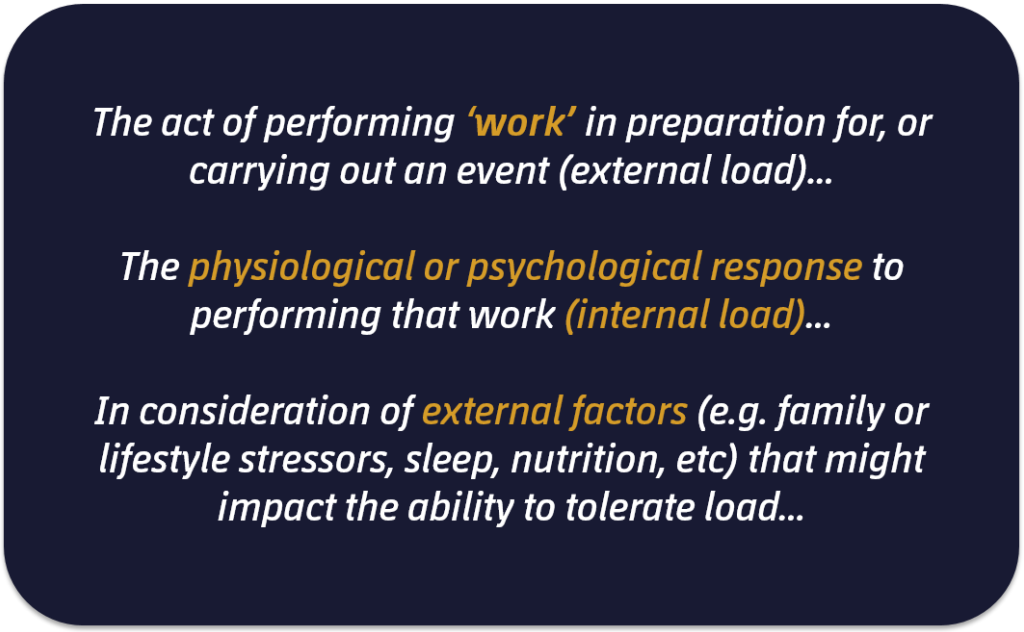
4. Training Smarter and Harder

There has been a lot of recent discussion that athlete monitoring reduces the risk of injury. There is a distinction that I want to make and athlete monitoring and athlete loading are two different things. They are closely tied together. In order for you to load appropriately it helps to monitor your athletes. But monitoring an athlete that isn't doing any loading is not going to result in a robust athlete, it's not going to result in reduced injury. The combination of both helps, but they are two different things.

Figure 1: What is load?



Source: Prepared by the author

Before we can understand "load monitoring" or "optimal loading" we need to define load. There are two types of load. External load is the 'work' that your athlete performs in preparation for their event, or the actual event. It is the physical act of doing work, which could be the distance that they run, the speed that they run, it could be the weights that they lift, or it could be the number of times they kick a ball. For a goalkeeper it could be the number of times they get down to the ground and have to get back up again.

Then we have an internal response to that load, we are talking about the physiological, the psychological or maybe the biomechanical response to performing that work.

