were statistically significant differences in the coefficient of restitution among the five different types of cricket balls. The analysis revealed a highly significant effect of ball type on their coefficient of restitution, $F(4,10) = 30.902$, $p = 0.000$. The between-group sum of squares was 0.213, with a mean square of 0.053, while the within-group sum of squares was 0.017, with a mean square of 0.002. The statistically significant result ($p < 0.001$) confirms that not all ball types perform similarly, warranting further post hoc analysis to determine which specific groups differ.

Table 1. Descriptive statistics of COR for five cricket balls across three pitch types

	Drop Height 120cm	Drop Height 150cm	Drop Height 180cm	Drop Height 200cm	Mean	Std. Deviation
Ball 1, Pitch 1	0.775	0.765	0.761	0.762	0.7658	0.00640
Ball 1, Pitch 2	0.763	0.760	0.755	0.754	0.7580	0.00424
Ball 1, Pitch 3	0.773	0.770	0.767	0.757	0.7668	0.00695
Ball 2, Pitch 1	0.761	0.751	0.749	0.753	0.7535	0.00526
Ball 2, Pitch 2	0.758	0.750	0.748	0.752	0.7520	0.00432
Ball 2, Pitch 3	0.768	0.760	0.758	0.762	0.7620	0.00432
Ball 3, Pitch 1	0.775	0.775	0.774	0.777	0.7753	0.00126
Ball 3, Pitch 2	0.771	0.774	0.769	0.774	0.7720	0.00245
Ball 3, Pitch 3	0.788	0.794	0.796	0.789	0.7918	0.00386
Ball 4, Pitch 1	0.488	0.504	0.503	0.491	0.4965	0.00819
Ball 4, Pitch 2	0.535	0.541	0.533	0.532	0.5353	0.00403
Ball 4, Pitch 3	0.536	0.537	0.533	0.524	0.5325	0.00592
Ball 5, Pitch 1	0.404	0.439	0.429	0.430	0.4255	0.01502
Ball 5, Pitch 2	0.546	0.554	0.559	0.566	0.5563	0.00842
Ball 5, Pitch 3	0.606	0.610	0.599	0.575	0.5975	0.01567

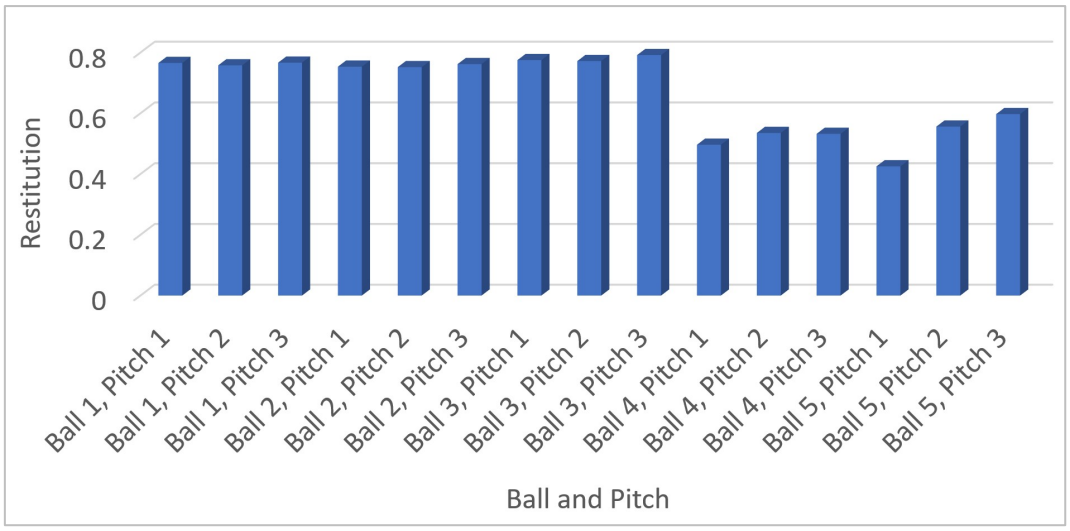

Figure 4. Mean coefficients of restitution for five cricket balls across three pitch types

Table 2. ANOVA results for COR across four drop heights (120 cm, 150 cm, 180 cm, and 200 cm)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	3	.000	.005	.999
Within Groups	.922	56	.016		
Total	.922	59			

Table 3. ANOVA results comparing COR across five cricket ball types

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.213	4	.053	30.902	.000
Within Groups	.017	10	.002		
Total	.230	14			

As shown in Table 4, the LSD test highlights statistically significant differences in mean values among the five groups of balls labeled Ball 1 – soft tennis cricket ball (Cosco) through Ball 5 – leather cricket ball (SG). Specifically, significant differences were observed between Ball 1 – soft tennis cricket ball (Cosco) and Ball 4 – synthetic cricket ball (SS) and Ball 5 – leather cricket ball (SG) ($p = 0.000$), Ball 2 – soft tennis cricket ball (Willson) and Ball 4 – synthetic cricket ball (SS) and Ball 5 – leather cricket ball (SG) ($p = 0.000$), and Ball 3 – hard tennis cricket ball (Headly) and Ball 4 – synthetic cricket ball (SS) and Ball 5 – leather cricket ball (SG) ($p = 0.000$). Additionally, Ball 3 – hard tennis cricket ball (Headly) was significantly different from Ball 4 – synthetic cricket ball (SS) (mean difference = 0.258, $p = 0.000$) and Ball 5 – leather cricket ball (SG) (mean difference = 0.253, $p = 0.000$). However, no significant differences were found among Ball 1 – soft tennis cricket ball (Cosco), Ball 2 – soft tennis cricket ball (Willson), and Ball 3 – hard tennis cricket ball (Headly), nor between Ball 4 – synthetic cricket ball (SS) and Ball 5 – leather cricket ball (SG), as all p-values for those comparisons were above 0.05.

