

Training Load Monitoring and Injury Risk in Elite Cricket Fast Bowlers: A Literature Review

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Abstract— The relationship between the training workload and the associated injury risks has emerged as a central theme of contemporary sports performance analytics. Elite cricket fast bowlers have a higher propensity to musculoskeletal injury due to the repetitive high-intensity biomechanical demands of the bowling action. Over the last two decades, the literature has progressed from descriptive injury surveillance to predictive modeling of the relationship between acute and chronic workloads, culminating in the Acute-Chronic Workload Ratio (ACWR). Although the literature has demonstrated a strong correlation between sudden spikes in workloads and associated injury risks, methodological controversies and contextual variability of the competitive environment continue to question the generalizability of these findings. This literature review aims to collate the available literature on the relationship between workload monitoring and injury incidence among cricket fast bowlers, with a focus on the use of the ratio, the use of the chronic workload, the use of spikes in injury incidence, and the associated injury risks. Additionally, the review aims to identify the lacuna of the available literature, which has yet to adequately address the use of franchise-based T20 competitions and the variability of the workload calculations. Within this context, the present paper seeks to provide a structured overview of the current state of knowledge through the integration of empirical research and theoretical approaches, while also highlighting avenues for future research directions in the field of sports analytics and cricket performance science.

Index Terms— Training load monitoring, Fast bowling, Injury risk, Acute-Chronic Workload Ratio, Cricket Performance Science

I. INTRODUCTION

Injury prevention is considered one of the biggest challenges facing elite sport, especially for sports that require repetitive high-load movement patterns. For professional cricketers, fast bowlers experience

considerable mechanical stress due to the high-impact forces experienced during the bowling action. The competition demands, as well as the training requirements, make fast bowlers more susceptible to musculoskeletal injuries, especially for the lumbar region and lower extremities. Injury incidence rates for fast bowlers, as identified by various epidemiological surveillance studies, are higher when compared to other roles.

Initial research on injury prevention for cricket has mainly emphasized the importance of descriptive surveillance, highlighting the injury frequency, anatomical distribution, as well as the time loss patterns. Although the initial studies identified that excessive bowling was associated with injury, they did not provide any predictive tools that could estimate the critical workload for injury. With the advancement of sports science, researchers started focusing on the quantification of the training load, as well as the association between the training load and injury incidence.

This trend has aligned with the broader sports science movement in sports analytics, in which objective performance and workload information has begun to influence the decision-making process in professional sports teams.

Perhaps the most prominent development in sports science has been the introduction of the Acute: Chronic Workload Ratio (ACWR). The ACWR model seeks to compare the acute exposure to the workload against the longer-term training history of the athlete. It has been theoretically proposed that the risk of injury will occur when the acute workload is significantly greater than the chronic workload, effectively beyond the capacity to adapt to the training. Empirical research on elite cricket fast bowlers has reinforced the ACWR model, indicating that sudden spikes in workload are related to increased rates of

injury. The ACWR model has reinforced the broader theoretical concept known as the “training-injury prevention paradox.”

While the trend in the implementation of workload monitoring systems has become more prominent, there has been a focus on the statistical limitations of the ratio-based system. Some have argued that the calculation process may inflate the statistical associations.

Moreover, the lack of homogeneity in injury definitions, quantification of workloads, and statistical modeling may limit the ability to compare the results across the literature. Finally, the vast majority of the empirical studies have been conducted in the context of national cricket programs and not T20 competitions, which may have more variable and fluctuating workloads due to the condensed tournament format.

In the context of the increased commercialization and competitive nature of professional cricket, the relationship between workload spikes and injury risk is an important consideration in the optimization of performance and the protection of the athlete. This literature review, therefore, aims to summarize the existing literature on the monitoring of workloads in elite cricket fast bowlers, critically assess the strengths and limitations of the methodology, and identify areas

that have not been well explored in the literature. This literature review, therefore, aims to summarize the existing literature on the monitoring of workloads in elite cricket fast bowlers and clarify the state of the science in the context of sports analytics and injury prevention in professional cricket.

