

# Proceedings of the World Congress of Science and Medicine in Cricket, November 3–5, 2023, India (Selected Abstracts)

*Journal of Postgraduate Medicine, Education and Research* (2023): 10.5005/jp-journals-10028-1645

## Investigation of Loading in the Lower Back during Cricket Fast Bowling

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**Aim:** A lumbar stress fracture is considered to be the most detrimental injury in professional cricket. The aim of this study was to quantify the magnitude of surface-measured accelerations at each major body segment during cricket fast bowling.

**Materials and methods:** A total of 11 male fast bowlers participated in this study with nine inertial measurement units used to measure acceleration transmission for back foot contact (BFC), front foot contact (FFC), and follow-through (FT). Peak resultant acceleration and its timing in relation to BFC, FFC, and FT were calculated. Two-way repeated measures analysis of variance (ANOVA) was performed in Statistical Package for the Social Sciences (SPSS) (version 24, IBM SPSS software) for each dependent variable. *Post hoc* comparisons performed were Bonferroni corrected.

**Results:** Both position ( $F = 113$ ;  $p < 0.001$ ) and phase ( $F = 28.1$ ;  $p < 0.001$ ) had significant effects on peak resultant acceleration, with peak accelerations significantly decreasing up the body to L5 and BFC accelerations were significantly less than FFC and FT. Position ( $F = 26.4$ ;  $p < 0.001$ ) but not phase ( $F = 4.45$ ;  $p = 0.025$ ) or interaction ( $F = 1.15$ ;  $p = 0.331$ ) had a significant effect on the time of peak acceleration.

**Discussion/conclusion:** Most of the distal tibia acceleration is attenuated before reaching the L5 region ( $91 \pm 2$ ,  $86 \pm 5$ , and  $88 \pm 4\%$  following BFC, FFC, and FT, respectively), suggesting that the postimpact elastic wave may be unlikely to contribute to lumbar stress fracture risk. This is in line with previous findings in alternate high-impact activities. These findings should be taken into account as researchers search for the causes of lumbar stress fractures and aim to minimize the risk of bowlers getting a lumbar stress fracture.

## An Investigation of Within-subject Associations between Fast Bowling Mechanics and Ball Speed

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**Introduction:** Fast bowlers' ability to deliver the ball quickly is advantageous since it can reduce the time it takes the batter to execute strokes. Some studies have reported weak to moderate correlations between ball speed knee flexion angle and center of mass deceleration. Stride mechanics, including plant angle and ground reaction forces, are also important for ball speed. Most findings are based on within-participant approaches that may not be representative of any of the bowlers that composed the group's performance.

**Aim:** The aim of the current investigation was to apply a within-participant methodology to determine the correlations between kinematics and ball speed for an individual fast bowler.

**Materials and methods:** A grade-level medium-pace bowler wearing a full-body marker set was requested to bowl 30 balls at maximum speed while being captured by a 10-camera Vicon motion analysis system (250 Hz). The resulting motion analysis data was fed as input into a visual 3D (version 11.2, C-Motion, Inc.) model of the fast bowler for kinematic calculations. In the within-participant analysis, Pearson product-moment correlation coefficient tests (two-tailed) were used to find correlations between the ball release speed and the chosen method parameters ( $\alpha = 0.05$ ).

**Results:** A significant Pearson correlation with ball speed was found for maximum shoulder-hip separation angle in about the flexion-extension axis ( $r = -0.435$ ,  $n = 25$ ,  $p = 0.0298$ ). A nearly significant correlation was the front knee flexion-extension angle at maximum vertical ground reaction force ( $r = -0.3561$ ,  $p = 0.0743$ , medium effect size). A nonlinear correlation (quadratic) between stride length and ball speed was also found ( $r = 0.3302$ ).

**Discussion/conclusion:** This within-participant analysis suggested that an increased stride length, increased front knee angle, and a lower maximum thoracic flexion angle (relative to the pelvis) positively influenced ball speed. This bowler could benefit from the nonstandard technique of achieving a long stride length with a flexed knee and a relatively upright trunk during front foot contact. Quantifying techniques using a within-participant is consistent with the problem of redundant degrees of freedom in the human body.

## Mental Health Services and Support for Elite Cricketers

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**Introduction:** The challenges of a career in sport, including the stigmas surrounding mental health, have meant overt support of well-being has been slow to develop. Further, opinion is divided on whether athlete development makes them naturally resilient to mental health problems or, conversely, they are more susceptible due to the stress of the competitive environment. Over the last 20 years, England Cricket has experienced several high-profile cases of well-being challenges and as such, has taken early steps to improve support for players and staff. This field continues to gain traction in society and sports, with governments, administrators, players, and support staff increasingly active.

**Aim:** To provide an overview of frameworks used to support athlete, coach, and support staff mental health, providing practical examples of implementation in elite sport, focusing on England Cricket.

**Discussion:** While a systematic approach to sports person mental health was only instituted within United Kingdom Olympic and Paralympic Sport in 2018, a program of embedded performance psychology and counseling training for science and medicine staff, clinical psychology support, safety plans for at-risk players, player formulation, and monthly well-being forums have been in place within England Cricket for many years. This has included the expansion of independent referral networks, mental health training for support staff, buddy systems and now an extensive PhD research program to understand the make-up of players throughout and following a career. Retired cricketers' analysis has also been undertaken and there has been a longstanding requirement for teams to have robust well-being pathways incorporating player welfare officers. The sport's track record has helped to make progress in reducing stigma. However, the expansion of education, screening and prevention programs based on research is required. These approaches are not unique and similar approaches and indeed, increasing resources is increasing standards both in the United Kingdom and internationally. The example of processes undertaken by the United Kingdom Sports Institute will be included to illustrate how, in a relatively short period, these learnings can be implemented across a large system of athlete support.

**Conclusion:** The demand for comprehensive mental health support within elite sports is likely to continue to rise. Cricket is no exception and poses unique challenges to the mental health of players and support staff within the expanding professional and international environment. Examples of good practice are available; however, sustained, universal implementation will require continued and increased investment in support service development.

### England Cricket Board (ECB) Mental Health Research: Insight into Men's Professional Game

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**Aim:** The ECB recognizes that professional sports, specifically cricket, by reputation, may pose significant challenges to well-being and mental health. However, there is a paucity of research and no substantial foundation for understanding the baseline population that enters professional cricket and the subsequent impact of the career on their well-being. In response, the ECB has embarked on a program of research PhDs with Bangor and Loughborough University.

