Journal of Science and Medicine in Sport xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

High chronic training loads and exposure to bouts of maximal velocity running reduce injury risk in elite Gaelic football

Shane Malone[a,b,*], Mark Roe[b], Dominic A. Doran[a], Tim J. Gabbett[c], Kieran Collins[b]

[a] *Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, United Kingdom*
[b] *Gaelic Sports Research Centre, Institute of Technology Tallaght, Ireland*
[c] *Gabbett Performance Solutions, Australia*

ARTICLE INFO

Article history:
Received 25 April 2016
Received in revised form 13 July 2016
Accepted 2 August 2016
Available online xxx

Keywords:
Injury prevention
Team sport
Odds ratios
Maximal velocity distance

ABSTRACT

Objectives: To examine the relationship between chronic training loads, number of exposures to maximal velocity, the distance covered at maximal velocity, percentage of maximal velocity in training and match-play and subsequent injury risk in elite Gaelic footballers.
Design: Prospective cohort design.
Methods: Thirty-seven elite Gaelic footballers from one elite squad were involved in a one-season study. Training and game loads (session-RPE multiplied by duration in min) were recorded in conjunction with external match and training loads (using global positioning system technology) to measure the distance covered at maximal velocity, relative maximal velocity and the number of player exposures to maximal velocity across weekly periods during the season. Lower limb injuries were also recorded. Training load and GPS data were modelled against injury data using logistic regression. Odds ratios (OR) were calculated based on chronic training load status, relative maximal velocity and number of exposures to maximal velocity with these reported against the lowest reference group for these variables.
Results: Players who produced over 95% maximal velocity on at least one occasion within training environments had lower risk of injury compared to the reference group of 85% maximal velocity on at least one occasion (OR: 0.12, $p = 0.001$). Higher chronic training loads (≥4750 AU) allowed players to tolerate increased distances (between 90 to 120 m) and exposures to maximal velocity (between 10 to 15 exposures), with these exposures having a protective effect compared to lower exposures (OR: 0.22 $p = 0.026$) and distance (OR = 0.23, $p = 0.055$).
Conclusions: Players who had higher chronic training loads (≥4750 AU) tolerated increased distances and exposures to maximal velocity when compared to players exposed to low chronic training loads (≤4750 AU). Under- and over-exposure of players to maximal velocity events (represented by a U-shaped curve) increased the risk of injury.

1. Introduction

Training load has been reported as a modifiable risk factor for subsequent injury.[1] Several studies have investigated the influence of training workload and injury risk in team sports. In professional rugby union, players[1] higher 1-week (>1245 AU) and 4-week cumulative loads (>8651 AU) were associated with a greater risk of injury. Furthermore, Rogalski et al.[2] observed that larger 1-weekly (>1750 arbitrary units, OR = 2.44–3.38), 2-weekly (>4000 arbitrary units, OR = 4.74) and previous to current week changes in load (>1250 arbitrary units, OR = 2.58) were significantly related to greater injury risk throughout the in-season phase in elite Australian rules football players.

The ability to produce high speeds is considered an important quality for performance, with athletes shown to achieve 85–94% of maximal velocity during team sport match-play.[3] Well-developed high-speed running ability and maximal velocity are required of players during competition in order to beat opposition players to possession and gain an advantage in attacking and defensive situations.[4,5] In order to optimally prepare players for these maximal velocity and high speed elements of match play, players require regular exposure to periods of high-speed running during training environments[6]. Recent evidence suggests that lower limb injuries are associated with excessive high-speed running exposure.[7,8] Within elite rugby league and Australian football cohorts, players who performed greater amounts of very high-speed running

* Corresponding author.
E-mail address: shane.malone@mymail.ittdublin.ie (S. Malone).

http://dx.doi.org/10.1016/j.jsams.2016.08.005

within training sessions were 2.7 and 3.7 times more likely to sustain a non-contact, soft tissue injury than players who performed less very-high speed running.[8,9] However, these studies failed to assess the potential impact that chronic training load could have on reducing the injury risk in these players. Currently there is a lack of understanding of the potential benefits of maximal velocity exposures and also the minimum dose required to provide protection against injuries.

Recent evidence suggests that high chronic training loads can offer a protective stimulus for team sport athletes.[10,11] Australian rules football players with higher 1 week training loads (>3519 AU) were at reduced risk of injury (OR = 0.199) compared to players exposed to lower training loads (<3518 AU).[12] Additionally Cross et al.[1] have reported a U-shaped curve for training load and injury risk in elite rugby union players with low and high training loads increasing injury risk, and intermediate loads reducing injury risk. High aerobic fitness has been reported to offer a protective effect against subsequent lower limb injury for team sport players.[6] Higher training loads may be needed to provide the appropriate stimulus for aerobic fitness improvements[6] with lower training loads potentially placing players at increased risk due to a lack of exposure to the physical stimulus required for competitive play.[6]

Although greater amounts of high-speed running have been associated with injury risk, there is evidence that players are often required to perform maximal efforts over short to moderate distances during competition and training.[13,14,15] Training for team sport ultimately requires a balance between appropriately prescribed training loads to develop the required physical qualities to compete while also allowing the appropriate recovery between sessions and match-play to minimise injury risk for players. Given the need for players to perform maximal efforts during match-play, exposure of players to these maximal efforts during training may offer a "vaccine" against soft-tissue injury.[6] However, the interrelationship among these training variables and potential injury risk is poorly understood. Therefore the aim of the current investigation was to examine exposure to maximal velocity events as a potential modifiable risk factor for injury within Gaelic football. Additionally with higher chronic training loads offering a protective effect from injury in other sports, there is a need to investigate the interaction of chronic training loads, maximal velocity exposure, and injury risk within Gaelic football. Accordingly, we explored the relationship between training load, the number of maximal velocity exposures during training and match-play, the distance covered at maximal velocity and injury risk in elite Gaelic football players.