Definition of Elite Athletes

For the purpose of this review, “elite fast bowlers” is defined as cricketers who compete at the highest level in professional and/or international cricket. This includes cricketers who compete in international formats such as test cricket, one-day international cricket, and T20 international cricket, as well as those who compete in professional domestic leagues such as the Indian Premier League and other professional leagues. In addition to this, elite cricketers can be described as those who have access to professional training environments, coaching staff, sports science support, and regular participation in high-level competitive environments. This is consistent with previous sports science research, where elite athletes have been defined by level of competition, performance level, and training environments, not by age or amateur status.

II. MAIN CONTENT

Table 1. Key studies examining workload monitoring and injury risk in elite cricket fast bowlers and team sport contexts

Study	Year	Study Type	Population / Data	Key Focus	Main Finding
Dennis et al.	2003	Prospective cohort	Elite Australian fast bowlers	Bowling workload vs injury risk	High short-term workloads linked to increased injury risk, especially lumbar spine injuries
Orchard et al.	2009	Epidemiological study	Multi-season elite cricket database	Injury incidence by player role	Fast bowlers had highest injury rates among all roles
Foster et al.	2001 / 2010	Validation study	Elite athletes (multi-sport)	Internal load (session-RPE)	Validated session-RPE as reliable internal workload measure
Hulin et al.	2014	Prospective cohort	Elite fast bowlers	ACWR and injury risk	Workload spikes (high ACWR) increased injury likelihood
Hulin et al.	2016	Prospective cohort	Professional cricketers	Workload bands vs injury	Non-linear relationship; both spikes and low chronic load increase risk
Gabbett	2016	Conceptual review	Elite team sport athletes	Training–injury paradox	High chronic load improves resilience if progression is gradual
Carey et al.	2017	Observational study	Elite cricket players	Dose-response workload relationship	Greater weekly workload increases → higher injury probability
Windt & Gabbett	2017	Systematic review	Multiple team sports	Workload–injury relationship	Consistent association but high methodological variability

Impellizzeri et al.	2019	Methodological critique	Sports analytics studies	Validity of ACWR	Ratio-based metrics may create artificial correlations
Wang et al.	2020	Meta-analysis	Multi-sport studies	Evidence strength of workload spikes	Moderate evidence supports workload–injury link, but high heterogeneity
Bourdon et al.	2017	Consensus statement	Elite sport experts	Athlete monitoring frameworks	Integration of internal, external, and recovery load is essential
Drew & Finch	2016	Methodological review	Sports injury studies	Injury prediction models	Multifactorial models outperform single-variable approaches
Colby et al.	2020	Longitudinal study	Elite team sport athletes	Monitoring system application	Structured monitoring reduces injury burden
Johnston et al.	2022	Monitoring study	Professional athletes	Integrated monitoring models	Load + recovery + context improves injury prediction
Recent cricket research	Post-2020	Emerging literature	T20 professional cricket	Workload in condensed tournaments	High match density increases workload variability and injury risk

Epidemiology of Injuries in Elite Fast Bowlers

1. Dennis et al. (2003)

Dennis et al. (2003) is one of the first prospective studies to examine the relationship between bowling workload and injury risk in elite fast bowlers. The study tracked professional Australian fast bowlers throughout the duration of the sporting season and quantified the workload by measuring the number of overs bowled during both training and competition. Injuries were documented and verified based on the amount of time loss. The study concluded that elite fast bowlers subjected to higher short-term workloads, particularly above the recommended thresholds for bowling during the week, showed a significantly higher injury incidence rate. The study also showed that stress injury to the lumbar spine was particularly common among the subjects. The study concluded that insufficient recovery periods between bowling sessions was the primary cause of overuse injury among the subjects. Although the study did not use the rolling average and ratio-based workload metrics currently used in the sport, the study showed that the accumulation of absolute workload is directly proportional to injury risk among fast bowlers.

