Module 3

The importance of a good preseason

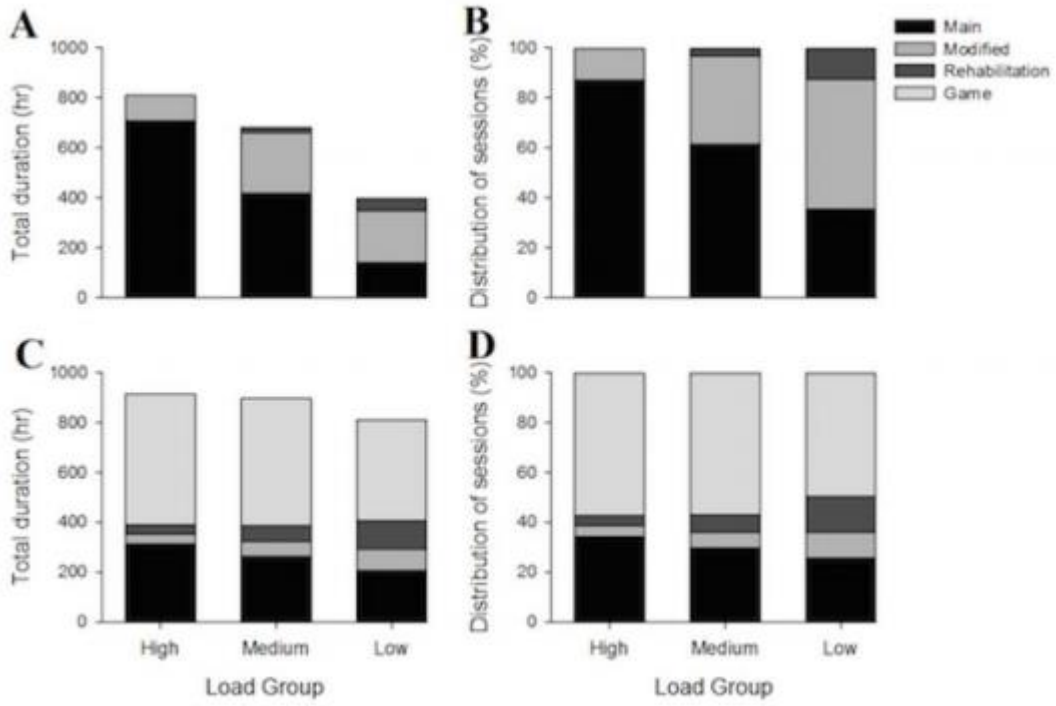
It is well-established that it is difficult to predict injuries. It is a very uncertain science. This may be because that despite all of the training load information we can collect, other factors can contribute to injury risk. Capturing all of this information and the way that it changes over time is a challenging pursuit.

So, rather than focusing on the prediction of injuries, is it possible to identify the factors that create robust athletes? If we can identify the factors that contribute to robustness then perhaps we can develop those factors to reduce injury risk and foster good performances. In this module, some of the factors that contribute to robustness in athletes will be explored.

If we visited any team in the world and asked players what they wanted to achieve from their preseason, they would all say the exact same thing: "I want to have a good preseason because it will set me up for a good season". From the many teams I have worked with, I have heard that a lot but until recently there was limited evidence to support it. So we decided to explore this more closely in Australian football players (Murray, Gabbett & Townshend, 2016).

Our question was: "Does a good preseason set players up for a good season?" Firstly, we divided our players into three groups. The first group had numerous training sessions during the preseason, the second one had a moderate amount of training sessions and the third one had a low number of training sessions. Then we looked at the type of activities that they performed in that preseason. The high load group was able to complete a greater proportion of "main" sessions (i.e. sessions that weren't modified or part of a rehabilitation training). Conversely, the low load group completed considerably fewer "main" training sessions. Most of their training time was made up of modified sessions or rehabilitation sessions (Figure 1).

Figure 1: Participation in training.

