Module 2

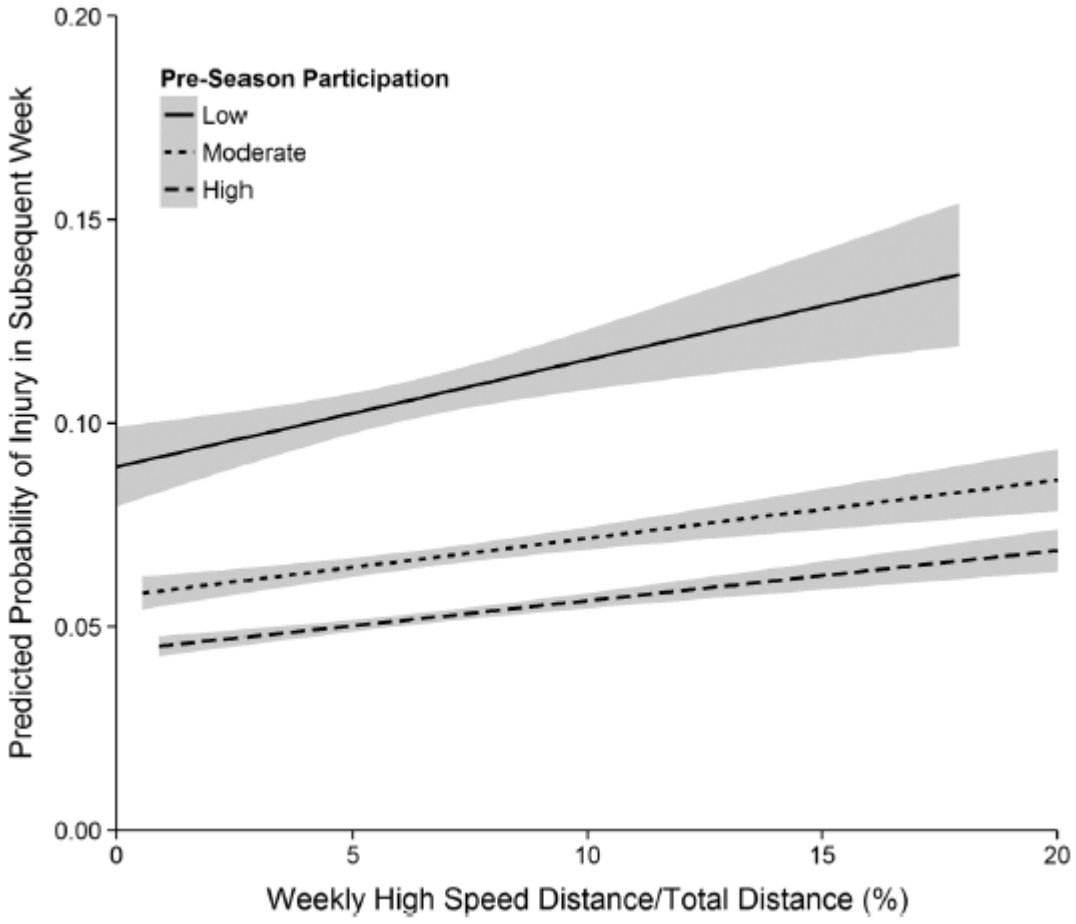
Is training really the problem?

Based on our discussions in Module 1, it would be easy to conclude: "Well, training is obviously the problem. There is data showing that more high-speed running is associated with greater injury risk; higher training loads are associated with greater injury rates. When training loads were decreased, injury rates also decreased. So, clearly, the problem is training! If we don't train, we don't get injured!" ***Let me be very clear about this, I've never actually said that.*** Anyone who suggests that we should stop training should actually read the studies in greater detail because at no point has it been stated that athletes need to stop training.

I will now show you some of the reasons why we need to keep athletes training hard. I will also show you the exact same data that has been presented but with a different interpretation. Interpreting data in at least two ways is an important skill that you will develop during this course. So, does the data that I have shown to this point mean that athletes should stop training? The answer is absolutely "*NO*". And here are three key reasons why.

Firstly, even though there is a link between training load and injury, there is also some strong evidence to suggest that load protects athletes against injury (see Figure 1).