2. Orchard et al. (2009)

In their epidemiological study of elite-level cricketers from multiple seasons of competition, Orchard et al. (2009) further clarified the injury profile of professional cricketers. By using a centralized injury surveillance database, the study calculated the injury incidence rates of elite-level cricketers based on their exposure time and also categorized the injuries based

on the playing role and body regions affected. In this study, the fast bowlers were found to be the most injury-prone category of players, with injury incidence rates significantly higher than the injury incidence rates of batsmen, spin bowlers, and wicketkeepers. Soft tissue injuries and lumbar spine injuries were also found to be more common. Though the study did not perform any injury prediction modeling, the longitudinal nature of the data showed the increased injury burden on the fast bowlers and the importance of developing strategies to monitor the workloads of these players.

Evolution of Workload Monitoring in Cricket

3. Foster et al. (2001/2010 validation literature)

Foster et al. validated the session Rating of Perceived Exertion (session-RPE) method, which is a viable tool to measure internal training load in elite sport. By multiplying the perceived exertion ratings provided by the athlete with the length of the training sessions, the researchers were able to prove strong correlations between the perceived exertions and physiological parameters. This method was widely accepted due to its ease of use and practicality. Though not related to the sport of cricket, the study significantly impacted the way the athlete monitoring system is structured, particularly with the introduction of a standardized measure of internal training load. With respect to the sport of fast bowling, the study provides a viable measure that can be used to augment the more traditional external parameters of balls bowled or overs taken.

Acute:Chronic Workload Ratio (ACWR) Framework

4. Hulin et al. (2014)

Hulin et al. (2014) was one of the initial studies to implement the Acute:Chronic Workload Ratio (ACWR) model on elite-level cricket fast bowlers. In this prospective cohort study, professional cricketers were monitored over time, with the workloads of the bowlers quantified based on the number of balls bowled. For the study, the acute workload was defined as the rolling sum of the workloads over the preceding week, while the chronic workload was defined as the rolling sum of the workloads over the preceding four weeks. The results of the study showed that the cricketers who were exposed to acute spikes relative to their chronic workloads were more likely to experience non-contact injuries. It was also evident that moderate levels of chronic workloads were beneficial to the players, indicating that cumulative workloads make the players more resilient to injury. Though the study had limitations, the work still stands on the cornerstone of modern cricket workloads and injury modeling using the concept of spikes.

5. Hulin et al. (2016)

In a follow-up study, Hulin et al. (2016) extended the findings of the original investigation by using a larger sample to examine the effect of different bands of workloads on injury risk.

Utilizing logistic regression, the researchers investigated the non-linear relationship between ACWR and injury risk. The results of the investigation confirmed the relationship between sudden spikes in workloads and the incidence of injury, as well as the fact that low workloads can put athletes at risk of injury when exposed to sudden spikes in workloads.

6. Gabbett (2016)

Gabbett (2016) conceptualized the “training-injury prevention paradox,” which is considered to be highly influential in the injury prevention literature, specifically in team sports. Gabbett (2016) suggested that “high chronic training loads may actually increase resilience and decrease injury risk provided that the increases are progressive.” This study suggested that the risk of injury is not related to the absolute amount of training load but rather to “sudden changes from the athlete's chronic training load.” Gabbett (2016), through the analysis of cohort and regression study designs in elite sports environments, demonstrated that

athletes with well-developed chronic training loads were able to tolerate high levels of acute exposure. This study is considered to be highly relevant to the context of fast bowling, which is characterized by congested competition schedules.

7. Carey et al. (2017)

Carey et al. (2017) examined the dose-response relationship in the association between fluctuations in workload and the risk of injury in elite cricket players. The study used prospective monitoring of workload and verified injury data to conduct regression modeling on the effect of different amounts of variation in workload on the probability of injury. The study found that greater increases in workload from one week to the next were associated with greater probabilities of injury, supporting a graded model as opposed to a binary effect. The study reinforced the importance of tracking relative increases in bowling exposure as opposed to absolute numbers.

