ACUTE-TO-CHRONIC WORKLOAD RATIO AND INJURY RISK IN PROFESSIONAL VOLLEYBALL: A TWO-MONTH MONITORING STUDY

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***Abstract**: Monitoring training load is crucial for optimizing performance and minimizing injury risk in elite athletes. The acute-to-chronic workload ratio (ACWR) has gained attention as a potential tool for managing training loads. This study aimed to present ACWR in professional volleyball players and explore its relationship with injury occurrence. Fifteen male professional volleyball players from a Turkish team were monitored over two months. Training load was quantified using the rating of perceived exertion (RPE), recorded daily to calculate both acute (7-day) and chronic (28-day) workloads. The ACWR was then computed weekly to assess fluctuations in training intensity. Two players sustained injuries during periods of elevated ACWR, suggesting a potential link between rapid workload increases and injury risk. When ACWR exceeded recommended thresholds (>1.5), injury occurrences aligned with previous research indicating that sudden workload spikes may contribute to injury susceptibility. However, individual variability and other contributing factors, such as biomechanical and physiological responses, must be considered. The findings suggest that ACWR could be a useful tool for monitoring training loads and potentially reducing injury risk in professional volleyball players. However, further studies with larger sample sizes and additional monitoring methods are needed to establish definitive conclusions on its predictive validity. Implementing structured workload management strategies may enhance performance while minimizing injury occurrence.*
***Key words**: acute-to-chronic workload ratio, training load monitoring, injury risk*

INTRODUCTION

Monitoring training load has become a central component of contemporary sports science, particularly in elite team sports where athletes are exposed to high physical and physiological demands. The primary objective of systematic workload monitoring is to balance training stimulus and recovery to optimize performance while minimizing the risk of injury (Impellizzeri, Marcora, & Coutts, 2005). In this context, the acute-to-chronic workload ratio (ACWR) has emerged as one of the most frequently used models for interpreting fluctuations in training stress and identifying periods of potential vulnerability among athletes (Gabbett, 2016).

Acute workload is commonly defined as the cumulative training load over a short period, typically seven days, whereas chronic workload represents the average load accumulated across a longer period, most often four weeks. The ratio between these two metrics provides insight into whether an athlete is progressing through gradual, planned increases in workload or being exposed to sudden spikes that may exceed their current level of preparedness (Hulin et al., 2016). Previous research has suggested that excessive increases in ACWR—often operationalized as values exceeding 1.3 to 1.5—may be associated with elevated injury risk, as the athlete may not have sufficient time to physiologically adapt to the rapid change in training demands (Gabbett, 2016; Windt & Gabbett, 2018).

While ACWR has been widely studied in sports such as soccer, rugby, and basketball, far fewer investigations have examined its application in volleyball. This is noteworthy given the biomechanical and physiological complexity of the sport, which includes frequent jumping, rapid accelerations and decelerations, high-impact landing actions, and repetitive overhead movements. These demands place substantial stress on both the lower limbs and the shoulder complex, increasing the importance of structured workload monitoring to support performance enhancement and injury prevention (Gabbett & Domrow, 2007). Moreover, positional roles in volleyball differ markedly in their physical demands—liberos, setters, middle blockers, outside hitters, and opposites each experience unique movement patterns and load profiles—which further highlights the need for individualized and context-specific monitoring approaches.

Despite its growing popularity as a practical monitoring tool, ACWR remains a topic of debate due to methodological considerations, such as mathematical coupling and the variability of individual

responses to training. Nevertheless, its accessibility and ability to capture rapid fluctuations in workload have contributed to its widespread adoption among coaches, sports scientists, and performance staff seeking early indicators of increased injury risk (Windt & Gabbett, 2018).

Given the growing importance of workload monitoring in elite volleyball and the limited empirical evidence specific to this sport, additional research is needed to clarify how changes in weekly training loads relate to injury occurrence in professional players. Therefore, the aim of this study was to monitor the acute-to-chronic workload ratio over a two-month period in professional male volleyball players and examine its relationship with injury occurrence.

METHODS

Participants

Fifteen professional male volleyball players competing in the Turkish national league participated in this study. All players were members of the same professional club and were monitored continuously over a two-month period during the competitive season. The sample included athletes from different playing positions (setters, outside hitters, opposites, middle blockers, and liberos), all of whom were healthy and actively participating in full training at the beginning of the monitoring period. Player characteristics such as age, body mass, height, and playing experience were recorded as part of the team's standard profiling procedure; however, only workload data were used for the purposes of this analysis. The study utilized workload information routinely collected as part of the club's standard monitoring process

Study Design

A prospective observational design was employed to monitor internal training load and calculate the acute-to-chronic workload ratio (ACWR) over an eight-week period. Training sessions and matches were tracked daily, and players independently provided subjective ratings of perceived exertion (RPE) following each session. Weekly acute and chronic workloads were computed, after which ACWR values were calculated and compared with the occurrence of injuries documented during the same period.