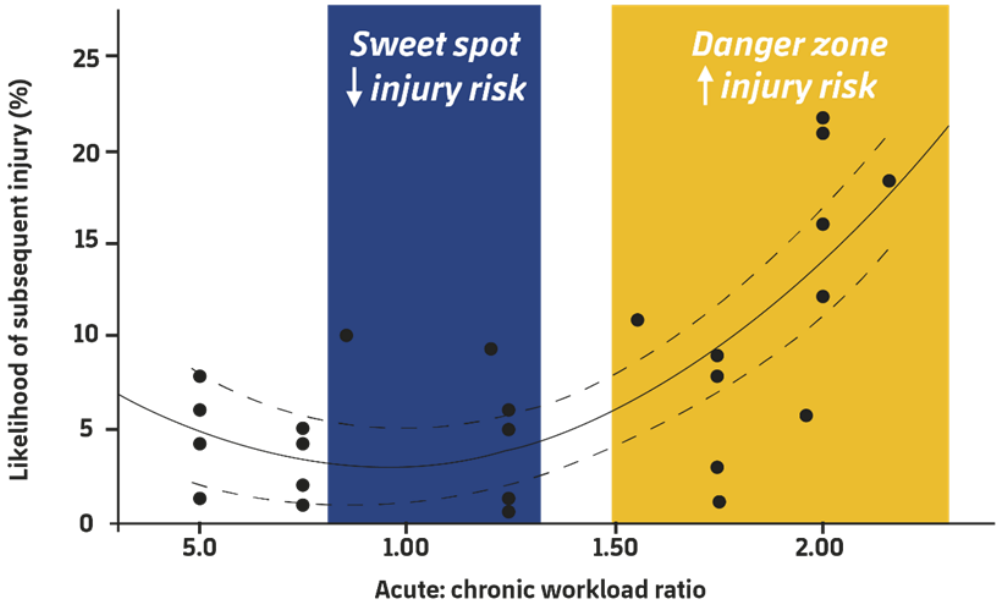
And the third part is, we are talking about, it's in consideration of a whole heap of external factors that can impact on a player's ability to tolerate load. So, as an example, there are external factors: stress, life style factors, sleep, family factors, work-life balance, exam stress. They all interact to either increase or decrease the stress on the player and changes their ability to tolerate load on a given day.

Let's say we have a session and we want to cover 4 kilometers, and we want do one kilometer of high speed running. That's a particular type of external load that would bring about a certain internal load, the internal load it's going to be dependent on a whole heap and your ability to tolerate that load. It's going to be dependent on all of these external factors that are going out on the background.

There are factors that a lot of the time we don't measure, we know they are going on, we talk to our athletes about them but a we don't quantify them very well. I see it sort of like a lever, if you pull back on a lever then you either increase or you decrease the activity there. So if you pull back on a lever you might increase the amount of stress that you are under; or decrease the amount of sleep. When you do that, it changes your ability to tolerate load, and if you push for on a lever maybe you get the opposite result. So, our ability to tolerate the load is dependent on those factors, external load, internal load and these external factors.

The last point about external and internal load is that internal load is what drives adaptation, so things like heart rate or our effort, our perceived effort, it drives adaptation but it's the external load that we modify in order to increase or decrease the internal stress. So, if we want to produce a greater adaptation, a greater intensity of our training session, then we can increase the external load. If we want to pull back on that internal load, decrease the internal load to provide greater recovery then we modify our external load to do that, therefore they interact together.

Figure 2: Acute:chronic workload ratio and injury risk



Source: Adapted from Blanch and Gabbett, 2015. p.3.

Let's discuss the acute:chronic workload ratio and injury risk. There are some important points in this graph that we have already discussed. In general (or on average), we can state that if the ACWR is maintained between 0.8 and 1.3 then the risk of injury (on average) will be low. However, if loads are increased too rapidly, then that can increase the risk of injury. Based on this finding it would be easy to suggest that practitioners should never increase training loads quickly and never unload our athletes. This couldn't be further from the truth!

When we train athletes, we are always balancing the risks and rewards of training. So, yes there's a risk that goes if I push a little hard in training, it's important to keep in mind that if I keep my athlete in the safe zone, in this average zone, with the average risks of injury really low, then your athlete is going to stay average. Sometimes it is important to consider that in order to obtain greater physiological adaptation, we may have to 'push' our athletes.

For performance outcome, if we think of some of the best ways to maximize adaptations, is through intensified training. We call those "shock blocks", with this intensified training periods, it's not uncommon for you to push your player into a danger zone.

