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Different methods of training load quantification and their relationship to injury and illness in elite Australian football

Kristopher R. Veugelers [a,*], Warren B. Young [a], Brendan Fahrner [b], Jack T. Harvey [a]

[a] School of Health Sciences, University of Ballarat, Australia
[b] Richmond Football Club, Australia

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ABSTRACT

Objectives: To compare different methods of training load (TL) quantification and their relationship to injury and illness in elite Australian footballers.
Design: Prospective cohort study.
Methods: Forty-five elite Australian footballers (mean ± standard deviation: age = 23.4 ± 3.8 years) from one elite club participated in this 15 week pre-season study. TL was quantified every session for each individual using four different methods involving rating of perceived exertion (RPE). Two of these methods enabled the quantification of TL for all exercise modalities whilst two were applicable only to outdoor field activities. One- and two-weekly cumulative TL was investigated against injury and illness data using a logistic regression model where the low TL group was considered as the reference group.
Results: A general trend existed across all TL methods which suggested lower odds of injury and illness in high TL groups. The one-week RPE (all) and one-week RPE x Duration (all) methods detected reduced odds of injury in high TL groups compared to low TL groups ($p < 0.05$, OR = 0.199–0.202). Similarly, the one-week RPE (field) method identified lower illness odds in the high TL groups ($p < 0.05$, OR = 0.083–0.182).
Conclusions: Higher TL appeared to provide a protective effect against both injury and illness. The inclusion of duration in the quantification of TL via RPE did not improve the ability of RPE to predict change in odds of injury or illness.

1. Introduction

The ultimate goal in the physical preparation of the elite athlete is to prescribe a training load (TL) which is conducive to an increase in performance[1]. A less than adequate TL will not result in the required level of physiological development, whereas excessive TL may predispose the athlete to a greater risk of injury and illness[2]. The pre-season period is seen as vital in an athlete's progression as it represents a time frame where fitness can be improved without the need to allow for recovery from competitive matches[3]. An effective pre-season will ensure an athlete's peak level of physical readiness coincides with the start of competition[4].

Australian rules football (ARF) is a high-paced team sport which places great physiological, technical, tactical and psychological demands on players[5]. These demands have increased substantially over the past decade[6]. A comparison of the past 20 years of injury surveillance in the elite competition shows that soft tissue injuries are the most common type of injury in ARF, accounting for the greatest number of matches missed and having high rates of recurrence[7]. Excessive TL and/or inadequate recovery may increase the risk of non-contact soft tissue injury[8], therefore the quantification and monitoring of TL is a vital component of injury prevention.

Effective methods of TL quantification may enable the more accurate prescription of exercise and recovery, subsequently improving player health and fitness[9]. While there is currently no gold standard measure of TL, one of the most popular methods involves a rating of perceived exertion (RPE) scale[10]. This allows an individual to estimate the intensity required to perform a bout of physical work[11]. The given value is then multiplied by the duration of the session in minutes to calculate a global TL score, termed session RPE (sRPE)[12].

The relationship between sRPE-derived training loads and injury risk has been previously explored in team sport. For example, greater overall TL was associated with increased injury risk ($r = 0.86$, $p < 0.05$; $r = 0.82$, $p < 0.01$) in rugby league players[13,14]. Specific loads attributed to field training were also found to have a significant relationship with non-contact soft tissue injury ($r = 0.68$, $p < 0.05$)[14].

* Corresponding author.
E-mail address: krveugelers@gmail.com (K.R. Veugelers).

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Table 1
Methods of quantifying training load via RPE.

TL quantification method	Applicable activities
RPE[a]	All
RPE[a]	Field
RPE x Duration (min)[a]	All
RPE x Duration (min)[a]	Field

[a] Foster et al. [12].

This highlights the possibility that TL from different training modalities may influence the risk of specific injury types.

Research in this area specific to ARF is limited. Previously, no statistically significant relationships were reported to exist between TL and the incidence of injury or illness over one pre-season[9]. However, this study may have been limited by a small sample size ($n = 16$) and low injury tally ($n = 5$). In contrast, ARF players who experienced a substantial increase in load from the previous week to the current week (>1250 arbitrary units) during the competitive season were 2.58 times more likely to sustain an injury ($p = 0.002$) in comparison to a reference group (<250 arbitrary units)[15]. Furthermore, low absolute changes in load were associated with greater odds of injury in comparison to moderate absolute changes in load[15]. This suggests that both insufficient and excessive loads may be risk factors for injury.