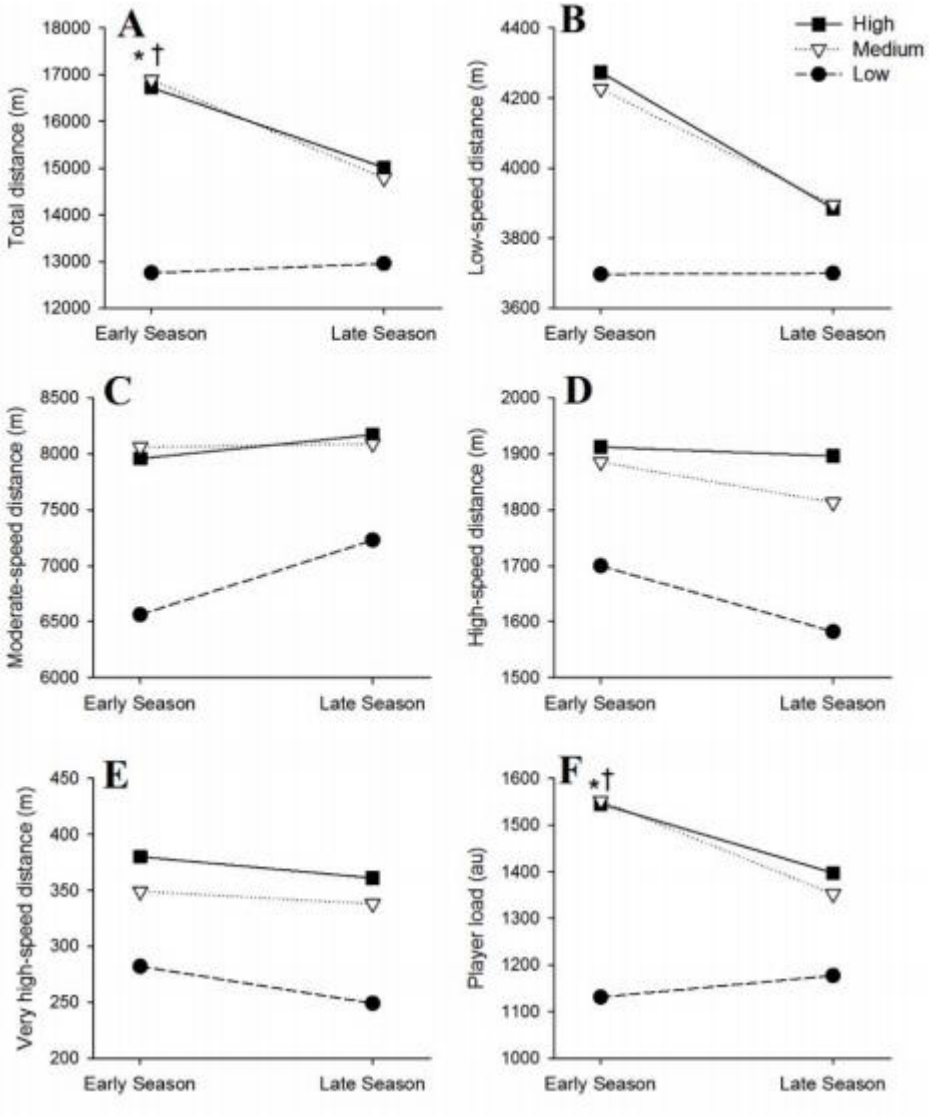


Source: Murray, Gabbett & Townshend, 2016.

Total duration of training hours during the pre- (A) and in-season (C) periods, with proportion of sessions completed for each load group (i.e. high, medium and low) during the pre- (B), and in-season (D) period

We then followed the three groups throughout the season. Firstly, the high load group maintained higher *in-season loads* and, even though there was a drop-off in in-season loads towards the end of the season, they still maintained higher loads than the low load group.

Figure 2: Quantification of weekly training and game loads (i.e. total loads) throughout the first and second half of the in-season period for each load group (i.e. high, medium and low).