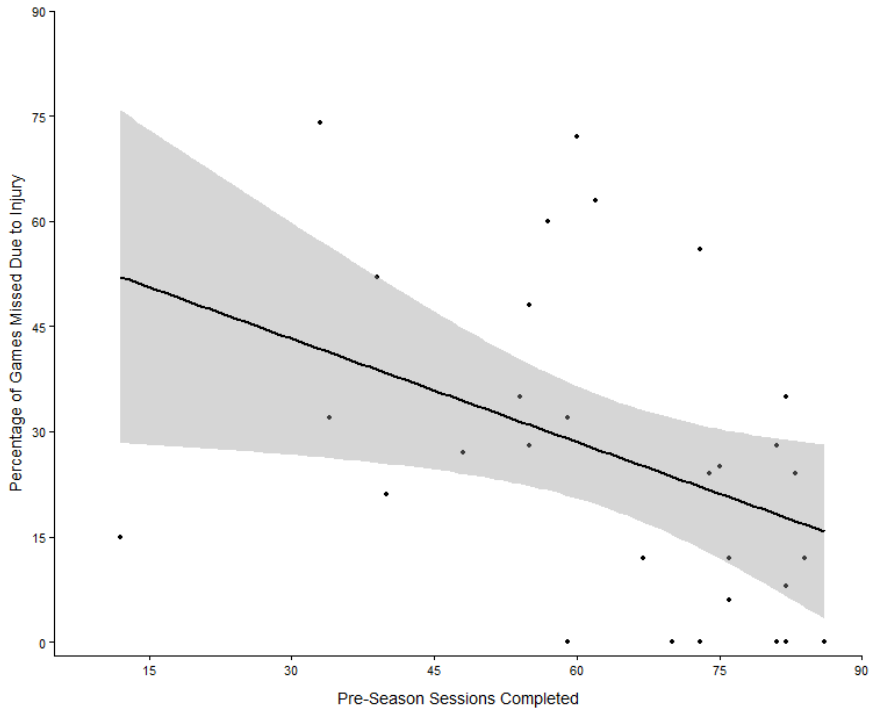
Figure 1: Predicted injury probabilities for percentage of total distance covered at high speeds, depending on preseason participation



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

In Figure 2 the linear regression slope shows that for every 10 additional preseason sessions, the predicted percentage of games missed decreases by 5%. Percentage of games missed due to injury was calculated by dividing the number of games missed due to injury by the number of games that players were eligible to play.

Figure 2: Games missed due to injury vs pre-season sessions completed.



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

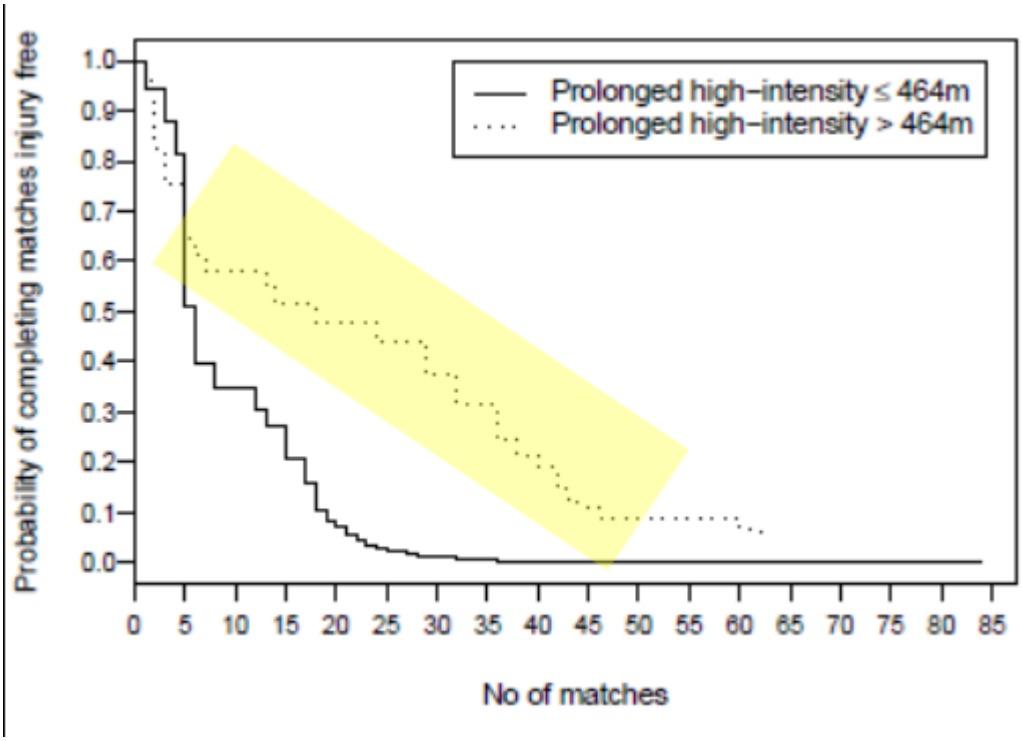
One of our early studies (Gabbett and Domrow, 2005) investigated the volume of training players performed before sustaining their first injury. We found that, the more training a player performed, the longer it took them to sustain an injury. Across a wide range of sports, there is a strong relationship between physical qualities and injury risk; well-developed physical qualities are associated with lower injury risk. So, how do athletes get fit? They have to train, and they have to train pretty hard!