Rating of Perceived Exertion (RPE)

Internal training load was quantified using the session rating of perceived exertion (sRPE) method, a widely validated and frequently used tool in team sports (Foster et al., 2001). Approximately 30 minutes after each training session or match, players provided an RPE score on the CR-10 Borg scale, indicating their subjective perception of effort. Session load was calculated by multiplying RPE by session duration (minutes): Session Load=RPE×Duration (min).

All RPE data were collected individually to minimize peer influence and ensure independent reporting.

Acute and Chronic Workload Calculation

Acute workload was defined as the total accumulated session load across the previous seven days (7-day rolling sum). Chronic workload represented the mean session load over the preceding 28 days (28-day rolling average). These time windows were selected in accordance with existing literature on ACWR modeling (Hulin et al., 2016; Gabbett, 2016).

ACWR Calculation

The acute-to-chronic workload ratio (ACWR) was calculated using the rolling average model: ACWR=Acute Workload (7-day)/Chronic Workload (28-day).

ACWR values greater than 1.5 were considered potentially indicative of rapid workload increases and elevated injury risk, based on previous research in team sports (Gabbett, 2016).

Injury Definition and Recording

All injuries occurring during the monitoring period were recorded by the club's medical staff as part of routine medical oversight. For the purposes of this study, an injury was defined as any physical

complaint resulting from training or match play that led to at least one day of modified, reduced, or missed participation. Two injuries were documented during the two-month period, both occurring in weeks characterized by elevated ACWR values.

Procedure

All training and match sessions were monitored daily by the coaching staff. RPE values were collected using standardized forms after each session. Workload calculations and ACWR values were computed weekly and aligned with injury records for descriptive analysis. No interventions were introduced; players completed their usual training program designed by the club.

RESULTS

During the eight-week monitoring period, weekly acute and chronic workloads were successfully calculated for all 15 athletes, allowing for the computation of ACWR values across the entire sample. ACWR values fluctuated throughout the monitoring period, with several weeks showing moderate workload changes, while two weeks demonstrated marked increases in the acute-to-chronic ratio, exceeding the commonly referenced risk threshold of 1.5.

A total of two injuries were recorded during the study period. Both injuries occurred during weeks in which players exhibited elevated ACWR values (>1.5), indicating a substantial rise in short-term workload relative to the chronic load. No injuries were reported during weeks in which ACWR remained at or below 1.5. These findings align with prior research suggesting that rapid increases in training load may heighten the likelihood of injury.

To provide a clear overview of the relationship between ACWR ranges and injury occurrence in the present study, a categorical summary is presented in Table 1.

Table 1 Injury Occurrence Relative to ACWR Categories During the Monitoring Period

ACWR range	Weeks	Injuries	Incidence
≤ 1.0	Several	0	None
1.01 – 1.50	Majority	0	None
> 1.5	2	2	High

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DISCUSSION

The primary aim of this study was to examine the acute-to-chronic workload ratio (ACWR) over an eight-week period in professional male volleyball players and to explore its relationship with injury occurrence. The results demonstrated that both injuries recorded during the monitoring period occurred in weeks where ACWR values exceeded 1.5, whereas no injuries were observed in weeks with lower or moderate ratios. Although the findings should be interpreted with caution due to the limited sample size, they offer further support for the growing body of evidence suggesting that sudden increases in training load may elevate injury risk in team sport athletes.

Previous research has consistently highlighted the association between rapid workload spikes and injury incidence. Studies in rugby, soccer, and basketball have reported that ACWR values above commonly cited thresholds—typically between 1.3 and 1.5—are linked to higher injury likelihood, as athletes may be exposed to acute stress that surpasses their current level of physical preparedness (Gabbett, 2016; Hulin et al., 2016). The present findings appear to align with this pattern, suggesting that volleyball athletes may be similarly vulnerable when acute workloads rise faster than the chronic load

can accommodate. Given the high biomechanical demands of repeated jumping, landing, and overhead actions in volleyball, athletes might be particularly sensitive to abrupt workload escalations.

The absence of injuries in weeks where ACWR remained at or below 1.5 is also consistent with the concept of the "training sweet spot," a range in which workloads are sufficient to promote adaptation without imposing excessive stress (Gabbett, 2016). Maintaining athletes within this workload window has been proposed as an effective strategy for injury prevention, as it balances the need for performance improvement with the protection of athlete health. In the present study, the majority of training weeks fell within this moderate range, which may have contributed to the absence of injury during those periods.

