Module 4. Training load moderators and mediators

4.1 Relationship between training load and injury

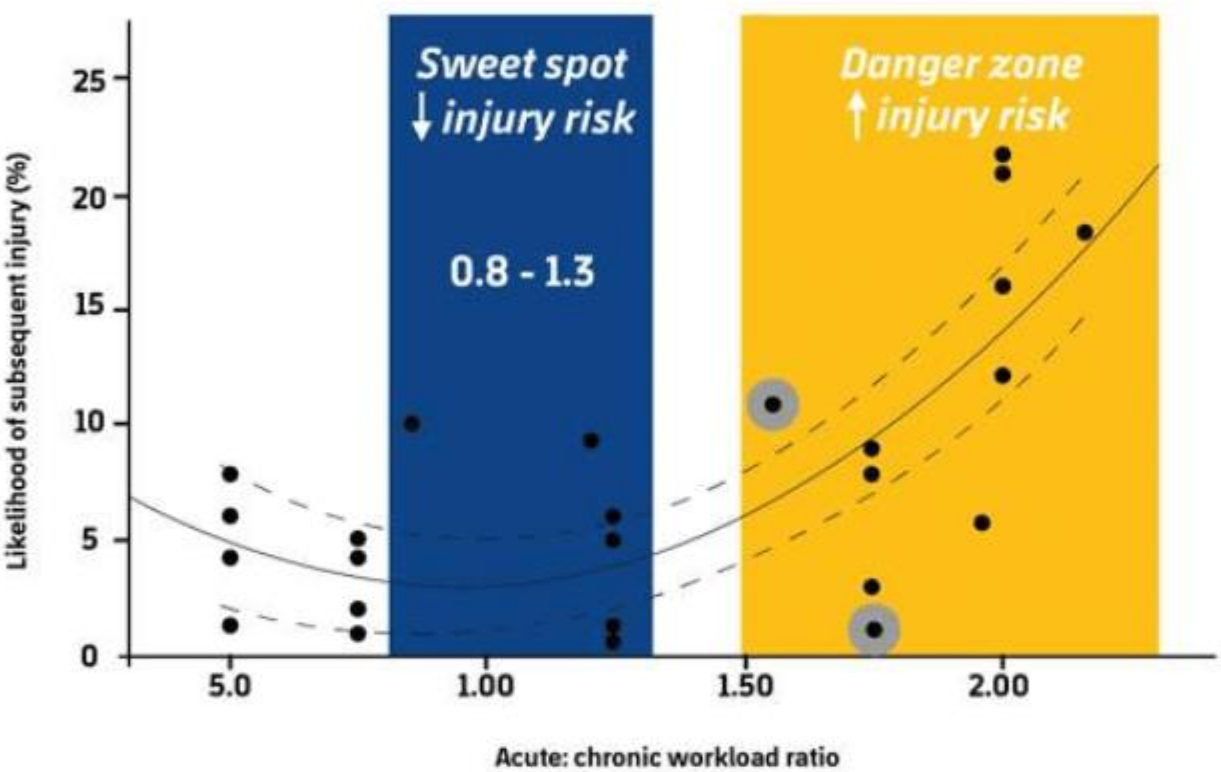
The injury process has been addressed by different models and/or paradigms in recent years. There seems to be a consensus on defining the sports injury process as complex, dynamic, multifactorial, and context-dependent (Windt J, Zumbo B, Sporer B, MacDonald K, and Gabbett TJ, 2017).

Today, we can identify a series of intrinsic risk factors that predispose athletes to injury. The most classic are age, somatotype, and previous injuries. In addition, there is a series of external and internal risk factors that increase the athlete's susceptibility to injury. Among them, we can mention the use of protective gear, the state of the playing field, and climate conditions. Thus, it is the presence of internal and external factors that determines the risk of injury, although they themselves are not sufficient to cause an injury. It is the sum of these factors and their interaction that predisposes the athlete to injury in a particular situation. Meeuwisse, Tyreman, Hagel and Emery (2007), describe the inciting event as the last link in the chain that causes an injury to occur. This triggering event is an action that surpasses the body's adaptation limits and causes an injury.