Finally, we need an understanding of the physical demands of competition. If we ask anyone in our group to describe the physical demands of their sport, let's say football, they will say something like: "players have to cover ten kilometers in a game, maybe a thousand or two thousand meters of high speed running, three hundred meters of sprinting". What this person has described are the demands of *one* game. But if you are playing in an elite football team, you are playing multiple games in a row, you are playing multiple games throughout a season. So, we are not actually preparing athletes for the demands of *one game*, we are preparing for the demands of a "marathon" of games, *multiple games*.

Professional players spend the entire preseason preparing themselves for the first game of the competition. However, during the tournament, they usually have three days to prepare for the next match. That first game entails a huge physical

and mental stress, which can impact on subsequent performances. The way that we can help our players prepare for these demands is through physically intense and mentally appropriate training.

Figure 3: Well-developed physical qualities protect against injury



Source: adapted from Gabbett, Ullah & Finch, 2012.

Let's discuss the protective effect of fitness. In Figure 3 I have presented a "survival curve". This survival analysis examines "injury-prone" versus "resilient" or "robust" athletes. Our question was "is there certain qualities that differentiate robust from fragile athletes?" We tested a number of different physical qualities, such as strength, high-intensity running ability, aerobic fitness, speed and body mass. We used that data to determine if a robust or injury-prone athlete could be identified. Figure 3 shows the results of this analysis: it is a survival curve using fitness data applied to sports. On the vertical axis we have the probability of completing matches injury free. One of the tests we used was a measure of prolonged high-intensity running ability. The test involves 8 x 12-second repetitive shuttles on a 48-seconds cycle. This corresponds to 12 seconds of work and 36 seconds of recovery. Players who scored greater than 464 meters on this test were considered the fittest players (based on a median split). The players who scored below 464 meters were considered the less fit group. The results demonstrate that players with greater running ability and fitness, tended to survive matches injury free for longer. Again, how do athletes achieve this fitness

that protects them from injury? How do they get that fitness that helps them survive matches injury free? They have to train and they have to train hard!

Previously I showed this data demonstrating the risk of non-contact, lower-body soft-tissue injury when players were exposed to higher or lower workloads.

Figure 4: Relative risk of soft-tissue injury with high and low running loads in professional football players