Methodological Critiques of ACWR

8. Windt & Gabbett (2017)

Windt and Gabbett (2017) present an exhaustive systematic review that explores the relationship between training load and injury risk in team sports. By assessing more than 30 studies, the researchers found consistent evidence of the relationship between increased training loads and injury risk. Nevertheless, the review also found significant variability in injury reporting, training load quantification, and statistical approaches. This review is particularly important to the sport of cricket, where the training load may be quantified through a variety of methods, such as the number of balls bowled, match density, and internal training load.

9. Impellizzeri et al. (2019)

Impellizzeri et al. critically examined the statistical properties of the ACWR model, which the authors believed might produce artificial correlations in the results using particular calculation methods that involve mathematical coupling. The authors advised against the indiscriminate use of ratio-based statistics and suggested alternative modeling techniques such as exponentially weighted moving averages and sensitivity analyses. The applicability of the ACWR model in cricket contexts in relation to the methodological critique is significant.

10. Wang et al. (2020)

Wang et al. (2020) carried out a meta-analysis study where they combined various studies on the relationship between training loads and injury risks in sports. The combined results revealed moderate evidence of the relationship between workload spikes and injury incidence. However, the heterogeneity of the studies was substantial. The study also pointed out the importance of conducting studies for each sport individually. The results of this study offer a broader perspective on workload-injury relationships but also show the existing gaps in cricket.

Integrated and Multidimensional Monitoring Models

11. Bourdon et al. (2017)

In their paper, Bourdon et al. (2017) discussed a consensus paper on monitoring training loads in elite sports. By taking into account physiological, biomechanical, and perceptual variables, the authors were able to provide a recommendation on combining internal and external training load variables along with recovery variables. The paper also emphasized the importance of not relying on a single variable in injury prediction, as it is not comprehensive. This is an essential concept in creating a cricket injury prediction model.

12. Drew & Finch (2016)

Drew and Finch (2016) also explored the statistical methods used to predict injury and the relative merits of univariate and multifactorial frameworks. Their review showed the superiority of injury prediction frameworks using multiple risk factors such as workload, recovery status, and athlete history over the use of individual injury predictors. The review also showed the limitations of simple threshold-based injury predictors and the benefits to using complex regression and machine learning techniques. All these findings can be used to improve the methodology used to predict fast bowling injury.

13. Colby et al. (2020)

Colby et al. (2020) investigated the practical application of structured systems of monitoring workloads in elite team sport contexts. The authors found, via longitudinal study, that injury burden decreased as a result of systematic monitoring and load adjustment protocols. This study provides an example of the practical application of analytics-based

decision-making, highlighting the potential for decreased time loss injuries, thus increasing the importance of workload modeling in professional cricket leagues.

14. Johnston et al. (2022)

Johnston et al. examined an integrated system of monitoring athletes that incorporated workload measures with recovery and readiness data. The study concluded that injury prevention was optimally achieved when load data was analyzed in relation to contextual factors such as travel demands, competition density, and athlete wellness indicators. This framework follows the new trend in sports analytics and allows for more complex modeling in cricket analysis.

Contextual Challenges in Modern T20 Leagues

15. Recent Cricket-Specific Monitoring Research (Post-2020)

Recent research in professional cricket has highlighted contextual factors such as tournament congestion, travel schedules, and physical demands of T20 cricket. It appears that short-form, high-intensity competitions may accentuate workload variability, particularly for fast bowlers. Recent research supports investigating weekly workload spikes in such condensed tournament schedules and therefore T20 professional leagues are an interesting area of further research.