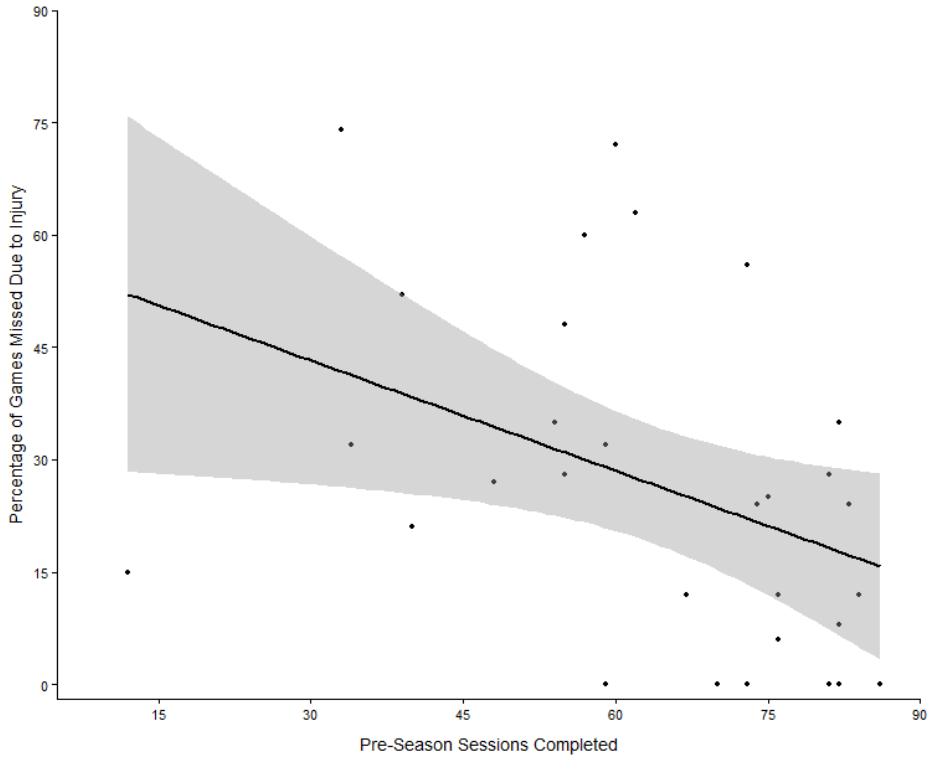
Source: Murray et al., 2016.

Secondly, the injury rates of the low load group, the group that had only completed a low amount of preseason training, was twice as high during in-season. These results suggest that if an athlete sustains an injury in preseason, they are at increased risk of sustaining an injury during the competitive phase of the season. It provides an example of the "chronic rehabber" loop that has been described previously.

This work coincides with other work we have completed examining the relationship between the number of preseason sessions completed and the in-

season injury risk (Windt, J., Gabbett, T., Ferris, D., & Khan, K. 2016). That is, our question was "If an athlete completes more of the preseason, does this protect them against injuries in-season?"

Figure 3: The association of preseason participation with games missed due to injury



Source: Windt, Gabbett, Ferris & Khan, 2016.

Players who have completed a greater proportion of the preseason (relative to their plan) had a lower in-season injury risk. Conversely, players who spent most of preseason in rehabilitation, spent more time in rehabilitation during the competitive phase of the season (Figure 3).

Figure 4: Effect of preseason participation on injury likelihood in current and subsequent week, controlling for training load variables.