Risk factors	Relative risk (95% CI)		
	Transient	Time lost	Missed matches
Injury history in the previous season (no vs. yes)	1.4 (0.6–2.8)	0.7 (0.4–1.4)	0.9 (0.2–4.1)
Total distance (≤3,910 vs. >3,910 m)	0.6 (0.3–1.4)	0.5 (0.2–1.1)	1.1 (0.2–6.0)
Relative distance (≤60 vs. >60 m·min^{-1})	1.2 (0.5–2.6)	0.8 (0.4–1.6)	0.7 (0.2–2.8)
Very-low intensity (≤542 vs. >542 m)	0.6 (0.2–1.3)	0.4 (0.2–0.9)†	0.4 (0.1–2.8)
Low intensity (≤2,342 vs. >2,342 m)	0.5 (0.2–1.1)	0.5 (0.2–0.9)†	1.2 (0.2–5.5)
Moderate intensity (≤782 vs. >782 m)	0.4 (0.2–1.1)	0.5 (0.2–1.0)	0.5 (0.1–2.3)
High intensity (≤175 vs. >175 m)	0.8 (0.2–3.1)	0.9 (0.3–3.4)	2.9 (0.1–16.5)
Very-high intensity (≤9 vs. >9 m)	2.7 (1.2–6.5)†	0.7 (0.3–1.6)	0.6 (0.1–3.1)
Total high intensity (≤190 vs. >190 m)	0.5 (0.1–2.1)	1.8 (0.4–7.4)	0.7 (0.1–30.6)
Mild acceleration (≤186 vs. >186 m)	0.2 (0.1–0.4)‡	0.5 (0.2–1.1)	1.5 (0.3–8.6)
Moderate acceleration (≤217 vs. >217 m)	0.3 (0.1–0.6)‡	0.4 (0.2–0.9)†	1.4 (0.3–7.5)
Maximum acceleration (≤143 vs. >143 m)	0.4 (0.2–0.8)†	0.5 (0.2–0.9)†	1.8 (0.4–8.8)
Repeated high-intensity effort bouts (≤3 bouts vs. >3 bouts)	0.9 (0.4–2.0)	1.6 (0.8–3.3)	1.0 (0.2–4.4)

Source: adapted from Gabbett & Ullah, 2012.

It was highlighted that the more high-speed running players engaged in, the greater their risk of injury (2.7 times greater risk of injury). But what I didn't discuss was what happens when players perform high-intensity acceleration efforts which involve short, sharp accelerations separated by low speed activity. *The risk of injury is halved under those conditions.*

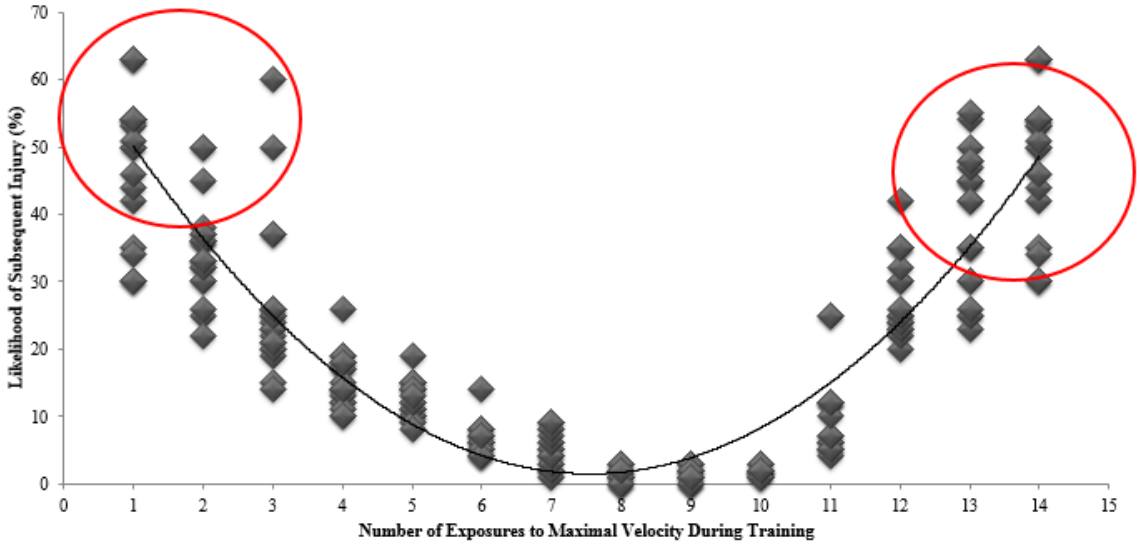
Let's think about the demands of our team sport competitions. Typically, they involve short, sharp acceleration efforts. Some high-speed running may be required at times, but the game usually consists of short, sharp efforts separated by low-intensity work. Therefore, the problem may not be training itself, but rather the kind of training that we are prescribing. If we train appropriately, we may reduce athletes' risk of injury. This doesn't mean that we should remove high-speed running from training programs altogether. Players sometimes need to engage in high-speed running and they need to be ready to tolerate these demands. If athletes do not perform high-speed running in training, then they are set up to fail. Firstly, they can't execute the tasks that are required during a game; they can't perform the high speed running that is required of them in games. Secondly, they sustain an injury while attempting the tasks.