**Materials and methods:** The nature of the prevalence of mental health and the degree of changes of markers are being examined prospectively both in-season and across seasons. Close working with the Professional Cricket Association (PCA) has been instrumental in enhancing compliance and subsequent implementation of learnings. Information at the beginning, mid-season and end-of-season includes extensive documentation of established measures of mental health (Phq9, WHO5, Gad7, AUDIT-C) as well as associated and novel factors.

**Results:** As of April 2023, data from 442 out of 650 current professional and additional academy players has been collected and is being analyzed. A further full-year post-COVID-19 is ongoing. The results of the ongoing data collection, subsequent analysis, and many of the important and potentially unique findings are yet to be published. However, some important early data outlines overall prevalence figures that suggest mental health in relation to

depression and anxiety is similar to that of the general population in the years that coincide with and followed the COVID-19 pandemic. However, mid-season increases have been observed. In addition, data does suggest behaviors such as alcohol consumption were potentially increased with seasonal trends and are going to be subject to closer analysis. Additionally, the period of research provided a unique analysis of the detrimental impact of biosecure bubbles on well-being.

**Discussion:** Initial findings suggest that the prevalence and degree of mental health markers are similar to the general population, albeit with seasonal trends and additional findings yet to be published. This research lays the foundation for understanding norms within the cricket-playing population and the impact of changes and interventions. It is already beginning to help identify planning of the timing, nature of support and education and resourcing of mental health and well-being programs with alcohol interventions as an initial steer. Future biosecure bubbles need careful panning by tournament organizers.

### Factors Associated with Mental Health Symptoms among Semiprofessional Cricket Players after the Reopening of Sporting Activities Following an Extensive Lockdown

*Lesego Malele, Habib Noorbhai*

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**Aim:** The mental health of athletes has received considerable attention in the last few years. There are limited studies on how mental health affects cricket players. The purpose of this study was to investigate the extent of mental health symptoms among semiprofessional male cricket players experienced during COVID-19, as well as the relationship between Depression, Anxiety, and Stress Scale-21 (DASS-21) subscales and how they influence each other.

**Materials and methods:** Mental health symptoms were assessed ( $n = 90$  cricket players) using the following instruments—DASS-21; Athlete Burnout Questionnaire (ABQ) and Satisfaction with Life Scale (SWLS). Descriptive (means  $\pm$  standard deviations) and inferential (Spearman's correlations) statistics were calculated using Statistical Package for the Social Sciences (SPSS) (IBM version 27.0) at a significance level of  $p < 0.05$ .

**Results:** The study demonstrated that there was a strong, positive, and significant correlation between stress and anxiety ( $r = 0.793$ ;  $p = 0.000$ ), stress and depression ( $r = 0.767$ ;  $p = 0.000$ ), and anxiety and depression ( $r = 0.748$ ;  $p = 0.000$ ). In addition, the ABQ reported that cricket players sometimes experience symptoms of a reduced sense of achievement ( $2.99 \pm 0.97$ ). Lastly, SWLS reported that cricket players neither agree nor disagree that they are satisfied with life ( $4.46 \pm 1.61$ ).

**Conclusion:** Reducing burnout, mental health symptoms, and life dissatisfaction would extend the playing careers of cricket players. Destigmatizing mental health may result in more robust and accurate self-reports of mental health illness among elite athletes.

### Validations of the Batting Backlift Technique in Cricket Using Deep Learning Architectures and Sensor-based Technology Integrations

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**Introduction:** Cricket batting techniques, including the batting backlift technique (BBT), play a crucial role in successful batting performance. However, limited research has focused on validating batting techniques in cricket using machine learning and artificial intelligence (AI). Additionally, advancements in sensor-based technologies have provided opportunities to recognize batting techniques in video footage automatically. This paper comprises two parts—(1) it compares the performances of popular deep learning architectures and (2) it demonstrates the validity of the recognition of the batting backlift technique using sensor-based technology.

**Materials and methods:** A dataset containing lateral and straight backlift classes was created, and video footage was analyzed using deep learning architectures (AlexNet, Inception V3, Inception Resnet V2, and Xception). The dataset was evaluated based on standard machine learning metrics, including precision, recall, and F1-score. In addition, a StanceBeam sensor is utilized and attached to the distal end of the bat while keeping the bat at a stationary position (between  $-90$  and  $+90^\circ$ ).

**Results:** The deep learning architectures demonstrated similar performance, with a precision score of 100%, recall score of 95%, and F1-score of 98% for each architecture. However, the AlexNet architecture exhibited lower performance, misclassifying four images. The Xception architecture outperformed the others, achieving a loss of 0.03 and an accuracy of 98.25% in differentiating between lateral and straight backlifts. For the sensor, previous validations have shown that when comparing the values measured between StanceBeam and OptiTrack, there is a statistically significant correlation ( $r = 0.99, p < 0.001$ ), with the angles measured by the StanceBeam sensor, also showing a 99% accuracy.

**Discussion/conclusion:** The successful recognition of batting techniques using deep learning architectures and sensor-based technology opens up avenues for automatic pattern recognition, performance analysis, and motion capture in cricket. The findings demonstrate the capability of these approaches and provide valuable tools for sports scientists, biomechanists, and video analysts working in cricket. Future research can further explore the applications of AI and sensor-based technologies to augment performance analysis in cricket and provide real-time feedback to players and coaches.

### Fast Bowling Technique Associated with Lumbar Bone Stress Injury Using Machine Learning

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**Introduction:** Fast bowling technique has been implicated in the etiology of lumbar bone stress injuries (LBSI). Statistical analysis used previously is limited due to its linear outcome characteristics and removal of variables due to multicollinearity. This can potentially be overcome by nonlinear machine learning methodologies. The aim was to explore if machine learning can differentiate between technique characteristics of fast bowlers with or without LBSI.

**Materials and methods:** This study used the same dataset as Alway et al., incorporating full-body kinematic (Vicon Motion Analysis, 300 Hz) and kinetic (Kistler Force Plate, 1500 Hz) data. A total of 39 elite fast bowlers prospectively sustained LBSI within 2 years of biomechanical testing and 11 uninjured fast bowlers, tested before

22 years of age and subsequently played 150 professional match days without evidence of LBSI, participated in the study. Injury status was confirmed by radiographic evidence. Data was analyzed in matrix laboratory (classification learner app, version 2022a) with fivefold cross-validation.

**Results and conclusion:** Around 92% of fast bowlers were accurately classified into LBSI (97% correct) or uninjured groups (73% correct). The variables classified using the maximum relevance minimum redundancy algorithm were (ordered from strongest to weakest according to Shapley analysis) rear knee flexion at back foot contact, thoracolumbar rotation at ball release, and absolute vertical loading rate at front foot contact. A machine learning methodology improved model accuracy compared with previously used binary logistic regression, particularly in uninjured bowlers, and provides new insights into technique risk factors to LBSI in fast bowlers.