Multivariable injury prediction models increase the accuracy of prediction since they take the interactions between and moderating effects of different risk factors into account (Colby MJ., Dawson B, Peeling P, Heasman J, Rogalski B, Drew M, Stares J, Zouhal H, & Lester L, 2017). Therefore, a multidimensional approach is necessary in this sense, but what variables could interact to increase or decrease an athlete's likelihood of injury?

A very clear example can be seen in the now classic depiction by Gabbett regarding the likelihood of injury based on the acute:chronic load ratio. In Figure 1, we can look at the cases of two different athletes, in yellow. Both subjects were found to have A:C load ratios higher than 1.5, but different likelihoods of injury. We can observe that athlete A has a slightly lower ratio than athlete B (the first is situated more to the right than the second). With respect to the likelihood of injury (%), we can observe how athlete A, despite presenting a lower A:C load ratio, is around 10 times more likely to suffer an injury than athlete B. It appears, therefore, that athlete B presents a series of "characteristics" that make him less likely to suffer injuries (in this specific case with high A:C load ratios), but what are those characteristics? Should we take them into account when proposing training loads for our athletes? Based on the results shown, it seems clear that we should consider these aspects when managing workloads (training and competition) for our athletes.

Figure 1: Acute:Chronic Load Ratio and Likelihood of Injury

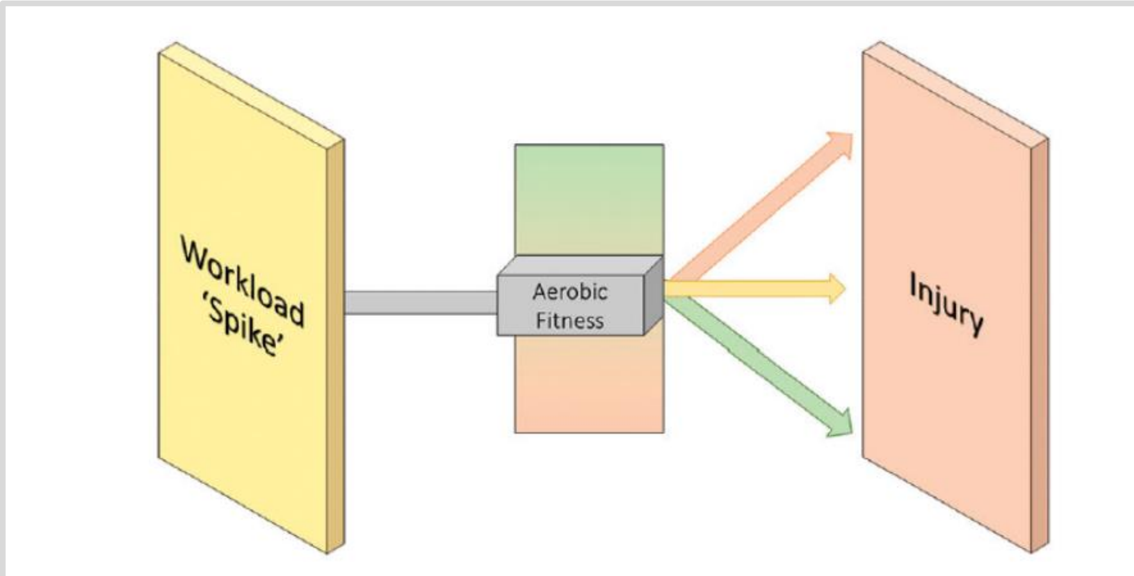


Source: adapted from Blanch and Gabbett (2016).

4.2 Training load moderators

Inadequate management of training loads is one of the risk factors that predisposes athletes to injury. However, "errors" in training management increase the likelihood of injury in some groups of athletes more than others. Moderators have been defined as characteristics that allow athletes to withstand/tolerate the training load and minimize its damaging effects (Windt et al., 2017).