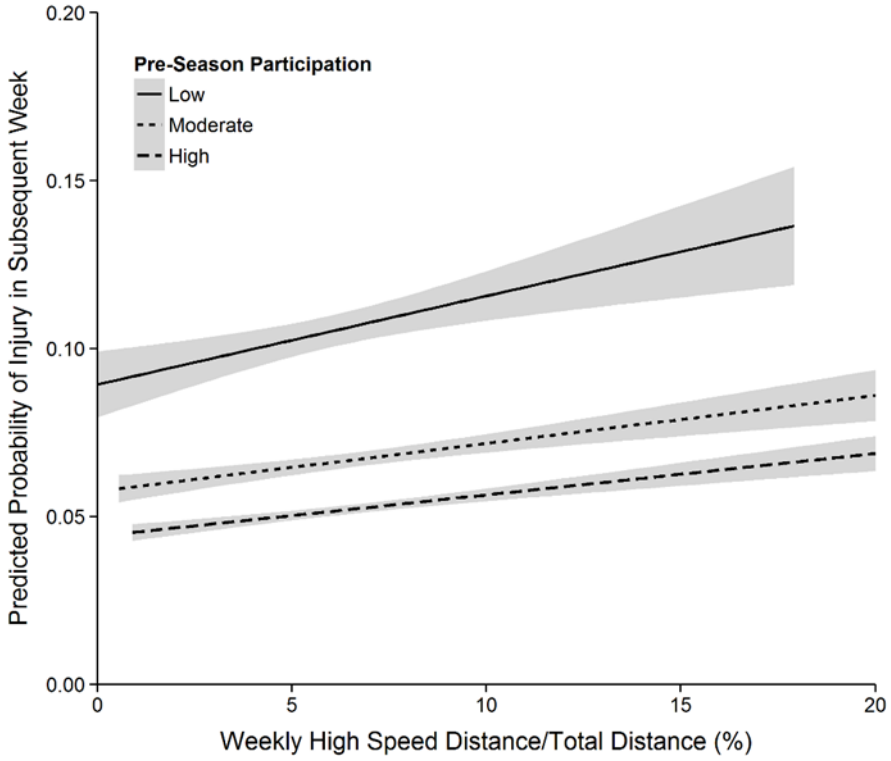
Model	Variable	OR (95% CI)
Model 1: injury likelihood in current week	10 preseason sessions	0.85 (0.70 to 1.02)
	High-speed distance/total distance	1.27 (0.99 to 1.63)
	Acute distance (1 SD increase)	0.56* (0.36 to 0.87)
Model 2: injury likelihood in subsequent week	10 preseason sessions	0.83* (0.70 to 0.99)
	High-speed distance/total distance	1.07 (0.79 to 1.45)
	Acute distance	0.82 (0.55 to 1.21)

Source: adapted from Windt et al., 2016.

There are several key points in this study that warrant discussion. Firstly, for every 10 additional preseason sessions completed, injury risk was reduced by 17%. Note, that this does not mean that practitioners can keep adding more and more preseason sessions and injury risk will decrease to zero! This reduction in injury risk is all *relative to your plan*. It's not a good idea to squeeze in more and more training sessions just to create fatigue! Rather, the aim should be to complete as much of the plan as possible. If a player sustains an injury during the preseason, they will miss a large part of the planned pre-season due to rehabilitation. So, in some cases, it might be better to reduce the training load to ensure they are able to continue training, and complete as much of the plan as possible. *The greater proportion of preseason completed relative to the plan, the lower the injury risk during the competitive phase of the season.*

An important question is: "Can what an athlete does in the preseason really protect them all season long?" I don't think this question has a simple answer. I don't think the answer is as simple as "if you complete more preseason sessions, you stay injury-free and protected". For example, I cannot state for certain if the additional preseason sessions protect athletes or if the fittest athletes are simply the ones that survive: if you are strong enough to survive a big preseason, then maybe you are strong enough to survive the competitive phase of the season. As part of this study, we examined high-speed running in-season. We divided our group into 3 groups smaller groups; players who had completed a low proportion, a moderate proportion or a high proportion of the preseason We then examined the risk of injury at a given high-speed running percentage. Our findings showed that the risk of injury was greater in the low training load group; the *low training load group had a higher risk of injury at a given high speed running percentage* (Figure 5)**.**

Figure 5: Predicted injury probabilities based on high-speed running percentage and preseason participation.