### Fast Bowling Technique Associated with Ball Release Speed Using Explainable Artificial Intelligence (AI)

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**Aim:** Inertial sensors have proved to be an accessible alternative for field-based biomechanical testing otherwise restricted by traditional lab-restricted systems. However, applications of these sensors to understand fast bowling technique remains to be widely explored. Explainable artificial intelligence (AI) techniques are gaining popularity for their ability to uncover valuable insights obtained from machine learning models. This research aimed at understanding the underlying relationship of best predictors of ball release speed (BRS) in a Cohort of fast bowlers.

**Materials and methods:** Eight professional fast bowlers were recruited for the study. Two Vicon blue trident inertial sensors (Vicon, Oxford, United Kingdom) sampling at 250 Hz and four high-speed Bonita cameras were used for qualitative reference. A two-over bowling spell was performed in-lab that allowed for a full-length run-up. An explainable AI technique of Shapley values was adopted to understand the relationship of the top predictors in the regression model with 64 deliveries (eight per bowler).

**Results and conclusion:** Shapley values ranked as the top predictors of BRS wherein the strongest predictor was change in thoracic linear velocity (anterior) from back foot contact (BFC) to front foot contact (FFC). Subsequently, change in thoracic angular velocity (transverse) from FFC to ball release (BR), time duration from BFC to FFC, change in pelvic linear velocity (lateral) from BFC to FFC, and change in thoracic linear velocity (anterior) from FFC to BR showed significant contributions. The top predictors provide valuable implications for performance optimization.

### Investigation of Loading in the Lower Back during Cricket Fast Bowling

*Mark King, Stuart McErlain-Naylor, Paul Felton*

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**Aim:** A lumbar stress fracture is considered to be the most detrimental injury in professional cricket. The aim of this study was



to quantify the magnitude of surface-measured accelerations at each major body segment during cricket fast bowling.

**Materials and methods:** A total of 11 male fast bowlers participated in this study with nine inertial measurement units used to measure acceleration transmission for back foot contact (BFC), front foot contact (FFC), and follow-through (FT). Peak resultant acceleration and its timing in relation to BFC, FFC, and FT were calculated. Two-way repeated measures analysis of variance (ANOVA) was performed in Statistical Package for the Social Sciences (SPSS) (version 24, IBM SPSS Software) for each dependent variable. *Post hoc* comparisons performed were Bonferroni corrected.

**Results:** Both position ( $F = 113$ ;  $p < 0.001$ ) and phase ( $F = 28.1$ ;  $p < 0.001$ ) had significant effects on peak resultant acceleration, with peak accelerations significantly decreasing up the body to L5 and BFC accelerations were significantly less than FFC and FT. Position ( $F = 26.4$ ;  $p < 0.001$ ) but not phase ( $F = 4.45$ ;  $p = 0.025$ ) or interaction ( $F = 1.15$ ;  $p = 0.331$ ) had a significant effect on the time of peak acceleration.

**Discussion/conclusion:** Most of the distal tibia acceleration is attenuated before reaching the L5 region ( $91 \pm 2$ ,  $86 \pm 5$ , and  $88 \pm 4\%$  following BFC, FFC, and FT, respectively), suggesting that the postimpact elastic wave may be unlikely to contribute to lumbar stress fracture risk. This is in line with previous findings in alternate high-impact activities. These findings should be taken into account as researchers search for the causes of lumbar stress fractures and aim to minimize the risk of bowlers getting a lumbar stress fracture.

### Physical Characteristics Associated with Lumbar Bone Stress Injury Related Technique in Male Fast Bowlers

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**Aim/purpose:** Lumbar bone stress injuries (LBSI) have the highest prevalence of any injury in male cricket fast bowlers. Fast bowling technique has been identified as a risk factor for the etiology of LBSIs, but it is unknown whether injurious technique characteristics are related to physical characteristics. The aim was to determine if physical characteristics were associated with technical characteristics associated with LBSI.

**Materials and methods:** Around 39 academy and professional male cricket fast bowlers, aged 16–22 years old, underwent biomechanical bowling analysis (Vicon Motion Analysis, 250 Hz) and participated in strength and conditioning-based physical capacity assessments (Table 1). Data were analyzed in matrix laboratory (version R2021b) and Statistical Package for the Social Sciences (SPSS) (version 28 IBM, United States of America) with the use of Pearson's, Spearman's rho, and Kendall's Tau-b correlation coefficient statistical tests, at 95% confidence of interval (CI) ( $p < 0.05$ ).

**Results and conclusion:** Moderate correlations were found between rear hip flexion angle at back foot contact and the following physical variables—the prone plank hold ( $r = -0.315$ ,  $p = 0.154$ ), lumbopelvic stability on the ipsilateral (to bowling hand) side ( $r = 0.300$ ,  $p = 0.080$ ), lumbopelvic stability on the contralateral side ( $r = 0.306$ ,  $p = 0.075$ ) and the 2 km run ( $r = -0.326$ ,  $p = 0.084$ , Table 1). Lumbopelvic flexion angle at front foot contact showed a moderate correlation with the rear leg triple hop distance ( $r = 0.416$ ,  $p = 0.054$ , Table 1). The technique associated with LBSI

in fast bowlers may be underpinned by inadequate physical conditioning.

### Kinetic Differences between Good Length and Bouncer Deliveries in Cricket Fast Bowling

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**Background:** Previous studies have purported that bowlers who release the ball at faster speeds generate higher peak ground reaction forces (GRF), braking forces, and faster loading rates. Fast bowlers utilize deliveries of varying styles in matches, such as “good length” and “bouncer” deliveries. The bowling effort is very different for these two deliveries and we hypothesize that the kinetics will also have differences. Larger GRF, braking forces, and faster loading rates are known risk factors for lumbar spine injury. There are no previous studies that analyze kinetic differences between fast bowling deliveries of varying lengths and their implications on injury risk and performance.

**Aim and objectives:** This study aims to analyze the differences in kinetic parameters between good length and bouncer deliveries in fast bowlers.

**Materials and methods:** A total of 15 university-level fast bowlers underwent biomechanical analysis of their bowling action in an indoor three-dimensional (3D) biomechanics laboratory with an artificial indoor turf. Advanced Mechanical Technology's force plates embedded in the floor at the bowling crease were used to record the peak vertical ground reaction forces (pVGRF) and peak horizontal ground reaction forces (pHGRF), and loading rates were also calculated from one over of good length and bouncer deliveries each and were normalized to body weight. Bowling speed was recorded using a hand-held radar gun. Statistical analysis of the data was done using the t-test with significance set at 0.05.

