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The acute:chonic workload ratio in relation to injury risk in professional soccer

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ABSTRACT

Objectives: To examine the association between combined sRPE measures and injury risk in elite professional soccer.
Design: Observational cohort study.
Methods: Forty-eight professional soccer players (mean ± SD age of 25.3 ± 3.1 yr) from two elite European teams were involved within a one season study. Players completed a test of intermittent-aerobic capacity (Yo-YoIR1) to assess player's injury risk in relation to intermittent aerobic capacity. Weekly workload measures and time loss injuries were recorded during the entire period. Rolling weekly sums and week-to-week changes in workload were measured, allowing for the calculation of the acute:chronic workload ratio, which was calculated by dividing the acute (1-weekly) and chronic (4-weekly) workloads. All derived workload measures were modelled against injury data using logistic regression. Odds ratios (OR) were reported against a reference group.
Results: Players who exerted pre-season 1-weekly loads of ≥1500 to ≤2120 AU were at significantly higher risk of injury compared to the reference group of ≤1500 AU (OR = 1.95, p = 0.006). Players with increased intermittent-aerobic capacity were better able to tolerate increased 1-weekly absolute changes in training load than players with lower fitness levels (OR = 4.52, p = 0.011). Players who exerted in-season acute:chronic workload ratios of >1.00 to <1.25 (OR = 0.68, p = 0.006) were at significantly lower risk of injury compared to the reference group (≤0.85).
Conclusions: These findings demonstrate that an acute:chronic workload of between 1.00 and 1.25 is protective for professional soccer players. A higher intermittent-aerobic capacity appears to offer greater injury protection when players are exposed to rapid changes in workload in elite soccer players. Moderate workloads, coupled with moderate-low to moderate-high acute:chronic workload ratios, appear to be protective for professional soccer players.

1. Introduction

Soccer is an intermittent sport characterised by repeated bouts of high-intensity running interspersed with periods of rest or low-intensity running.[1] Within professional soccer the occurrence of competitive matches is high and players are frequently required to play consecutive matches with 3-days recovery.[2] Therefore, these players have an inherently high training load due to poor recovery periods between games and subsequent training sessions. These elite players are often exposed to year-long training and high match frequencies, with periods of a congested calendar, which sometimes increases injury risk.[3] These competitive demands place physical stress on players, requiring well-developed physical qualities to avoid injury and illness, and to perform optimally.[3] The implications of a high number of training days and matches lost due to injury is suggested to be detrimental to team success,[4] especially for soccer teams unable to replace players of similar abilities due to limited resources.[5] Recently, Malone et al.[6] reported a clear association between higher training loads and increased likelihoods of

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injury within team sport athletes. The evolving nature of professional soccer has resulted in an increased interest in monitoring player activities quantitatively on a daily and weekly basis.[7] Interestingly to date, few studies have documented the relationship between training load and injury rates in elite football players.[8]

Although poorly investigated within soccer specific context the workload-injury relationship has been examined within other team sport contexts. In Australian rules football 1-weekly, 2 weekly and previous to current week changes of ≥75% were significantly associated with increased relative risk of injury during the in-season period compared against a reference grouping of ∼15%. Recently, Owen et al.,[5] reported that higher training time spent above 85% HR_{max} resulted in increased injury risk for players in subsequent match-play and training sessions. However, these results need to be contextualised given the known relationships between increased fitness and reduced injury risk for team sport players.[3] There is a requirement for coaches to prescribe an appropriate training load to increase players' fitness to protect from subsequent risk.[3]

Recent workload-performance investigations have examined absolute workload performed in 1-week (referred to as acute workload) relative to 4-week chronic workload (i.e. 4-week average acute workload).[9] A comparison of the acute load to the chronic load as a ratio is therefore a dynamic representation of a player's preparedness. The ratio ultimately considers the training load the athlete has performed relative to the training load the athlete has prepared for.[10] Using the acute:chronic workload ratio, it has been demonstrated that higher chronic workloads protect against injury in cricket.[9] Within Rugby League cohorts, higher workloads have been reported to have either positive or negative influences on injury risk. Specifically, compared with players who had a low chronic workload, players with a high chronic workload were more resistant to injury with moderate-low through moderate-high (0.85–1.35) acute:chronic workload ratios and less resistant to injury when subjected to 'spikes' in acute workload.[10,11] Due to the lack of current data available in elite soccer players, the current study aimed to investigate the relationship between workload measures and injury risk in elite soccer players.