III. LITERATURE SYNTHESIS

Past research has consistently identified the relationship between training workload and injury risk in elite sports. Previous studies examining injury patterns in cricket sports have identified that the greatest injury risk occurs in fast bowlers compared to all other playing positions due to the repetitive nature and impact of the high-speed bowling action. Dennis et al. (2003) was the first study to investigate the exposure to bowling workload in elite-level fast bowlers and identified the risk of overuse injury due to high bowling volumes and inadequate recovery periods. Specifically, the study identified the risk of lumbar stress fracture due to the cumulative effect of bowling workload. The findings of this study were further supported by Orchard et al. (2009), who utilized epidemiological surveillance to identify the

injury patterns in cricket sports and found that fast bowlers consistently had the greatest injury risk compared to all other playing positions.

More recent studies have focused on the development of workload monitoring systems to identify the threshold at which injury risk is elevated. Perhaps the most significant contribution to the development of workload monitoring systems was the introduction of the acute: chronic workload ratio (ACWR), which is the ratio of short-term exposure to workload in relation to the longer period of training history. A study done on elite fast bowlers by Hulin et al. (2014), which used this model to assess the injury risk in bowlers, measured the acute workload as the rolling sum of the number of balls bowled over the last week and the chronic workload as the rolling average over the last four weeks. From the results of the study, bowlers whose workloads increased substantially in relation to their chronic training history were at increased risk of sustaining non-contact injuries.

Other empirical studies built on the results of the study done on bowlers to further expound on the results. A study done by Hulin et al. (2016) showed that bowlers whose ratios were either too high or too low were at increased risk of injury, which further emphasizes the nonlinear relationship in the model. This is in line with the “training-injury prevention paradox” postulated by Gabbett (2016), which suggests that the higher the chronic exposure to training, the higher the injury resistance and the ability to withstand the demands of the high acute exposure to training. According to this structure, progressive build-up of workloads improves tissue adaptation, but sudden increments beyond the limits of the athlete’s previously developed potential may lead to physiological overload and increased injury risk. Further studies have also focused on the need to control internal and external workloads. For instance, Foster et al. validated the session rating of perceived exertion method of measuring internal training loads and showed that it correlated significantly with physiological markers of exercise intensity. Bourdon et al. (2017) also supported the need to incorporate the use of both internal and external workloads in athlete monitoring tools, arguing that the results would be more representative of the training stress than the results from the use of a single tool alone. This recommendation has also been integrated into modern sports analytics tools, especially in elite sports settings.

Although workload monitoring has been popular and widely implemented, various methodological issues still exist. In their systematic review of workload-injury study designs, Windt and Gabbett (2017) have indicated significant variability in workload measurement across different sports and study designs. Impellizzeri et al. (2019), in their review of workload-injury study designs, have expressed various concerns regarding the statistical properties of ACWR calculations and have indicated that certain types of ratio-based calculations may produce artificial correlations due to mathematical coupling of variables. Recent studies have highlighted the importance of workload monitoring from an analytics-based perspective. Colby et al. (2020) have indicated that structured workload monitoring programs implemented within professional sports teams have been linked with decreased injury burdens. Johnston et al. (2022) have indicated that workload monitoring in conjunction with athlete wellness and recovery measures can improve injury prediction models. It appears that such monitoring systems are the future of sports performance analytics.

Despite these improvements, the majority of the existing workload and injury research has taken place in a national cricket program or a multi-sport environment, as opposed to a franchise-based T20 league environment. Contemporary professional cricket leagues, defined by a condensed competition schedule and travel demands, potentially impose a different type of fluctuating workload patterns on fast bowlers, which might be different from traditional domestic or international cricket structures. Therefore, further investigation into whether the existing workload monitoring tools remain effective in these rapidly changing competitive structures is warranted.