**Results:** Mean pVGRF for good length and bouncers were  $5.54 \pm 1.23$  BW and  $5.44 \pm 1.54$  BW. There were no significant differences between each other ( $t = 0.208$ ,  $p = 0.836$ ). Mean pHGRF were  $3.71 \pm 0.764$  BW for good length deliveries and  $3.69 \pm 0.56$  BW for bouncers. There was no significant difference among the two ( $t = 0.055$ ,  $p = 0.957$ ). The horizontal loading rate was higher (mean 10 N/s) in the bouncers compared to good-length deliveries, though the change was not significant. There was no difference in vertical loading rates between the two delivery types.

**Conclusion:** There are no significant differences in the measured kinetic parameters between bouncers and good-length deliveries in this study. The findings of the present study negate the common belief that bouncers could result in higher forces on the bowler and hence provide a better understanding for the coaches and strength and conditioning professionals in this regard.

### Variables Associated with Run-out Opportunities in Cricket: Coaches' Perceptions vs Video Analyses of the Indian Premier League 2018/2019 Seasons

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**Introduction:** The purpose of this investigation was to add a scientific element to the understanding of run-out opportunities in twenty/twenty (T20) formats, which would, in turn, provide recommendations to players and coaches around the topic of runouts. Due to a lack of research in this field, the study was two-fold. Firstly, surveying experienced coaches on what they would expect

to take place during run-out opportunities from different areas of the field in a real-time T20 game. Secondly, the study looked at what happened during successful and unsuccessful runouts from different areas of the field in two Indian Premier League (IPL) seasons.

**Aim:** The aim of the study was to determine what variables within an area of fielding led to a successful or unsuccessful run out from different zones in the field and how this compared to coaches' perceptions.

**Materials and methods:** Coaches were required to fill out a survey that asked them to give their expectations on run-out opportunities during a T20 competition. The second part of the study investigated run-out opportunities in two consecutive IPL seasons, based on video footage, looking at how different variables impacted successful or marginally missed run-out opportunities in different areas of the field and at different times of the game. The areas were put into four different zones. Zone 1 is close to the batter, zone 2 is in the inner ring, zone 3 is on the edge of the ring, and zone 4 is the boundary fielders.

**Results:** Most of the coaches believed that in zone 1 of the field, the bowler would have the most opportunities, where, in fact, based on the video footage, these fell to the wicketkeeper. In zone 2, there was a larger range of fielding positions that runouts fell to when analyzing video footage. The coaches supported this by often naming the same fielding positions. There was a divide in zone 3. Most run-out opportunities from the video footage came to extra cover, where most coaches did not believe that would be the case and rather mentioned mid-off and mid-on. When analyzing video footage in zone 4, it had two fielding positions (long-on and deep mid-wicket) that make up the most run-out chances in this area, and these two positions were quoted by most of the coaches as having the most run-out opportunities. Throughout the findings, as concluded from the video footage, there were some results that matched the coaches' expectations and some results where findings from the video footage differed from the coaches' expectations. These findings are all useful. Firstly, it validates coaching practices. Secondly, it provides coaches with greater insight as to where they are not getting it correct in their fielding training.

**Conclusion:** In conclusion, this study found that although coaches' perceptions, for the most part, matched what took place on the field, there were instances where this was not the case. This has important practical implications for coaching and practice.

**Keywords:** Cricket, Fielding, Runouts, Throwing.

## Age Verification Young Cricketers

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**Background:** It is said that age is just a number, but when it comes to cricket and its offering, even at the young level, the temptations to maximize benefits may supersede everything. The legitimate age of a young cricketer in age-group tournaments has long been debated, questioning the concept of fair play that these young cricketers are nurturing. Cricketers have been disqualified from playing due to age fraud, leading to possible disadvantages to the sport due to the loss of a potential talent during crucial junior years, disadvantage to a deserving cricketer who was truthful about and long-term mental implications on the cricketer who was disqualified for fraud. All these necessitate the adoption of stringent measures for age verification for the benefit of all.

**Objective:** To review the existing age verification methods, their merits and demerits, and the existing policies adopted by leading cricket organizations.

**Materials and methods:** Literature is reviewed for the age frauds in cricket in the recent past and the age verification research studies in sports.

**Results:** Chronological age and biological age are currently the two most common methods for age verification. In India, nearly 38% of births do not get officially registered, giving scope to intentional and unintentional errors in chronological age documentation. Biological age remains the only avenue for age estimation in these situations. This can be accomplished through bone, dental, and physical examinations. Protocols like Tanner Whitehouse (TW), Greulich and Pyle (GP), and Fels are radiographic methods adopted for bone age estimation. These methods have been developed in specific populations, and hence, their applicability to another population like India is questionable. Besides, maturation is affected by ethnicity, diet, climate, disease, and genetics. A skeletal age range of 4 years is documented in a chronological age-group. Other methods of dental and physical examination are less explored in the sports setting and suffer from larger age variations. All these assessments also suffer from interobserver variations, which has opened up the avenue for artificial intelligence software, allowing quicker tests. Genetic testing of the DNA methylation levels is another avenue for further exploration within the sports arena.

**Conclusion:** Skeletal age estimation from radiography remains the gold standard of age verification in cricket until more research is done to develop newer techniques. A combination of various biological age methods and documents is being increasingly adopted by more cricket organizations in an attempt for more precise verification.

## Lessons for Sports going Forward from the COVID-19 Pandemic

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**Abstract:** In 2019, a dangerous new virus epidemic emerged in Wuhan, China, throwing the world into COVID-19 chaos as the virus rapidly spread across the globe. Shortly after this onset, the World Health Organization (WHO) declared a pandemic. As the world health authorities scrambled to respond to the pandemic, common responses were restrictions on travel, a severe limitation of mass gatherings, workplace shutdowns, and whole populations being forced to isolate. These controls significantly impacted all levels of sport, with many sporting events and competitions canceled or postponed. This, in turn, threatened the survival of some sporting organizations. In retrospect, we shouldn't have been surprised as the COVID-19 pandemic was one of 19 significant epidemics or pandemics that have caused >1 million deaths. Indeed, these widespread global infection outbreaks have been escalating in frequency, with seven of the 19 in the last 100 years. Sporting organizations responded to the pandemic by shutting down competitions, travel, and mass gatherings of spectators. International cricket was restricted for several months and only commenced with high-level controls after several months. During this early period of the pandemic, to facilitate the management of the pandemic, the CMOs of large sporting organizations worked together to share information and experiences. In this way,

COVID-19 prevention and management protocols were developed for each sport depending on the nature of each individual sport. What suited cricket wouldn't necessarily work for football and vice versa. Not surprisingly, all these protocols were similar. They included spectator restrictions, travel limitations, isolation, mask-wearing, vaccination, general hygiene controls, and contact tracing, to name a few. What has our pandemic experience taught us? Similar epidemics will occur, infection controls matter, new and emerging technologies can assist, and vaccination plays a key role. What we also learned was working together helps and we need to anticipate barriers to good infection control management, such as that spread via social media. We need to look back, learn, and prepare for the next epidemic that will impact sport.