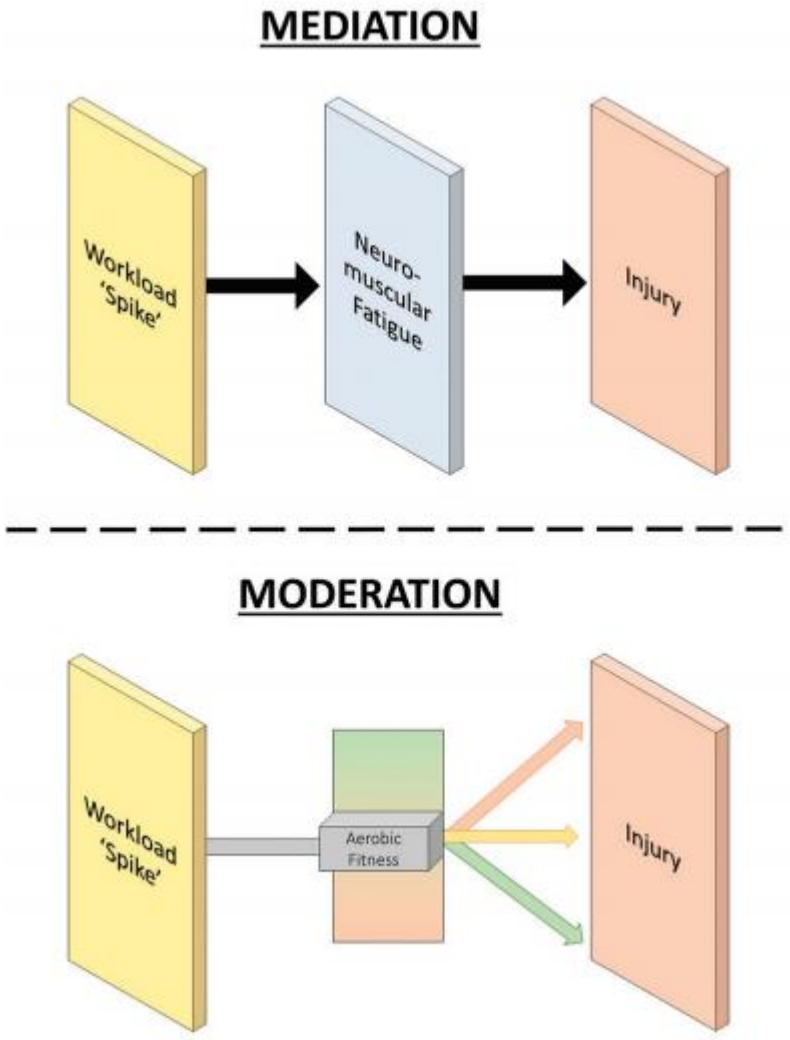


Source: Windt et al., 2016.

These findings have important implications: (1) preseason training involving high-speed running prepares athletes to handle the high-speed running required during the season, and (2) if an athlete can tolerate the high-speed running required during the competitive phase of the season, they have greater chance of remaining injury-free. In other words, preseason training prepares athletes to handle high-speed running, which then provides a protective effect against injury.

We have previously shown that spikes in training load increase injury risk. We've found that, *on average*, an acute:chronic workload ratio of ~1.5 is associated with an increased risk of injury. However, some players are injured at a very low acute:chronic workload ratio, while others remain injury-free at high acute chronic workload ratios. So, why is it that some players can handle high loads, high acute:chronic workload ratios and spikes in load whereas some others get injured when dealing with much lower loads? What are the factors that create robustness and what are the factors that result in fragility? This is where the concept of moderators and mediators is important.

Figure 5: How mediating and moderating variables explain the association between a workload spike and subsequent injury.



Source: Windt, Zumbo, Sporer, MacDonald & Gabbett, 2017.