Although the ACWR model has been widely adopted in applied settings, recent literature has pointed out conceptual and mathematical limitations. Critics argue that the ratio may oversimplify the complexity of training load and that its predictive capacity may vary depending on the model used and the characteristics of the sport (Windt & Gabbett, 2018). Moreover, individual differences—such as training history, positional roles, neuromuscular resilience, and recovery capacity—can influence how athletes respond to workload changes. For volleyball in particular, positional differences may play a substantial role: middle blockers experience a high density of jumps, setters have unique movement patterns, and libero players have different loading profiles than hitters. Such variability underscores the importance of individualized monitoring.

Another important consideration is that workload measures based solely on RPE may not fully capture the multidimensional nature of physical stress in volleyball. While RPE-based methods are valid and practical, integrating additional metrics—such as jump count, external load from inertial sensors, or biomechanical markers—could provide a more comprehensive understanding of how workload influences injury risk. Future studies incorporating multiple monitoring tools may offer deeper insights into sport-specific demands and adaptation patterns.

The primary limitation of this study is its small sample size and short monitoring period, which restrict the generalizability of the findings. Additionally, injury occurrence was low, preventing more advanced statistical analysis. Nonetheless, the clear pattern observed—injuries occurring only during high-ACWR weeks—reinforces the practical value of monitoring workload fluctuations in elite volleyball environments. Despite the limitations, the descriptive data provide meaningful insight into how sudden workload increases may relate to injury risk in this population.

Overall, the findings of this study suggest that ACWR can serve as a useful tool for identifying periods of heightened injury risk among professional volleyball players. Maintaining workloads within an appropriate range and avoiding abrupt spikes may be an effective strategy for reducing injury incidence and supporting consistent performance throughout the season.

CONCLUSION

The present study examined the acute-to-chronic workload ratio (ACWR) over an eight-week period in professional male volleyball players and explored its relationship with injury occurrence. The results showed that both injuries recorded during the monitoring period occurred exclusively in weeks where ACWR exceeded 1.5, whereas no injuries were observed during weeks with lower or moderate workload ratios. Although the study was limited by a small sample size and a low number of injuries, the findings are consistent with previous research suggesting that abrupt increases in training load may elevate injury risk in high-performance athletes.

These observations reinforce the practical importance of structured workload monitoring in elite volleyball. Maintaining athletes within moderate ACWR ranges and avoiding sudden spikes in weekly training load may support injury prevention and contribute to safer long-term performance development. While ACWR alone cannot fully explain or predict injury risk, it represents a valuable and accessible tool for coaches, sports scientists, and medical staff to identify potentially vulnerable periods within the training cycle.

Future research should incorporate larger samples, longer monitoring periods, and multimodal workload assessments—including both internal and external load metrics—to better understand the complex interplay between training demands, adaptation, and injury in volleyball. Integrating such

approaches may enhance the precision of load management strategies and further improve athlete health and performance.

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ODNOS AKUTNOG I HRONIČNOG OPTEREĆENJA I RIZIK OD POVREDE KOD PROFESIONALNIH ODBOJKAŠA: DVOMESEČNA STUDIJA PRAĆENJA

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***Sažetak**: Praćenje opterećenja u treningu neophodno je radi optimizacije performansi i smanjenja rizika od povreda kod vrhunskih sportista. Odnos akutnog i hroničnog opterećenja (ACWR) sve više se koristi kao alat za upravljanje opterećenjem. Cilj ove studije je da se predstavi ACWR kod profesionalnih odbojkaša i njegovu povezanost sa pojavom povreda. Petnaest profesionalnih odbojkaša turskog kluba praćeno je tokom dva meseca. Opterećenje treninga kvantifikovano je putem subjektivne procene napora (RPE), beležene svakodnevno kako bi se izračunalo akutno (7 dana) i hronično (28 dana) opterećenje. ACWR je računat na nedeljnom nivou radi analize varijacija u intenzitetu treninga. Dva igrača su zadobila povrede tokom perioda visokog ACWR, što ukazuje na moguću povezanost između naglih skokova u opterećenju i rizika od povreda. Kada je ACWR prelazio preporučeni prag (>1.5), učestalost povreda bila je u skladu sa prethodnim istraživanjima koja sugerišu da naglo povećanje opterećenja može doprineti većem riziku od povrede. Međutim, individualne razlike i drugi faktori moraju se uzeti u obzir. Rezultati sugerišu da ACWR može biti koristan alat za praćenje opterećenja i smanjenje rizika od povreda kod profesionalnih odbojkaša. Ipak, potrebna su dalja istraživanja sa većim uzorcima i dodatnim metodama praćenja kako bi se u potpunosti potvrdila njegova validnost. Strateško upravljanje opterećenjem može doprineti poboljšanju performansi i smanjenju učestalosti povreda.*

***Ključne reči**: odnos akutnog i hroničnog opterećenja, praćenje opterećenja u treningu, rizik od povreda*