### The Impact of COVID-19 on Male Semiprofessional Cricket Players' Mental Health and Performance Following the Resumption of Sporting Events

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**Aims:** The ability of cricket players to manage their mental health helps them to perform optimally. This study investigated how mental health is related to the performance of male cricket players during the resumption of sporting events after COVID-19 restrictions.

**Materials and methods:** Mental health profiles were established using the Depression, Anxiety, and Stress Scale-21 (DASS-21), Athlete Burnout Questionnaire (ABQ), and Satisfaction with Life Scale (SWLS) instruments among male semiprofessional cricket players ( $n = 63$ ). Performance metrics included %BF, ROM, push-abdominal test, crazy catch test,  $t$ -test, 40-meter sprint, and Cooper's test. Inferential statistics included Spearman's correlations with a significance level set at  $\alpha < 0.05$ .

**Results:** The Spearman's correlation reported a statistically significant relationship between SWLS and BMI ( $r = -0.263$ ;  $p = 0.037$ ) as well as between stress and abdominal test ( $r = 0.355$ ;  $p = 0.004$ ); crazy catch test ( $r = 0.249$ ;  $p = 0.049$ ); Cooper's test ( $r = 0.335$ ;  $p = 0.009$ ), peak oxygen consumption ( $r = 0.308$ ;  $p = 0.014$ ), stress and abdominal test ( $r = -0.313$ ;  $p = 0.012$ ); as well as anxiety and 40-meter sprint ( $r = 0.488$ ;  $p = 0.027$ ).

**Conclusion:** This study provides an important snapshot of how symptoms of mental health affect performance. Further research should investigate the relationship between mental health and performance parameters among male players at varied skill levels.

### Cricket in a Bubble: The Effectiveness of Maintenance of the Biosecure Environment (BSE) during the COVID-19 Pandemic

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**Introduction:** A Biosecure environment (BSE) or bio-bubble is planned to prevent the spread of COVID-19 infection. The International Cricket Council (ICC) tried to minimize the risk of disease transmission during tournaments using the BSE.

**Objective:** This study was designed to assess the effectiveness of COVID-19 containment, mitigation measures, and the outcome of the maintenance of the BSE.

**Methods:** This is a descriptive study evaluating international and national cricket tournaments held under the BSE recommended by the ICC from August to December 2021. Interviewer-administered questionnaires (via Google Forms) were updated weekly through a COVID-19 compliance officer at each of the events.

**Results:** A total of 1,230 participants in 15 events within six tournaments were followed up. The BSE was introduced and maintained in 15 locations in Sri Lanka. The BSE covered all Sri Lankan teams, visiting cricket team members, support staff, security, and match venue ground staff. Participants were tested using COVID-19 reverse transcription polymerase chain reaction (RT-PCR), rapid antigen tests (RAT), and COVID-19 antibody tests. Test coverage was 100% [test positivity—RT-PCR  $-7/2323$ , RAT  $-2/360$  (both PCR+), COVID-19 AB  $-0/42$ ]. Of the RT-PCR positives, two were isolated in the same place, one was transferred to an intermediate care center (private), and four were sent for home quarantine. The effectiveness of the "green corridors" created was 100%. Total participants with confirmed COVID-19 infection were 7 (0.56%). Tours with zero test positivity were 4/6 tours, while events were 12/15. No matches were canceled. No serious illness was reported.

**Conclusion:** Maintenance of BSE is very effective and crucial in minimizing COVID-19 outbreaks during ongoing cricket tournaments as long as the pandemic lasts.

### Cricket Science: Through an AI Lens

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**Introduction:** Cricket, a sport deeply rooted in tradition and strategy, is undergoing a transformative phase with the integration of artificial intelligence (AI). This review paper explores the burgeoning field of cricket science through the lens of AI, highlighting the potential applications and advancements that AI brings to cricket. By harnessing the power of AI, cricket can benefit from data-driven insights, strategic decision-making, and performance optimization.

**Aim:** The aim of this review is to provide a comprehensive overview of how AI is revolutionizing cricket science. By examining existing research, advancements, and case studies, a diverse range of AI applications in cricket, including match analysis, player performance evaluation, injury risk reduction, and game strategy development are explored.

**Materials and methods:** This review synthesizes and analyses existing literature, research papers, and case studies related to the integration of AI in cricket science. A systematic search of academic databases, sports science journals, and relevant online platforms was conducted to gather information on AI techniques, algorithms, and their impact on cricket.

**Results:** The integration of AI in cricket has yielded remarkable results across various domains. AI-powered match analysis systems have the capability to automatically extract and analyze data from cricket matches, providing valuable insights into player performance, game dynamics, and strategic patterns. Furthermore, AI algorithms can assist in player selection, injury risk reduction, and workload management by analyzing various forms of data and identifying risk factors.

**Discussion/conclusion:** The application of AI in cricket science presents immense opportunities for coaches, players, doctors, scientists, analysts, biomechanists, engineers, and the entire



cricketing fraternity. By leveraging AI technologies, cricket stakeholders can make data-driven decisions, optimize game strategies, and enhance player performance. However, it is crucial to strike a balance between AI's capabilities and human expertise. AI should be seen as a tool to augment human decision-making rather than replace it entirely. Ethical considerations, privacy concerns, and the interpretability of AI-generated insights also need to be addressed to ensure the responsible and effective use of AI in cricket.

## Quantifying Workload during Fast Bowling: Systematic Review

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**Introduction:** Fast bowlers in cricket have a high physical and biomechanical demand due to the complex nature of the bowling action and interaction with high-ground reaction forces during the landing phase. External workloads in fast bowling have been positively associated with injuries. Constable et al., 2021 through a review, suggested that in scientific literature, fast bowling workload is reported as a measure of fast bowling intensity, volume, frequency, and number of deliveries bowled. External training loads are objective measures of the work performed by the fast bowler and load is a mechanical variable that describes a force. Bowling intensity does not represent real forces involved in bowling; counting balls bowled may not provide an accurate measure of bowling workload because of the variability in bowler characteristics. Even with current guidelines on quantifying and monitoring the workload of fast bowlers, the incidence of injuries is not reducing. Hence, the aim of this review is to understand the mechanical variables described in the literature to refer to the intensity, volume, and frequency of fast bowling to quantify workload.