In the above example (Figure 5 top panel), neuromuscular fatigue is shown as a mediator of the effect of workload spikes on injury. In this example, a spike in workload causes an increase in neuromuscular fatigue, and an increase in neuromuscular fatigue leads to injury. Conversely, aerobic fitness acts as a moderator (bottom panel) of the relationship between workload spikes and injury. In this case, a given spike in workload will elicit a different injury risk dependent on an individual's fitness level (Windt et al., 2017)

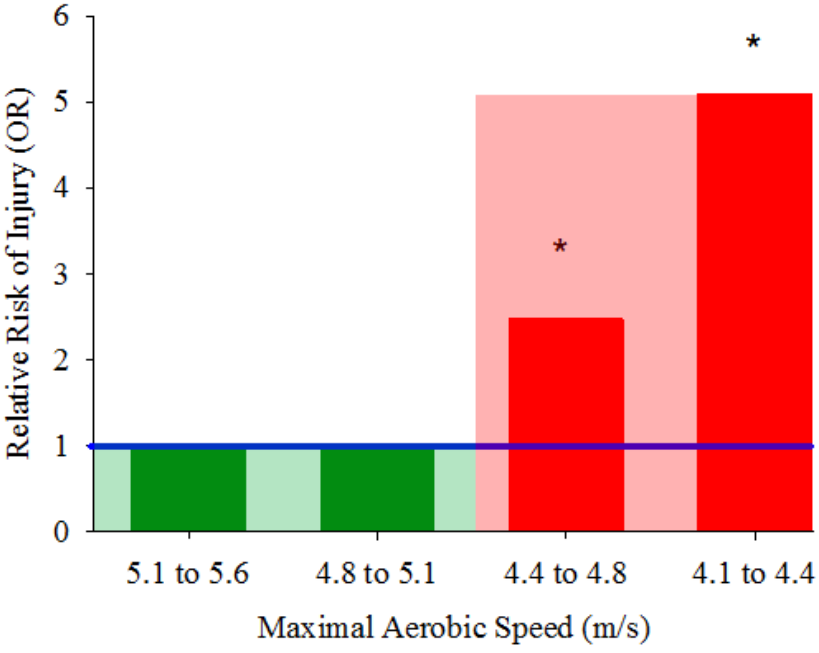
Moderators and mediators can explain the increased (or decreased) risk of injury in *different athletes* with the *same spike in workload*. What degree of workload spike can cause injuries in some athletes and not in others? A mediator is a

variable that produces a "flow-on" effect. Spikes in workload can result in neuromuscular fatigue and neuromuscular fatigue can lead to injury. This is a type of *mediation*. However, a moderator is a variable that can either increase or decrease the risk. Let's use aerobic fitness as an example: if we take a player with low aerobic fitness and expose that player to a workload spike, this will result in an increased risk of injury. But if we take a different player with high aerobic fitness and expose that player to the exact same workload spike, the high aerobic fitness will decrease the risk of injury.

The concepts of mediation and moderation improve our understanding of the causal mechanisms behind injuries. Identifying the factors that moderate the workload injury relationship will allow us to address these deficiencies. For example, if we have a player with low aerobic fitness or low strength (and we know that this is a moderator of the workload-injury relationship) and we improve those physical qualities (fitness and strength), we can potentially reduce the risk of injury.

Again, the rationale is to be able to train our athletes smarter *and* harder. Let's explore some of these moderators of the workload-injury relationship. What are some of the established moderators of the workload-injury relationship. Figure 6 shows the relative risk of injury at a given spike in workload, controlling for the effect of aerobic fitness.

Figure 6: Effect of aerobic fitness on tolerance to "spikes" in load.