As practitioners we have two options. We can either stay in the 'safe zone' and stay average or on occasions we can push harder and get a a little more out of your athlete. Nevertheless you do it as part of a plan. You don't just turn

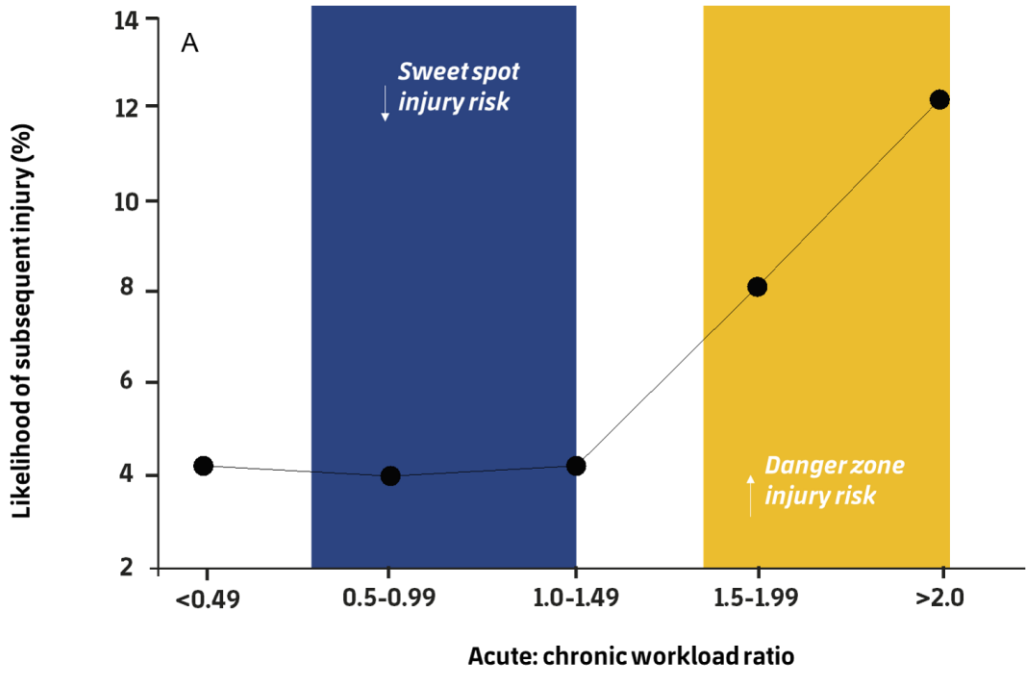
up on the first day of pre-season and say: “We are going through a shock block”. Athletes have to earn the right to go through a shock block and the way you earn the right to go through an intensified period of training is, you first build chronic workloads. You will achieve that by training consistently, you get players to train consistently and when they’ve done that, over a period of time, they’ve earned the right to go through this intensified period of training.

Equally, players in rehabilitation don’t go through a short block. Only athletes that have developed an adequate chronic load are taken into a shock block because they have demonstrated the capacity to tolerate high(er) loads.

Some other “scientists” have suggested that because injury risk increases at lower ACWRs, that we should never unload our athletes either! That ridiculous statement stems from a lack of understanding of the training process. Of course I'm going to unload (recover) my athletes because that’s where they produce training adaptation. We train hard and the recovery is where we adapt and we get better. However, a player in rehabilitation who has not been training consistently and has not built any chronic load, also hasn’t earn the right to go through an unloading block. So, in this case, they may benefit from maintaining loads. There will be times when your athletes go outside of the ‘sweet spot’ and it’s not cause for panic.