**Objective:** To identify the mechanical variables used to quantify external workloads of fast bowling and find an association between those variables and the risk of injury.

**Materials and methods:** Five online databases (PubMed, Embase, Scopus, Web of Science) were systematically searched. Keyword search terms included cricket fast bowling, bowling load, and workload; keywords were combined using a Boolean search strategy. The supplementary search was conducted using Google Scholar. The search of studies included documents from 1995 to April 2023; only human studies and studies in the English language were included. After screening for duplicates, excluding studies not relevant to the scope of the review, 63 studies were selected to be included in the review.

**Results:** Studies demonstrated bowling workload through intensity and volume by measuring the number of deliveries bowled, bowling duration, IMU-based acceleration kinematics, and movement patterns.

**Conclusion:** There is a need to include a measure of force to identify bowling intensity. Multiple studies describe bowling volume as insufficient to measure the external workloads of bowlers. Frequency and time do not provide adequate information to identify external workloads of fast bowlers.

## Impact of Hip Positions and Shoulder Movements on Muscle Activation of Posterior Oblique Sling among Cricket Population: An Observational Study

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**Introduction:** The proper alignment and stability of the pelvis and scapula are essential for effective energy transfer in overhead movements of the shoulder. When the muscles in these areas become fatigued during the game, it can have a detrimental effect on performance. Thus, setting goals for muscle strength and injury prevention becomes necessary.

**Aims and objectives:** To examine the activation of posterior oblique sling (POS) muscles in cricket players during three different shoulder movements (flexion, extension, and abduction) while assuming different hip positions (standing, sitting, and lunge).

**Materials and methods:** Muscle activation was recorded by surface electromyography [EMG: Noraxon United States of America (MR3 3.8.30)] in 24 male cricket players. Every player performed shoulder flexion, abduction, and extension in standing, sitting, and lunge positions.

**Results:** Raw data was evaluated by the Statistical Package for the Social Sciences (SPSS) version 26. An analysis of variance (ANOVA) test was conducted to assess the interaction between hip positions and shoulder movements. Results showed the significant ( $p < 0.05$ ) yet diverse changes in different hip positions and shoulder movements of the cricket population.

**Discussion/conclusion:** All hip position changes may be beneficial in scapular rehabilitation training because more muscles are recruited. The within-subject comparison showed that all muscles were recruited ( $p = 0.000$ ). However, in shoulder extension motions, POS muscles are activated more than abduction muscles. Previous studies indicate that specific muscles, such as the lower trapezius, serratus anterior, latissimus dorsi, upper trapezius, latissimus dorsi, and gluteus maximus, are highly activated during different shoulder movements like flexion, abduction, extension, and external rotation. Future studies should be conducted to unveil insight about nondominant side of players and also collect kinematic data or assess the precision of diagonal elevation.

**Keywords:** Electromyography, Hip positions, Shoulder movements.

## Preseason Bowling-related Exercise Volume and Injury Incidence Among Adolescent Cricket Pace Bowlers in Makhanda, South Africa

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**Introduction:** Pace bowlers are seemingly bowling faster over long periods. The physical demands on bowlers are increasing due to longer playing seasons, with more matches and less recovery time. Pace bowlers are prone to injury due to several risk factors, including the complexity of the bowling action, the repetitive nature of bowling, and the lack of physical preparation. A high bowling volume and the bowling technique can expose adolescent bowlers to an increased risk of injury, commonly leading to overuse injuries. Adolescent athletes still have developing musculoskeletal systems, which are susceptible to injury; therefore, it is important for athletes to build injury resilience through appropriate training. Bowling-specific training is vital to prepare adolescent pace bowlers to cope with bowling volumes. Further, exercise-based injury prevention strategies, including modifying poor bowling biomechanics and monitoring bowling volume, can decrease the chance of injury. The bowling volume can be adjusted as part of an overall strategy to reduce injury risk without adversely affecting bowlers' performance. Reducing injuries ensure longevity in the sport and promotes performance by allowing a more consistent bowling career.

**Aim:** The primary aim of this study was to describe the pre-season bowling-related exercise volume (BV) and injury incidence among adolescent pace bowlers and, secondly, to establish if there was an association between these variables.

**Materials and methods:** A selected cohort of 22 adolescent male cricket pace bowlers aged 13–19 from Kingswood College, Makhanda (Grahamstown) Eastern Cape, South Africa, were observed to measure bowling volume and any injury incidences. Bowlers bowling with a long run-up, with the wicketkeeper standing back, that is, pace bowlers, were included in the study. Each bowler's number of deliveries, run-up length per delivery, and session rating of perceived exertion (sRPE) for each session were recorded in logbooks. An injury surveillance questionnaire was used to identify players who sustained injuries during the observational period. Total BV was expressed as arbitrary units and calculated as follows:

Equation 1:  $sRPE \times \text{number of balls bowled} \times \text{total run-up distance}$  (in meters).

Equation 2:  $\text{Number of balls bowled} \times \text{total run-up distance}$ .

Equation 3:  $\text{Number of balls bowled} \times sRPE$ .

In 1 week, the total BV represented an acute BV. The chronic BV was calculated as the 2-week rolling average acute BV. The acute:chronic bowling volume ratio (AC-BVR) was calculated by dividing the acute BV by the chronic BV, providing the relative size of acute BV compared with chronic BV. A value  $>1$  represents an acute BV greater than the chronic BV.

**Results:** The bowlers bowled a weekly average of 58 deliveries [standard deviation (SD) =  $\pm 5.3$ ; coefficient of variation (CV) = 9.39%] with an average run-up distance of 879.10 m (SD =  $\pm 168.00$  m; CV = 19.11%) per training session. The mean sRPE was 6.20 (SD =  $\pm 1.38$ ; CV = 22.40%) per session. All the players' acute:chronic (A:C) ratios fell within the recommended range of 0.8–1.3, with the lowest ratio of 1.01 and the highest ratio being 1.3. The overall average for all the workloads together was 1.1. As a result, no injuries were recorded.

**Conclusion:** The most important finding of this study was that the players' A:C ratios were all in the recommended range of 0.8–1.3. This range falls within the recommended "sweet spot" of exercise volume and is where the risk of injury is at its lowest. As a result, there were no injuries over the reporting period.