IV. RESEARCH GAP

Although the existing literature has identified the relationship between sudden spikes in training workloads and the associated injury risk in elite athletes, there remain a number of critical areas of the literature that need to be addressed. Firstly, the majority of the existing literature has focused on the national cricket program or the long-format cricket environment, as opposed to the franchise-based T20 league environment, which has a more condensed tournament structure, more games played, and a more

fluctuating workload profile. Third, the methodological concerns raised against the Acute: Chronic Workload Ratio imply that more empirical investigations need to be carried out to assess its effectiveness in various forms of competitions. With the increased level of commercialization of T20 cricket, there has been a need to assess whether sudden spikes in bowling workloads during league competitions contribute to the incidence of more injuries among fast bowlers.

This would be an invaluable area of investigation to assist performance, sports science, and coaching staff in maximizing the availability of their athletes during such high-demand competitions.

V. CONCLUSION

The present literature review aimed to identify the relationship between the monitoring of training workload and the risk of injury for elite cricket fast bowlers by reviewing the relevant epidemiological studies, frameworks for monitoring workload, and methodological discussions in the field of sports performance analytics. Initial studies into cricket-related injuries have consistently reported that fast bowlers have the highest incidence of injury among all playing roles, and this is primarily attributed to the repetitive nature of the biomechanical stress associated with the bowling action. Initial studies have established that excessive bowling and inadequate recovery time significantly contribute to the risk of overuse injuries, such as stress injuries to the lumbar spine. These studies were the initial rationale for the systematic monitoring of workload for elite cricket players.

Recent advances in sports science have led to the focus being shifted from the absolute accumulation of workload to the relative fluctuations in workload and the capacity for adaptation. The Acute-Chronic Workload Ratio framework has been a significant advancement in the understanding of the impact of sudden peaks in workload and their possible impact on the probability of injury. Empirical studies conducted to assess the impact of acute workload peaks relative to the chronic workload base of elite cricket fast bowlers have indicated a significant increase in the probability of injury with sudden peaks in acute workload relative to the chronic workload base. Conversely, the studies conducted to assess the

training-injury prevention paradox have indicated the positive impact of well-developed chronic workloads, suggesting that athletes with higher chronic workloads have the capacity to withstand higher acute workload peaks.

Although the ratio-based monitoring framework has been widely adopted, the literature has also indicated some important methodological issues with the monitoring framework. Several systematic reviews and analytical studies have raised important concerns with the statistical basis of some of the workload metrics, suggesting the possible creation of artificial correlations through mathematical coupling, which could have significant implications for the accuracy of the monitoring framework. Additionally, the definitions of injury have been inconsistent with the monitoring framework, quantification methods, and statistical modeling techniques, which are applied in various studies, make it difficult to compare results and establish universal workload thresholds. Meta-analytic results show moderate support for the link between workload spikes and injury risk, but also highlight the variability that exists within the existing body of research.

Recent advances in sports analytics, however, have placed more emphasis on the need for integrated athlete monitoring systems. These are systems that can utilize various pieces of information. Modern athlete monitoring includes internal and external workload, as well as recovery, wellness, and contextual factors like travel and competition loads. A recent study suggests that multifactorial models can provide a more complete understanding of injury risk, as opposed to single-variable athlete monitoring. In relation to professional cricket, these integrated models may provide more accurate predictions as well as more applicable advice to coaches who are tasked with managing fast bowler workloads.

However, there are some gaps in the current literature. For instance, the majority of the research on the monitoring of workloads has been based on national cricket programs or sports settings, as opposed to franchise-based T20 competitions. The current T20 competitions are marked by a high number of games in a relatively short time, a high level of competition, and extensive travel requirements. These factors are likely to influence the variability of workloads, and further research on the variability of workloads within the T20 competition environment may be required to

further inform injury prevention for the elite fast bowlers.

In conclusion, the current research provides sufficient evidence for the importance of the monitoring of workloads in the prevention of injuries for the elite cricket fast bowlers. The current research on the ratio-based models of workloads has contributed significantly to the understanding of the relationship between workloads and injuries. However, the ongoing methodological debates and the changing competition environment suggest that further research is required in the area to further inform the development of more effective models for the management of workloads for the elite fast bowlers.

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