There does not appear to be any research in elite ARF which investigates different methods of TL quantification involving RPE and their relationship to the occurrence of injury and illness. Therefore the purpose of this study was to compare a number of RPE-derived TL methods to assess which may be the best predictor of change in the odds of injury and illness in an elite ARF cohort.

2. Methods

Forty-five elite ARF players (mean ± standard deviation: age = 23.4 ± 3.8 years; height = 188.0 ± 7.2 cm; body mass = 88.60 ± 6.9 kg, time spent on an AFL playing list = 4.4 ± 2.7 years) from one Australian Football League (AFL) club participated in this 15-week pre-season study. Each player provided informed consent and the research was approved by the University of Ballarat Human Ethics Committee.

For every session, each player estimated the intensity of training approximately 30 min post-session using Foster's modified RPE scale[12]. All players had been familiarized with the RPE scale according to standard procedure[12]. Rating of perceived exertion is strongly correlated with objective measures of exercise intensity such as heart rate, maximal oxygen uptake and blood lactate concentration[17]. Training load scores were then calculated via four different methods using the given RPE value. Each method is detailed in Table 1. The sRPE method of quantifying TL via the multiplication of RPE and duration has been employed in previous research[2,9,15,16]. The values recorded for the RPE and sRPE methods were split into two categories; "all" training sessions, which encompassed all training modalities, and "field" training sessions, which included only outdoor field-based activities such as running, skill and tactical development. The purpose of this was to compare "field" TL to occurrence of injury as club staff believed this form of training may be more likely to influence soft tissue injury risk than other training modalities such as resistance and cross training.

Similar to previous research[8], injury to a player was defined as a non-contact event that occurred during a training session which resulted in missed or modified training due to the presence of at least one of the following soft tissue attributes: pain, tenderness, swelling and restricted range of motion. Training load is believed to have a stronger relationship with non-contact soft tissue injuries compared to impact injuries[8]. Illness was defined as an event where a player missed a training session due to a medical condition which was diagnosed by a club doctor. This was subsequently recorded by the fitness staff.

For each training session that an individual player was involved in, their previous one- and two-weekly cumulative TL was calculated for each of the four different TL methods. One- and two-weekly, but not three- and four-weekly cumulative TL's were reported to alter odds of injury in elite ARF players[15]. The consideration of prior TL was deemed important due to the potential delayed effect it may have on injury risk[18]. Players undertaking modified training due to an identified injury risk or rehabilitation from a previous injury were excluded from the analysis until they returned to full training for at least one week.

There were too few injury and illness events to place the cumulative loads into multiple categories; therefore the basis of analysis for these data was a dichotomous median split into low and high TL groups for all methods. For the two outcomes of injury and illness, the association of each relevant cumulative TL group with the outcome measure was investigated with a bivariate logistic regression model fitted by the method of generalized estimating equations, with adjustment for intra-player cluster effects. Three error correlation structures were compared—independence (zero correlation—no cluster effects), and two repeated measures structures—exchangeable (correlation constant over time) and first order autoregressive (correlation diminishing with time). This statistical method was based on similar research investigating the effect of training and game loads on the odds of injury in elite ARF[15], with the addition of the examination of intra-player correlation.

3. Results

A total of 5164 individual training sessions were analysed, 1899 of which were classified as "field" sessions. There were a low number of injuries ($n = 13$) and illnesses ($n = 13$). For the analysis of the cumulative TL measures and the outcome variables of injury and illness, the error structure which produced the best fitting models was independence, indicating no significant cluster effects. Therefore the results of ordinary logistic regression are reported, with each low TL group considered as the reference group (Tables 2 and 3). Inverse associations are apparent between all but one of the cumulative TL measures and both outcome measures, but not all relationships were statistically significant ($p < 0.05$). There was a statistically significant association between injury incidence and the one-week RPE (all) and one-week RPE x Duration (all) methods. For occurrence of illness, only the one-week RPE (field) method demonstrated a statistically significant association.

4. Discussion

The purpose of this study was to compare different methods of TL quantification and their relationship to injury and illness in elite AF. A general pattern existed within all TL methods which suggest that the odds of injury were reduced for individuals in the high training TL compared to those in the low TL groups. This trend reached statistical significance in the one week RPE (all) method (OR = 0.202) and one-week RPE x Duration (all) method (OR = 0.199). It appears that methods which quantify all training sessions are better predictors of injury risk compared to field measures of TL. This may suggest that field-based measures of TL are limited by their failure to account for the stress from other forms of training such as resistance and cross-training, and that the cumulative load associated with these other modalities is likely to impact on injury risk. None of the two-week cumulative TL measures reached statistical significance, indicating that one-week cumulative TL was a better predictor of injury risk.

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