## Understanding the Choking Phenomenon in Cricket: A Qualitative Study

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**Introduction:** Cricket is a popular competitive sport that demands players to perform in the presence of many sources of pressure (Gucciardi et al.). Choking refers to "an acute and considerable decrease in skill execution and performance when self-expected standards are normally achievable, which is the result of increased anxiety under perceived pressure." Researchers have proposed multiple theories and mechanisms to understand choking. The two prominent mechanisms that can explain choking are self-focus theory and distraction theory. Existing literature shows that choking experience can be determined by several antecedents, moderators, and short-term and long-term consequences on the athlete. Researches have also shown that the use of specific psychological strategies can alleviate choking. There is a lack of research on choking in cricket. Cricket is a unique sport that allows

cricketers to experience various external (e.g., opposition, coaches) and internal (e.g., anxiety, fear of failure) sources of pressure. Hence, understanding the choking phenomenon in cricket will be crucial to help athletes prevent choking and handle such situations better.

**Aim:** The aim of this study is to examine the personal experiences of choking in professional cricketers to identify the antecedents, mechanisms, and factors that influence choking. It also aims at understanding the consequences of choking on cricketers and techniques they use to alleviate choking.

**Methods and procedures:** Eight professional cricketers were selected using purposive sampling ( $M = 3, F = 5$ ), with a minimum of 8 years of experience and age ranging between 20 and 30 years ( $m = 24.75$  years,  $SD = 7.93$ ). The data was collected using a semi-structured interview. The interviews were digitally recorded and transcribed verbatim. The data was analyzed using Interpretative Phenomenological Analysis (Sparkes and Smith). The transcripts were read-reread to gain familiarity. Meaningful units and codes were identified, followed by grouping common codes to form themes. Finally, the global themes were organized to represent participants' choking experiences.

**Results:** The cricketers reported a range of antecedents (e.g., perceived pressure, fear of failure), mechanisms (i.e., distraction, self-focus), moderators (i.e., control, social support), and coping techniques used (i.e., pre-performance routines, simulated training). The athletes reported a substantial drop in performance, negative effects, and temporary withdrawal as a consequence of choking.

**Discussion/conclusion:** The findings of this study revealed that the antecedents, moderators, mechanisms, and consequences of choking are in line with previous research (Gucciardi et al.). "Individual responsibility" was identified as a crucial antecedent. Being a captain of a team, opening the bowling—a huge responsibility lies on them to do well since that is considered to be the foundation for the team. "Experience level" was considered to be an important moderator by the majority of cricketers. More experience can help athletes handle the situation better due to familiarity. "Team environment" and "social support" are a pertinent moderating factor that needs to be focused on to prevent cricketers from choking. The finding also shows how choking can have a cyclic effect on the athletes. Low self-confidence as a result of a choking experience can act as an antecedent to another choking event if not dealt with effectively. Psychological strategies and techniques used by the cricketer to overcome such situations are in line with previous research findings (Gropel and Mesagno). The findings of this study can be used by practitioners to design interventions specifically for cricketers that can help them prevent or handle a "choking" event effectively.

## Observational Study of Cricket Batting Mechanics

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**Introduction:** Knowledge of muscle activation at the elbow joint and wrist during batting in cricket may provide a greater understanding of the mechanics, leading to the generation of faster bat speed.

**Aim:** The aim of the current investigation was to determine selected muscle activation of cricket batters' lead arm during a distance-hitting batting protocol.

**Materials and methods:** A total of 10 cricket players playing for a Makhanda school (in Makhanda, the Eastern Cape, South Africa).



First team aged 16–19 years completed a distance-hitting batting protocol. Participants attempted to hit straight lofted drives while facing full-length deliveries at 80–100 km per hour from a bowling machine. Participants faced 12–24 balls separated into overs while lead arm muscle activation, bat speed, and angle of elbow flexion were recorded on four muscles using a Biometrics DataLogger Miniature MWX8 at 100 Hz. Bat speed was recorded using an accelerometer placed on the rear of the toe of the bat. The angle of elbow flexion was recorded using a goniometer placed across the elbow joint. The muscles measured were the forearm flexors (located on the lateral elbow epicondyle), forearm extensors (located on the medial elbow epicondyle), biceps brachii, and triceps brachii. Muscle activation for each muscle was recorded in millivolts (mv) and divided by the maximum measurement of voluntary muscle activation to determine the percentage of maximum voluntary contraction (%MVC) during each shot. %MVC for batting phases of backlift (0.4 seconds), downswing (0.19 seconds), contact (0.01 seconds), and follow through (0.39 seconds) was averaged to compare average %MVC per muscle across all batters and obtain inter-participant variability.

**Results:** Successful lofted straight drives ( $n = 32$ ) were compared to unsuccessful shots ( $n = 101$ ) across all participants. The backswing phase recorded a more flexed elbow ( $155.25^\circ$ ) for lofted straight drive compared to unsuccessful shots ( $157.86^\circ$ ) and lower activation across all muscles for lofted straight drive. The lofted straight drive had a more flexed elbow ( $129.52^\circ$ ) compared to unsuccessful shots ( $149.24^\circ$ ) for the downswing phase, and muscle activation was similar, with unsuccessful shots having greater variation. At contact, lofted straight drive had a more flexed elbow ( $153.44$  vs  $160.13^\circ$ ) and higher activation in the bicep ( $34.61$  vs  $28.41\%$ ) and tricep ( $51.07$  vs  $43.02\%$ ) compared to unsuccessful shots. For the follow-through phase, lofted straight drives had a more flexed elbow ( $144.87$  vs  $149.59^\circ$ ) and greater forearm extensor activation ( $37.13$  vs  $31.28\%$ ) than unsuccessful shots. There was a large amount of variation across all phases [coefficient of variation (CV) between  $8.79$  and  $70.28\%$ ], with backswing having the least variation and contact having the greatest.

**Conclusion:** Muscle activation increased in the last few milliseconds prior to contact. During the backswing and follow-through phases, the forearm extensor had the greatest activation. During the downswing phase, forearm flexors had the greatest activation, and at contact, the triceps brachii had the greatest activation.