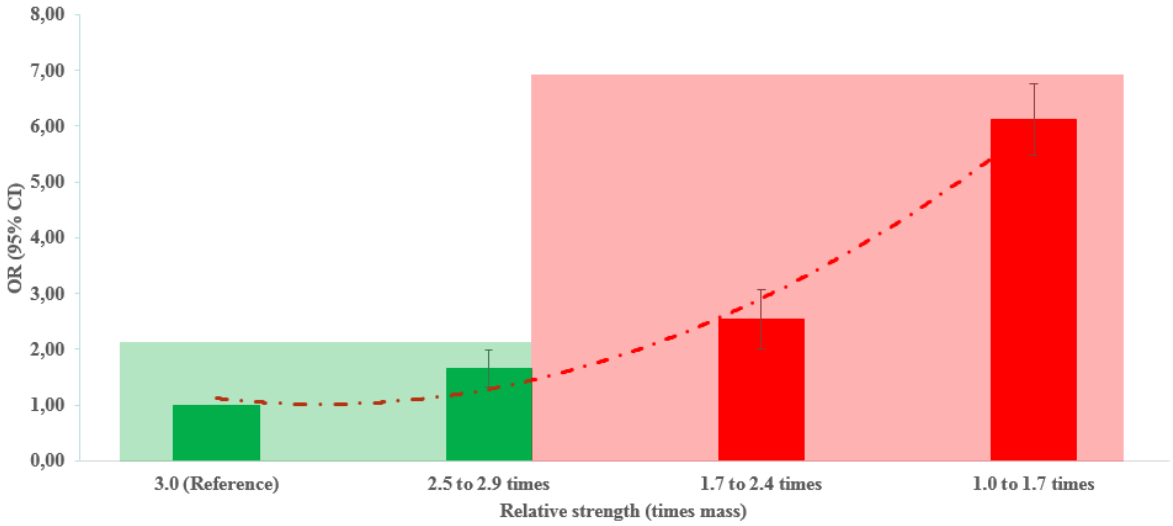


Source: Malone, Roe, Doran, Gabbett & Collins, 2016.

When players with higher maximal aerobic speed (i.e. higher aerobic fitness) are exposed to a workload spike, there is essentially no change in the risk of injury. However, when a player with poor aerobic fitness is exposed to the exact same spike in workload, their risk of injury is five times greater. So, aerobic fitness acts as a moderator to reduce the risk of injury when athletes are exposed to spikes in workload.

Let's discuss lower-body strength as a moderator of the workload-injury relationship.

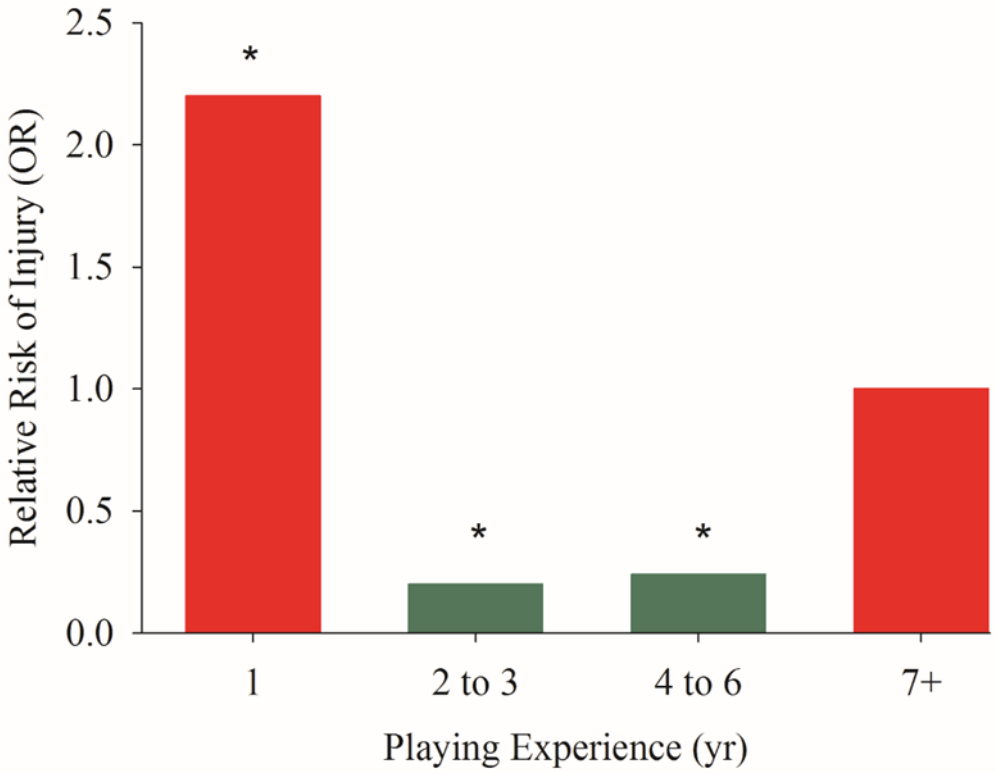
Figure 7: Effect of lower body strength on tolerance to "spikes" in load.