2. Methods

The current investigation was a prospective cohort study of elite Gaelic football players competing at the highest level of competition in Gaelic football (National League Division 1 and All-Ireland Championship). Data were collected for 37 players (Mean ± SD, age: 24 ± 3 years; height: 179 ± 5 cm; mass: 79 ± 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.

The intensity of all competitive match-play and training pitch based sessions (including recovery and rehabilitation sessions) were estimated using the modified Borg CR-10 rate of perceived exertion (RPE) scale, with ratings obtained from each individual player within 30 min of completing the match or training session.[16] Each player was asked to report their RPE for each session confidentially without knowledge of other players' ratings. Each individual player's session RPE in arbitrary units (AU) was then derived by multiplying RPE and session duration (min).[16] Session-RPE (sRPE) has previously been shown to be a valid method for estimating exercise intensity.[17] sRPE was then used to calculate 4-week chronic workload (i.e., 4-week average acute workload).[18,19]

Maximal velocity running and exposure to maximal velocity during all sessions was monitored using global positioning system (GPS) technology (VXSport, Lower Hutt, New Zealand) providing data at 4-Hz. Players were assigned individual units that were worn across all sessions to account for any inter-unit variability. Initially players' individual maximal velocity was assessed during a maximal velocity test. During the test, dual beam electronic timing gates were placed at 0-, 10-, 20-, 30- and 40-m (Witty, Microgate, Bolzano, Italy). Speed was measured to the nearest 0.01 s with the fastest value obtained from 3 trials used as the maximal velocity score. The calculated velocity between the 20 and 40 m gates was used as a measure of maximal velocity.[20] The intra-class correlation coefficient for test–retest reliability and typical error of measurement for the 10, 20, 30 and 40 m sprint tests were 0.95, 0.97, 0.96 and 0.97 and 1.8, 1.3, 1.3 and 1.2%, respectively. Analysis of calculated speeds revealed a significant correlation ($r = 0.85$, $p = 0.02$) between GPS and timing gate measures, with no significant difference between speeds measured by the timing gates (31.2 km h^{-1}) and GPS measures (31.0 km h^{-1}) ($p = 0.842$) therefore allowing for maximal velocity to be tracked with a high degree of accuracy with the GPS system. Maximal velocity exposures were recorded when a player covered any distance (m) at their own individualised maximal velocity (km h^{-1}) during training or match-play events. If a player produced a maximum velocity in training or match-play that exceeded the test value, this became the players' new maximum velocity for the period. During this period, the players' ability to produce maximal velocity was also tracked in relative terms by expressing data as a percentage of their maximal velocity. Therefore during this observational period, players' number of maximal velocity exposures, the distance covered at maximal velocity and their relative maximal velocity were tracked over weekly periods throughout the whole season in line with the internal and external training load measures. Training load (sRPE), maximal velocity distance, the number of maximal velocity exposures and the percentage of maximal velocity achieved were then analysed across acute 1-weekly workload periods (Monday–Sunday). Acute workload periods were compared to the chronic training load over the same period (previous 4-week average acute workload).[19]

All GPS and lower limb soft tissue injuries were classified into acute 1-weekly blocks and chronic 4-weekly blocks using a bespoke database. Data were collected from 95 pitch based training sessions from November through September. Each player participated in 2–3 pitch based training sessions depending on the week of the season. The pitch based training sessions were supplemented by 2 gym based, strength training sessions. The duration of the pitch based training sessions was typically between 60 and 130 min depending on session goals. 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 of injury mirrors that employed by Brooks et al.[21] and conforms to the consensus time loss injury definitions proposed for team sport athletes.[22,23] All injuries were further classified as being low severity (1–3 missed training sessions); moderate severity (player was unavailable for 1–2 weeks); or high severity (player missed 3 or more weeks). Injuries were also categorised for injury type (description), body site (injury location) and mechanism.[2]

SPSS Version 22.0 (IBM Corporation, New York, USA) and R (version 2.12.1) software were used to analyze the data. Descriptive statistics were expressed as means ± SD and 95% confidence intervals of maximal velocity running loads and the number of maximal velocity exposures during the season. Injury incidence was calculated by dividing the total number of injuries by the total

Please cite this article in press as: Malone S, et al. High chronic training loads and exposure to bouts of maximal velocity running reduce injury risk in elite Gaelic football. *J Sci Med Sport* (2016), http://dx.doi.org/10.1016/j.jsams.2016.08.005