Figure 2: Graphical representation of the role of a moderator, such as cardiovascular endurance, in the relationship between a spike in workload and the likelihood of injury in an athlete.



Source: Windt et al., 2017, p. 1.

Athletes' cardiovascular endurance manifests as a modulator of the load result. In Gaelic football, a high level of cardiovascular fitness protects against spikes in training and competitive workload (Windt et al., 2017). Malone, Roe, Doran, Gabbett and Collins (2017) divided Gaelic football players based on the time it took them to cover 1 km, and found that the athletes that performed the worst (longer times for 1 km) were generally more likely to suffer an injury (x1.5 - 2.5). Additionally, based on training load, they had a higher likelihood of injury when facing:

- Weekly loads greater than 1,750 AU (x4, 5).
- Weekly load changes between 550-1,000 AU (x4, 5).
- Acute:chronic load ratio >1.50 in the load (x5).

It should be noted that, in this study, the load was monitored through the session-RPE method, without information on other load indicators related to movements made by the athletes.

Malone, Owen, Newton, Mendes, Collins and Gabbett (2017) found that when facing moderately high loads (>2,450 AU, load obtained through the session-RPE method), professional soccer players with a lower intermittent endurance level (with results below 1,800 m on the level 1 Yo-Yo Intermittent Recovery Test) were 4 to 5 times more likely than athletes that covered a distance greater than 2,560 m on the test. Athletes with better performance on this test presented significantly lower likelihoods than the rest of the established groups based on performance on the test. Also, in this same study, players with a higher level of fitness were found to be able to tolerate mid-week load changes, and were 4 times less likely to suffer an injury than soccer players with worse fitness levels (in the context of weekly changes between 300 to 1,000 AU) and acute:chronic load ratios higher than 1.25, and were 5 times less likely to suffer an injury than their teammates with worse performance on the intermittent endurance test.

In another study, conducted by some of the same authors, it seems that endurance level can have a protective effect. Malone, Owen, Mendes, Hughes, Collins and Gabbett (2017) used the 30-15 Test to categorize the athletes. The results of this study indicate that the players with a lower intermittent endurance level were two to three times more likely to suffer an injury than the athletes with better performance on the 30-15 VIFT Test. Some of the results are shown below. The players with a lower intermittent endurance level (VIFT of 14.0-15.5 km·h^{-1}) are more likely to suffer an injury when facing:

- Weekly distance loads greater than 1,025 m (x3) covered at high speeds.
- Weekly distance loads greater than 350 m (x5) covered in sprints.
- Weekly changes in distance covered at high speed between 300-600 m (x3).
- Acute:chronic load ratio >1.25 in distance covered at high speed (x4).
- Acute:chronic load ratio >1.35 in distance covered at sprint (x4).

The values associated with x refer to the increased likelihood with respect to athletes with a higher endurance level (group with a VIFT between 20.0 and 22.5 km·h-1), such that, for example, the likelihood of injury is 5 times greater when the weekly distance covered at sprint exceeds 350 m in the group with a low intermittent endurance level compared to the group with a high intermittent endurance level.

In this sense, taking the fitness level of our athletes into account when managing training load is an interesting idea. Thus, when this capacity is evaluated, and athletes with low fitness levels are detected, their allowable load threshold should be reduced while we attempt to resolve this limitation. This is usually contrary to what is typically done in the soccer world, where the load that the players with the worse fitness levels tolerate or experience tends to be the highest of the entire team, since we add extra work to resolve this limitation to group training. Applying these load levels to players with low fitness levels could increase the likelihood of injury.

In contrast, athletes who are "injury-resistant" – with a high fitness level and without previous injuries – would allow greater training loads to be applied if we pursue certain performance objectives, since the modulators present will prevent this load from increasing the athlete's likelihood of injury. Acute:chronic load ratios of 1.7 could turn out to be "safe" for these athletes, while the likelihood of injury would increase for athletes with a long history of previous injuries and/or low fitness level as we would find ourselves outside the safety zone.