Of course, we can look at this data differently. Even though high-speed running is associated with a higher injury risk, it's important to keep in mind that it also

protects athletes against injury. So, how do athletes get protection against high-speed running related injuries? How do athletes get the protection that prepares them to handle high speed running? The answer: by regularly receiving a "vaccine": the "*high speed running vaccine*!". Regular doses of high-speed running improves an athletes ability to cope with high-speed running. It improves their ability to stay injury-free when they engage in high-speed running.

Is speed really a problem? How much evidence is there to conclude that sprinting actually increases injury risk?

Figure 5: Exposures to high-speed running influencing likelihood of subsequent injuries

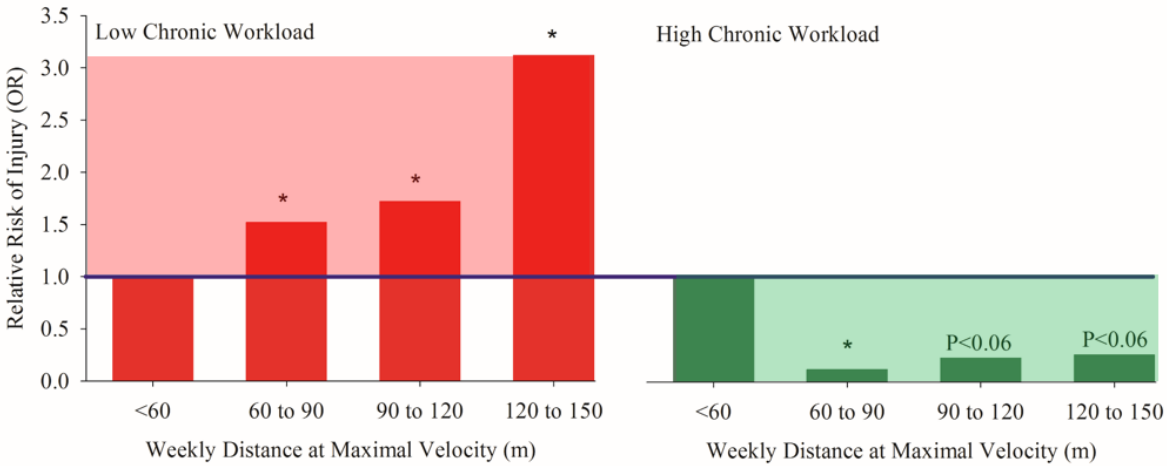


Source: adapted from Malone, Roe, Doran, Gabbett & Collins, 2016.

There is a fine line between doing too much and too little sprinting during the week. If athletes do too much sprinting, the risk of injury increases. But at the same time, if players don't do sprint training during the week, the injury risk also increases due to lack of training. They haven't been prepared adequately to handle the demands of competition. The exact number of sprints athletes need to perform in a week, will vary from sport to sport and, probably, the intense actions that are important for one sport are going to be completely different from another. But, if athletes are regularly exposed to high-speed running, this will improve their chances of coping with high-speed running during the game. Equally, regular exposure to sprinting improves athletes ability to perform the sprints they need to do in a game and improves their ability to handle those sprints. It is important to keep in mind that sprinting (like all high-intensity actions) is performed following some level of chronic load. Recently, we

conducted a study with ~40 players divided into two groups of ~20 players each. One of the groups had built a high chronic load and the other had a low chronic load. We wanted to determine the effect of different chronic loads on the players' ability to tolerate sprinting demands (Figure 6).

Figure 6: Combined effect of chronic load history and maximal velocity on injury risk



Source: adapted from Malone et al., 2016.

The data show that when athletes with a low chronic workload are required to sprint, their risk of injury is three or four times greater. But if athletes have safely built high chronic workloads and then sprint over the exact same distance, *their risk of injury is halved*. This demonstrates that high chronic workloads set players up to handle the sprinting demands of competition. ***High chronic workloads prepare athletes to sprint.***

As shown previously, the following figure shows the accuracy of our "prediction" model for forecasting training load related soft-tissue injuries. I previously demonstrated that the model was very sensitive and very specific. However, what I did not highlight was that it had much more true negatives than it did of any of the other classifications.