## Chronic Injury Sequela of Elite Cricket Players in Sri Lanka

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**Abstract:** Various types of injuries in cricket are reported worldwide. They are categorized into acute and chronic in nature based on the mechanism, onset, and duration of the injuries. The reasons for the chronicity of acute injuries and chronic injuries themselves in cricketers need to be studied in depth. It enhances the knowledge and better understanding of the nature of the longstanding issues and their impact and burden on the players and the team's performance. The five cases of chronicity injuries in elite cricketers were assessed with detailed information history in chronological order. The first case scenario is an all-rounder with recurrent lower limb muscle injuries for over four years involving hamstring and quadriceps due to unproportionate upper and lower body muscle

strength and cross-sectional size ratio. The second case describes the unidentified lower limb length discrepancy, which resulted in biomechanical derangement of the pelvis, hips, and lower limbs of a fast bowler. The consequences were distal biceps femoris tendinopathy, iliotibial band (ITB) tightness contralateral, and ilio-lumbar-ligament tightness for 2 years duration, with difficulty in maintaining the proper line and length of bowling action. The third cricketer is a fast bowler who had chronic lumbar degenerative disk disease causing referred pain to bilateral lower limb mimicking recurrent hamstring sprains with spastic back muscles for a period of 2 years. The fourth chronic injury is a problematic ankle due to recurrent ankle sprains, resulting in osteoarthritic changes of the joint. The issue has led to the development of frequent injuries involving other various parts of the body and recurrent dropouts. The fifth case describes the negligence of acute ankle injury, giving rise to overall dysfunction of the joint with chronic disability. The management of various injuries that become chronic and recurrent is a challenge to the medical team. The integrity of the player's team position, level of performance, prevention of recurrence, and longevity of sports career will depend on the proper management of the chronic injuries. It is mandatory to have the accuracy of the diagnosis and an understanding of the complexity of the issues to produce better results in chronic injuries in cricketers.

## Bridging the Gap: Navigating Challenges and Empowering Women in Cricket

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**Abstract:** The realm of women's cricket has witnessed remarkable growth in recent years, with a surge in participation and skill level. Yet, as the sport thrives, it is imperative to address the multifaceted challenges faced by women cricketers, both on and off the field, along with unique medical challenges: both in terms of sports injuries and other medical concerns. The "Bridging the Gap" addressing Women's Cricket Issues on and off the field during the symposium creates a dynamic platform for interdisciplinary discussions on gender-specific disparities, injury prevalence, and innovative management approaches while comparing them to their male counterparts. Sports injuries are an inherent part of competitive cricket, affecting players' performance, careers, and overall well-being. A significant focus of the conference symposium lies in the injury landscape specific to women cricketers, focusing on prevalence, types, and risk factors. Furthermore, it will examine the physiological and biomechanical differences between female and male athletes that may contribute to divergent injury patterns. By uncovering these distinctions, the event aims to discuss the existing protocols of management and rehabilitation of injuries and illnesses, medical support systems, and recovery timelines of female athletes with existing literature. This symposium serves as a platform for examining gender disparities in cricket, including unequal resources, limited investment, inadequate media coverage, and limited opportunities for women players relative to their male counterparts. The event also explores sociocultural barriers impacting female participation, including restricted career pathways and underrepresentation in leadership roles within cricketing organizations, especially in South Asia. By identifying the barriers encountered by women in roles as coaches, administrators, and analysts, the conference highlights successful initiatives and mentorship programs that pave the way for enhanced female involvement and leadership in cricket's decision-

making bodies. In conclusion, by uniting diverse stakeholders—players, coaches, administrators, researchers, and advocates—the “Bridging the Gap” conference symposium facilitates collaborative efforts to address pressing challenges and catalyze change within the cricketing community, enabling women players to receive the same standard of care and attention as their male counterparts, while facilitating the development of evidence-based strategies that elevate the overall standard of care for women cricketers.

### Bibliometric Analysis of Cricket Injury Research: A Global Perspective

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**Introduction:** Cricket, a widely popular sport in the Indian subcontinent and Commonwealth countries, has amassed a massive global following of over 1 billion enthusiasts. However, injuries in cricket are a significant concern, negatively impacting player performance and leading to considerable absenteeism from the game. In recent times, there has been a surge in interest in understanding the epidemiology, biomechanics, and prevention of cricket-related injuries. To gain comprehensive insights into the existing research landscape, this study presents a bibliometric analysis of published research on cricket injuries.

**Methods:** The Web of Science database was utilized, employing a well-defined search strategy to identify original research articles focusing on injuries in cricket. The obtained search results were then analyzed using the R Bibliometrix package. Bibliometric parameters, including top authors, journals, countries, and keywords, were examined. Cooccurrence networks were generated, and thematic mapping was performed to identify emerging research topics.

**Results:** A total of 423 publications from 126 journals were included in the analysis, showcasing a notable increasing trend in the number of publications over time. JW Orchard emerged as the highest-published author, while Australia stood out as the leading country in terms of the number of publications. The published research predominantly focused on injuries sustained by fast bowlers, with major research themes centered around epidemiology, consensus definitions, and spinal issues in fast bowlers. On the other hand, there was relatively limited research on injuries concerning batsmen, wicketkeepers, and fielders. Furthermore, the representation of research from the Indian subcontinent was scarce, despite the immense popularity of cricket in the region.

**Conclusion:** The study findings reveal that a majority of cricket injury research originates from developed countries. The primary research

areas include epidemiology, injury prevention, and biomechanics, with a particular emphasis on fast bowlers. However, there is a need for more research to encourage publications that focus on injuries experienced by batsmen, wicketkeepers, and fielders, as well as cricket in the developing world. These insights are essential for researchers interested in exploring cricket-related studies and organizations aiming to advance injury prevention research in cricket.

### Lumbar Spine Injury in Indian Fast Bowlers: 3D Biomechanical Analysis and Prevention Strategies

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**Abstract:** Lumbar spine injuries are among the most common overuse injuries in a fast bowler. Among various causative factors, the bowling action technique is a crucial one. Three-dimensional (3D) motion analysis has been accepted as a gold standard tool to identify incorrect techniques. Previous studies have identified key biomechanical variables associated with lumbar injury risk in fast bowlers. Despite the large popularity of the sport, there is limited information available on the subject in Indian fast bowlers.

**Aim:** This study aims to analyze the lumbar spine injury risk in Indian fast bowlers with respect to key biomechanical variables, using 3D motion analysis.

**Methods:** Forty-seven male first-class fast bowlers underwent 3D motion analysis in an indoor biomechanics' lab. Motion capture was done with 3D cameras and two-dimensional (2D) video cameras using a standard marker set. Data processing analysis was done using proprietary software. Biomechanical variables associated with lumbar spine injury risk, including lateral trunk flexion (LTF) and knee angle at front foot contact (KA at FFC), were measured, and peak vertical ground reaction forces (pVGFR) were simultaneously recorded using force plates. A descriptive analysis of the data was done.

**Results:** About 26% of bowlers had a high LTF, 29% had low KA at FFC, and 43% had high pVGFR. Thus, a large proportion of bowlers in this study were at risk of lumbar spine injury with respect to the assessed variables.

**Conclusion:** This highlights the role of 3D motion analysis in the early identification of injurious techniques, which can be modified by coaching and training interventions to prevent injuries. This study thus has implications for the coaching and training of fast bowlers in India.

**Keywords:** Biomechanics, Cricket, Fast Bowling, Lumbar spine injuries.