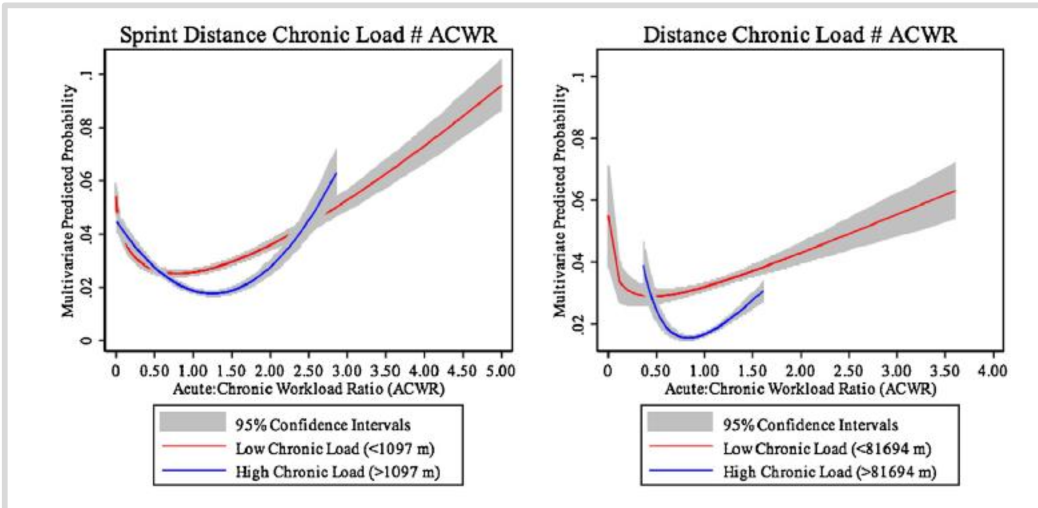
Another moderator on the effect of load is the athlete's chronic load level. It seems that habituating athletes to high load levels increases their resistance to injury. In this sense, Malone, Owen, Mendes, Hughes, Collins and Gabbett (2017) find that in terms of lower load levels, athletes with a low chronic load level (<2,584 AU) are more likely to suffer an injury when facing:

- Weekly loads of distance covered at high speed greater than 705 m (x5).
- Weekly loads of distance covered at sprint greater than 350 m (x3).

However, when facing these same situations, the likelihood of injury does not significantly increase for players with a high chronic load level. It should be noted that a certain protective effect is present when load is moderately high.

Along this same line, but this time in Australian rules football (Colby et al., 2017), a high chronic load in total distance covered allows athletes to tolerate higher acute:chronic load ratios with a lower level of risk. Thus, when the chronic load of distance covered was higher than 81.0 km, the likelihood of injury in the context of acute:chronic load ratios of >1.21 was x1.36. Values of x2.6 (with statistically significant differences) were reached when the ratio reached the same value (>1.21) but with lower chronic loads (<86.0 km). There is a similar effect when the variable analyzed is distance covered at sprint. For subjects with a higher sprinting value in the previous month (distance at sprint >1097 m), the likelihood of injury reaches values of x0.91 in the context of acute:chronic load ratios greater than 1.40 (always in distance sprinted), and they reach values of x1.6 when the chronic load is low (distance at sprint <1,097 m). Therefore, it would seem that a high chronic load allows athletes to tolerate higher acute:chronic load ratios without excessively increasing the likelihood of injury and, in some cases, it even reduces the likelihood of injury, as is the case with the sprint variable.

Figure 3: Multivariable prediction model displaying the likelihood of injury in the following week, based on the acute:chronic load ratio for the distance covered variable (left) and total distance covered (right) based on the athlete's chronic load (sum of 4 weeks)



Source: Colby et al., 2017, p. 20.