Figure 7: Accuracy of model for predicting non-contact, soft-tissue injuries

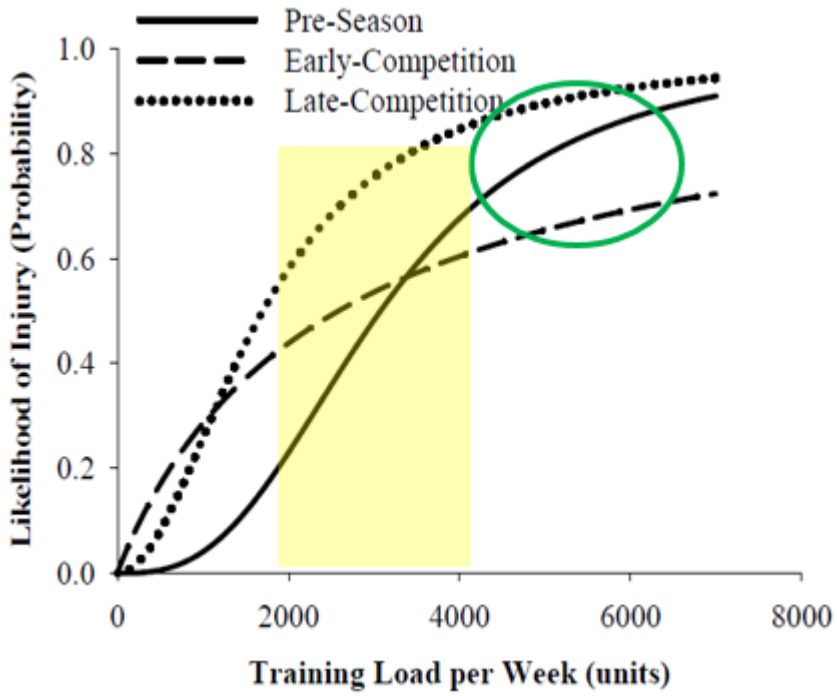
		Actual Status		
		Injured	**Not Injured**	
Predicted Status	**Predicted Injury**	True Positive $N = 121$	False Positive $N = 20$	**Positive Predictive Value** 85.8%
	Predicted No Injury	False Negative $N = 18$	True Negative $N = 1589$	**Negative Predictive Value** 98.9%
		Sensitivity 87.1%	**Specificity** 98.8%	

Source: adapted from Gabbett, 2016.

This means that the model is much better for identifying when an injury is *not* going to occur than it is for identifying when an injury is going to occur.

As a practitioner, if you focus your training monitoring on injury reduction rather than on performance enhancement and you only think about managing your players away from training load thresholds so that they don't get training load related injuries, then of course they are not going to get a training load related injury – because they are not training hard enough to get injured! Equally, they will never train hard enough to develop the physical qualities that actually set them up to succeed in competition. We need our players to perform high level tasks and we need them to perform them consistently. So, let's look at this figure from another perspective.

Figure 8: Likelihood of injury with different training loads



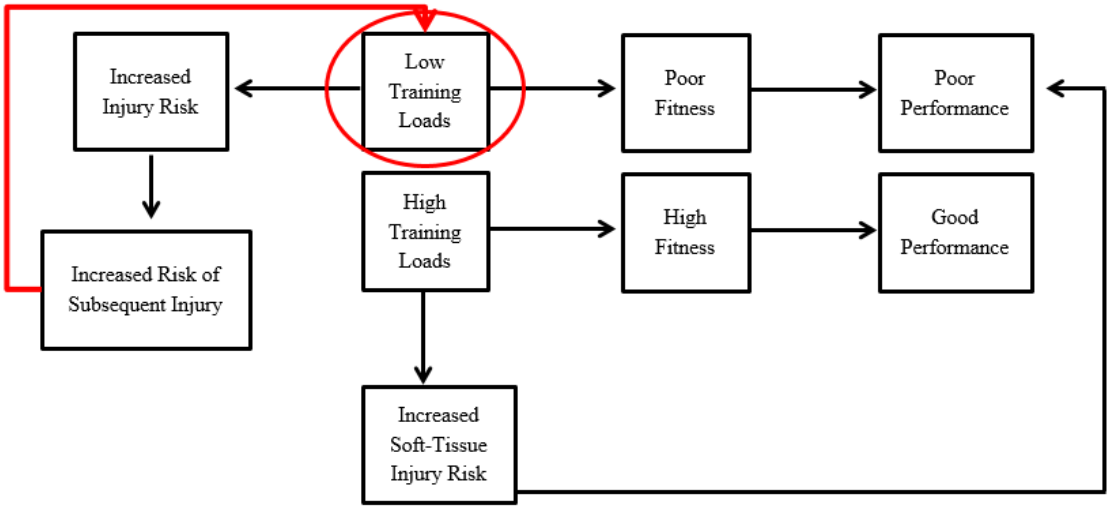
Source: adapted from Gabbett, 2010.