2. Methods

The current investigation was a prospective cohort study of elite soccer players competing for two teams at the highest level of European competition. Data were collected for 48 players (Mean ± SD, age: 25.3 ± 3.1 years; height: 183 ± 7 cm; mass: 72 ± 7 kg) over one season. The study was approved by the local institute's research ethics committee and written informed consent was obtained from each participant. All time-loss injuries were recorded using a bespoke database for data collection. All injuries that prevented a player from taking full part in all training and match-play activities typically planned for that day, and prevented participation for a period greater than 24 h were recorded. The current definition mirrors that employed by Brooks et al.[14] and conforms to the consensus time-loss injury definitions proposed for team sport athletes.[15–17] All injuries were classified as being low severity (resulting in training modification or 1–3 missed training sessions); moderate severity (where a player was unavailable for 1–2 weeks training); or high severity (where a player missed 3+ weeks of training). Injuries were also categorised for injury type (description), body site (injury location) and mechanism.[20] The intensity of all training sessions (including gym based and rehabilitation gym and pitch sessions) and match-play were estimated using the modified Borg CR-10 rate of perceived exertion (RPE) scale, with ratings obtained from each individual player immediately after the end of each match and training session. They were prompted for their RPE individually using a custom-designed application on a portable computer tablet (iPad, Apple Inc, California, USA). Each player selected his RPE rating by touching the respective score on the tablet, which was then automatically saved under the player's profile. This method helped minimize factors that may influence a player's RPE rating, such as peer pressure and replicating other players' ratings.[7] Each individual RPE value was multiplied by the session duration to generate an internal load score.[12] The fitness of players was assessed by the strength and conditioning staff at two time points during each phase of the season (at the start of each phase). Players completed the Yo-Yo Intermittent recovery test level 1 (Yo-Yo IR1) with players final distance used for the analysis of aerobic fitness. All players were familiarised with the test during the pre-season phase prior to testing. The test was administered to both teams according to the procedures described by Bangsbo et al.[13]. The Yo-Yo IR1 consists of 2 × 20-m shuttle runs at increasing speeds interspersed with a 10-s active recovery (controlled by audio signals from a compact disc player). The Yo-Yo IR1 has been shown to be a valid test in soccer populations[13,14] and has been related to positional match-play running performance within soccer cohorts.[13,14] All testing took place between 10:00 and 12:00 h. Temperatures during testing ranged from 10 to 22 °C. The competitive season was divided into two distinct phases for descriptive purposes: 'pre-season' (between July and August) the 'early in-season' (September–May).[15] In addition to weekly training load, a number of other training load measures were derived based on previous studies: (1) cumulative two, three and four weekly loads (2) the absolute change in load from the previous week, and (3) the acute:chronic workload ratio.[3,10,11] Data were analysed in SPSS Version 22.0 (IBM Corporation, New York, USA). Initial analysis of injury incidence was calculated by dividing total number of injuries by exposure time and reported as rates per 1000 training and game hours. Analysis of workload across phases took place using a one-way ANOVA. A chi-squared analysis was used to compare the frequency of injuries between seasonal phases, and workloads in players with different fitness levels (Yo-Yo IR1 performance). Based on a total of 75 injuries from 22,080 player-sessions (48 players participating in 460 training sessions), the calculated statistical power to establish the association between internal loads and soft-tissue injuries was 90%. Weekly load exposure values and all injury data (injury vs. no injury) including subsequent week injuries were then modelled using a logistic regression analysis. Data were divided into four groups, with the lowest workload range being the reference group. Odds ratios (OR) were calculated to determine the injury risk at a given cumulative workload (1, 2, 3 and 4-weekly cumulative), acute:chronic workload ratio and for absolute change in workload (the previous to current week). Correlation coefficients between the training load measures, alongside Variance Inflation Factors (VIF), were used to detect multi-collinearity between the predictor variables. A VIF of ≥10 was deemed indicative of substantial multi-collinearity.[16] Within our current model all load measures provided a VIF of ≤10 therefore providing acceptable levels of multi-collinearity. When an OR was greater than 1, an increased risk of injury was reported (i.e. OR = 1.50 is indicative of a 50% increased risk) and vice versa.

3. Results

During the investigation 75 time-loss injuries were reported. The incidence proportion was 1.6 per player. Overall, match injury incidence was 4.9/1000 h, (95% CI: 4.11–5.12) and training injury incidence was 6.9/1000 h (95% CI: 6.15–7.33). Lower limb injuries resulted in the highest incidence across the year 10.2/1000 h (95% CI: 9.45–10.84) with muscular injuries being the highest sub group of injury types (8.5/1000 h; 95% CI: 7.44–9.15) (Supplementary Table 1). There were significant differences between pre-season