3.4. Effect of Pitch Type

The one-way ANOVA results shown in Table 5 examine whether the coefficient of restitution varies significantly across different cricket pitch types: turf, astro turf, and concrete. The analysis showed that there was no significant difference among the three pitch types, $F(2,12) = 0.151$, $p = .862$. The mean square between groups was 0.003, while the mean square within groups was 0.019.

In summary, the coefficient of restitution (COR) was significantly influenced by the type of ball, with tennis balls (Cosco, Willson, Headly) exhibiting higher restitution values than the synthetic (SS) and leather (SG) balls. No significant differences were observed among the three tennis balls or between the synthetic and leather balls. In contrast, drop height and pitch type did not significantly affect COR, indicating that ball type was the dominant factor in determining bounce characteristics.

Table 4. LSD post hoc comparisons among ball types (Cosco, Willson, Headly, SS, SG)

(I) Ball	(J) Ball	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Ball 1	Ball 2	0.00767	0.03386	0.825	-0.0678	0.0831
	Ball 3	-0.01600	0.03386	0.647	-0.0914	0.0594
	Ball 4	0.24200*	0.03386	0.000	0.1666	0.3174
	Ball 5	0.23733*	0.03386	0.000	0.1619	0.3128
Ball 2	Ball 3	-0.02367	0.03386	0.500	-0.0991	0.0518
	Ball 4	0.23433*	0.03386	0.000	0.1589	0.3098
	Ball 5	0.22967*	0.03386	0.000	0.1542	0.3051
Ball 3	Ball 4	0.25800*	0.03386	0.000	0.1826	0.3334
	Ball 5	0.25333*	0.03386	0.000	0.1779	0.3288
Ball 4	Ball 5	-0.00467	0.03386	0.893	-0.0801	0.0708

* The mean difference is significant at the 0.05 level.

Table 5. ANOVA results comparing COR across three pitch types

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.006	2	.003	.151	.862
Within Groups	.224	12	.019		
Total	.230	14			

4. Discussion

The observed statistical differences among the cricket balls can be attributed to their material composition and construction. Balls 1 and 2 (soft tennis: Cosco and Willson) and Ball 3 (hard tennis: Headly) showed no significant differences in their coefficients of restitution (COR), reflecting the similar rubber-based cores and elastic properties that dominate their bounce behavior. This aligns with Cross (1999), who highlighted that internal material elasticity and energy conservation strongly determine bounce characteristics across a wide range of sports balls [5].

In contrast, the synthetic (SS) and leather (SG) cricket balls (Balls 4 and 5) demonstrated significantly lower restitution values than tennis balls, although they did not differ significantly from one another. The reduced restitution of leather balls is consistent with their layered cork-and-yarn core and stitched leather covering, which dissipate more energy during impact compared to rubber-based tennis balls. Similar findings were reported by Mehta [10], who emphasized how seam structure and material stiffness affect post-impact motion in cricket balls. Fuss [1] also showed that construction details such as core hardness and seam orientation substantially influence energy loss and ball–surface interactions in cricket.

Interestingly, pitch type (turf, astro turf, or concrete) did not produce statistically significant differences in restitution values in this study. This suggests that ball type exerts a stronger influence on bounce than surface compliance under controlled conditions. However, prior work in sports engineering has demonstrated that surface stiffness and friction can meaningfully alter spin, bounce angle, and post-impact trajectory [3]. Thus, while no significant effect was detected here, in real match contexts, even subtle surface variations could influence batter timing, bowler strategies, and consistency of bounce.

Haake, Goodwill, and Choppin [11] demonstrated that the dynamic impact characteristics of tennis balls depend significantly on material design and ball–racket interaction, a finding consistent with the present study where ball type had a greater effect on restitution than the pitch surface. The theoretical framework of impact mechanics suggests that COR is governed primarily by material properties and energy dissipation during collisions, which aligns with the current finding that ball type is a more critical determinant than pitch type [12].

From a practical cricket perspective, these findings highlight several implications. First, training with tennis balls—common in grassroots cricket—may overestimate rebound behavior and not accurately replicate the dynamics of leather balls used in competitive play. Second, bowlers accustomed to tennis balls may misjudge release velocity and tactical adjustments required with lower-restitution match balls. Third, the reduced rebound of leather and synthetic balls could increase ground

reaction forces upon impact, potentially heightening fielding injury risks on harder pitches. Comparable evidence from other sports such as baseball and tennis also indicates that lower restitution balls demand greater technical precision but may transfer more kinetic energy during bat–ball contact [7], [8].

Overall, this study reinforces that ball type, rather than pitch type, is the dominant factor influencing COR. Coaches and practitioners should consider this when designing training drills and selecting practice equipment to ensure skill transferability to competitive settings. Future research should incorporate additional parameters such as ball wear, seam orientation, spin rate, and environmental conditions (temperature, humidity), which prior studies have shown to be critical in shaping ball–surface interactions [9].

5. Conclusions

The coefficient of restitution of cricket balls is influenced more by ball material and construction than by pitch surface. Soft and hard tennis balls demonstrated higher restitution compared to synthetic and leather balls, with minimal differences across turf, astro turf, and concrete surfaces. These findings are relevant for coaching, training, and recreational cricket, where ball selection may significantly affect performance outcomes. Future research should extend this work by testing under different environmental conditions and integrating biomechanical and material science perspectives.

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