This is our model of training load versus injury risk. Previously, I highlighted the preseason curve and that, at around 3000 units, players had ~50% chance of sustaining a non-contact, soft-tissue injury. But when we say that a player has a 50% chance of sustaining an injury, we are essentially saying that there is a 50% chance that they won't sustain an injury.

You will recall that on the steep part of the curve, small changes in training load result in large changes in risk. But, you will also notice that if you can safely train athletes through the steep part of the curve, you will notice that the curve begins to flatten out. Here, large changes in training load result in small changes in risk. I would suggest to use the acute:chronic workload ratio to *safely* push your players through the unsafe zone; that's what training is about. Based on these findings, as practitioners should prescribe high training loads to our athletes, to our sportsmen and women. But keep in mind this does not mean excessive loads or rapid changes in load; it means systematically building to high chronic loads. When we prescribe high training loads, this allows us to identify players who are susceptible to injury under physically stressful situations. These are the ones who won't be able to tolerate the demands of competition. Equally, by prescribing high training loads, we can identify players who are not susceptible to injury under physically stressful situations. These are the type of players that we want to take into competitions, because we know, they will get the job done when it really matters. They have shown us during training that they can handle the

demands of competition. They consistently handled high loads in training so they are likely to handle it consistently during competition.

Figure 9: Relationship between physical qualities, training load and injury risk in athletes



Source: adapted from Gabbett, 2016.

So, does training cause injuries or could training prevent them?

Figure 9 summarises the relationship between training load, fitness, performance, injury and subsequent injury. All of these factors interact in a sporting environment. Low training loads lead to poor fitness and when athletes are unfit, their performance suffers. On the other hand, higher training loads lead to fitness and good performance. But, if training loads are excessive or if there are large spikes in load, this increases an athlete's risk of soft-tissue injury. And if teams don't have as many of their best players available for selection each game, this changes the team's dynamics which can potentially result in poor performance.

There is also evidence that low training loads can increase injury risk. And previous injury is a strong risk factor for subsequent injury. I refer to these players as the "chronic rehabber". These players have been exposed to low training loads, sustained an injury and then spent almost the entire season in rehabilitation. It could be a player who gets injured early in preseason because they came back with low chronic loads and couldn't handle the demands of preseason training. It could be a player who has had multiple injuries and just unable to build chronic loads. They spend the majority of their time in the chronic rehabber loop: they never get out of rehabilitation because they never are exposed to training loads which are high enough to actually protect them from injury. Therefore, what we suggest is using high training loads: not excessive loads and not large spikes in

loads. We should try to systematically build high chronic loads. This develops the physical qualities of players, and, when athletes are fit, the injury risk decreases and this also leads to good performance.

To summarize this section, the problem is not training in itself, but rather the training that is often prescribed. When practitioners prescribe excessive loads or large spikes in load, there is a large increase in injury risk. Conversely, physically hard *and* appropriate training offers a protective effect against injury and it does this in three ways. Firstly, it develops physical qualities and when athletes have well-developed physical qualities (e.g. strength and aerobic fitness), they are protected against injury. Secondly, consistent training allows athletes to build high chronic loads. High chronic workload protects athletes against non-contact injury. Finally, , when athletes have higher chronic loads, they are protected against spikes in workload. It is much harder to spike from the "ceiling" (i.e. a high chronic load) than it is from the "floor" (i.e. low chronic loads). By building chronic workloads, athletes build fitness, which also protects them against spikes in load.

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