Another moderator described in the literature refers to the years of competitive experience. The athletes were grouped by the number of years on senior elite teams. The results found by Malone, Roe, Doran, Gabbett and Collins (2017) in Gaelic football indicate that the athletes with more years of experience are the most injury-resistant, and the likelihood of injury increases in athletes with little experience (1 year) when facing:

- Weekly loads greater than 1,750 AU (x3).
- Weekly load changes between 550-1000 AU (x2).
- Acute:chronic load ratio >1.50 in the load (x2).

In this sense, the results indicate that the group of athletes that has accumulated between 2-3 and 4-6 years of experience are more resistant to injury than the athletes with more than 7 seasons of experience in senior sports. It seems, therefore, that the likelihood of injury in this sense is U-shaped, with a higher likelihood of injury in novice athletes and those with long-term experience.

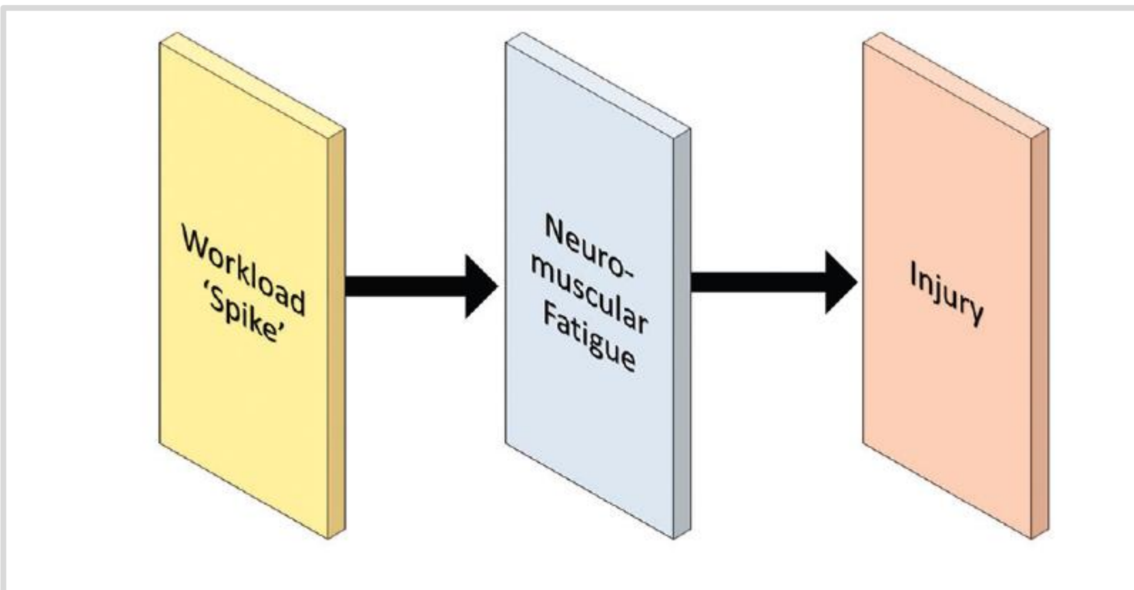
Finally, the athlete's maximum speed is a moderator for the likelihood of injury. Although there is only one study to date that has addressed this phenomenon (Murray N, Gabbett T, and Townshend A, 2017), it seems that fast athletes are more sensitive to increases in acute:chronic load ratio (>2.0), regardless of whether they use absolute or relative speed ranges when configuring speed ranges. However, an increase in acute:chronic load ratio

(>2.0) in a group of slow athletes does not increase the likelihood of injury for those athletes. Despite the need for more studies to confirm this aspect, it appears that slow athletes could be more resistant to these changes in acute:chronic load ratio and could tolerate these spikes in load management with a lower likelihood of injury.

4.3 Training load mediators

On the other hand, there are intermediate aspects between the load and the results that can increase the likelihood of injury. These characteristics have been defined as mediators, and they make the athlete more susceptible to injury (Windt et al., 2017). Neuromuscular fatigue is a mediator that can increase an athlete's likelihood of injury.

Figure 4: Graphical representation of the role of a mediator (such as neuromuscular fatigue) in triggering a sports injury when there is a spike in training load



Source: Windt et al., 2017

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