Source: Malone et al., 2016.

In Figure 7, we have measured lower-body strength using the trapbar deadlift. Strength has been expressed relative to body mass. The reference group was made up of very strong athletes (they are able to lift weight of 2.5 or 3 times their body mass). Well-developed hip and knee extensor strength protected those athletes against workload spikes. On the other hand, if weak athletes are exposed to workload spikes, the risk of injury is six times greater. in this example, lower-body strength moderates the workload-injury relationship. When athletes are exposed to a workload spike, relatively stronger athletes are protected against injury. A third moderator is age.

Figure 8: Player experience (as a surrogate measure for age) related to injury risk.



Source: Malone et al., 2016.

As seen in Figure 8, there is a "sweet spot" when it comes to age, load and injury. When players are in the middle of their career (i.e. they are not "too young" or "too old"), they train consistently and they appear to be able to remain relatively injury-free. However, very young or old players have an increased risk of injury. When workloads are increased abruptly for those players, their risk of injury also increases. It is also worth considering that the type of injuries differs depending on the age of the player. For example, if very young players are exposed to workloads spikes, they are more likely to sustain bone stress injuries (up to about the age of 23 years of age). After that period, in the 25 to 29 age group, they are relatively protected against bone stress injuries. Conversely, at the other end of the age continuum, when workloads are increased abruptly in older players, their risk of muscle related injuries (e.g. strains) increases.

I have previously discussed the protective effects of higher chronic training loads, so in this respect training history is also a moderator of the workload-injury relationship. The last moderator that should be considered is injury history. Prior injury history increases an athletes risk of sustaining subsequent injuries.

Finally, when interpreting training load information, one variable is not going to be the “magic bullet”. I would always advise making interpretations in combination with other data. For example, the acute:chronic workload ratio should be interpreted in relation to chronic load.

Other aspects to keep in mind when interpreting data are the factors that moderate the workload-injury relationship. In this module, five moderators of the workload-injury relationship have been identified: age, injury history, training history, aerobic fitness and strength. it is likely that many other moderators of the workload-injury relationship also exist.

To summarise, these 5 moderators (age, training history, injury history, aerobic fitness, and lower-body strength) should be considered when interpreting training monitoring data and prescribing training load to athletes.

References

Malone, S., Roe, M., Doran, D., Gabbett, T. J., & Collins, K. (2016). Aerobic Fitness and Playing Experience Protect Against Spikes in Workload: The Role of the Acute:Chronic Workload Ratio on Injury Risk in Elite Gaelic Football. *International Journal of Sports Physiology and Performance.*doi: http://dx.doi.org/10.1123/ijspp.2016-0090

Murray, N. B., Gabbett, T. J., & Townshend, A. D. (2016). Relationship between Pre-Season Training Load and In-Season Availability in Elite Australian Football Players. *International Journal of Sports Physiology and Performance*. DOI: http://dx.doi.org/10.1123/ijspp.2015-0806

Windt, J., Gabbett, T., Ferris, D., & Khan, K. (2016). Training load–injury paradox: is greater preseason participation associated with lower in-season injury risk in elite rugby league players? *British Journal of sports Medicine*. doi:10.1136/bjsports-2016- 095973

Windt, J., Zumbo, B., Sporer, B., MacDonald, K., & Gabbett, T. (2017). Why do workload spikes cause injuries, and which athletes are at higher risk? Mediators and moderators in workload–injury investigations. *British Journal of Sports Medicine*, doi:10.1136/bjsports-2016-097255