The other thing that I’ve seen a lot is this comment: “It’s all about the ratio”

Figure 3: It's all about the ratio



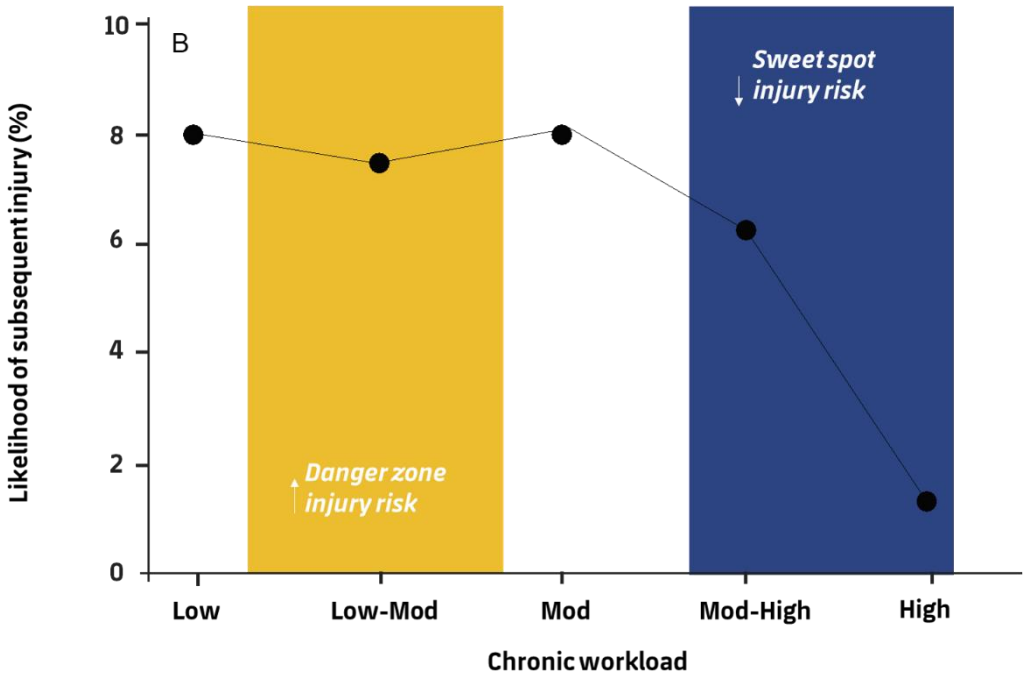
Source: Gabbett 2018. p.4.

I have said this multiple times, one variable is not going to be the Holy Grail, it's not going to be the only thing that you measure and then suddenly all of your injuries disappear. Injuries are multi-factorial and they are very hard to prevent, and (at this point in time) not possible to predict. One variable is not going to be the "magic bullet", which means *it's not all about the ratio*.

The ratio in its purest sense, the real strength of it is we know that progression in training is important (progressive overload) and that recovery is important. However, real strength of the ACWR is that now we have a method available to actually build load. We can unload our athletes based in real data.

There's definitely a sweet spot for keeping our athletes at lower risk of injury, and there's a danger zone. However, just to highlight that it's "not all about the ratio", observe figure 4. This figure shows the relationship between chronic load and injury risk.

Figure 4: It's NOT all about the ratio



Source: Gabbett 2018. p.4.

When an athlete's chronic load is low, injury risk is at it's highest (i.e. they are in the "danger zone"). However, when chronic load is high, injury risk is at its lowest (i.e. it is the "sweet spot"). So, there is a "sweet spot" and "danger zone" for the ACWR but there is also a "sweet spot" and "danger zone" for chronic load.

Just because you are in this sweet spot for the ratio, if your chronic load is low, you are actually not prepared for any type of high intensity training. Monitoring acute and chronic load is a good starting point. However, monitoring alone and simply knowing the risks, will not reduce injuries. You actually have to train physically hard and gradually build your loads in order to minimize your risks of injury.

We can't do randomized controlled trials in sports, if you go to a coach and say: "we want to do an intervention and we think this is going to be the best for the team but only half of them are going to do it, this half is going to do the intervention, this half isn't". The coach is not going to let you do it, he is going to say, "if that's the best approach I want everyone doing it", so we can't do randomized controlled trials in sports but what we can do is track players over time.

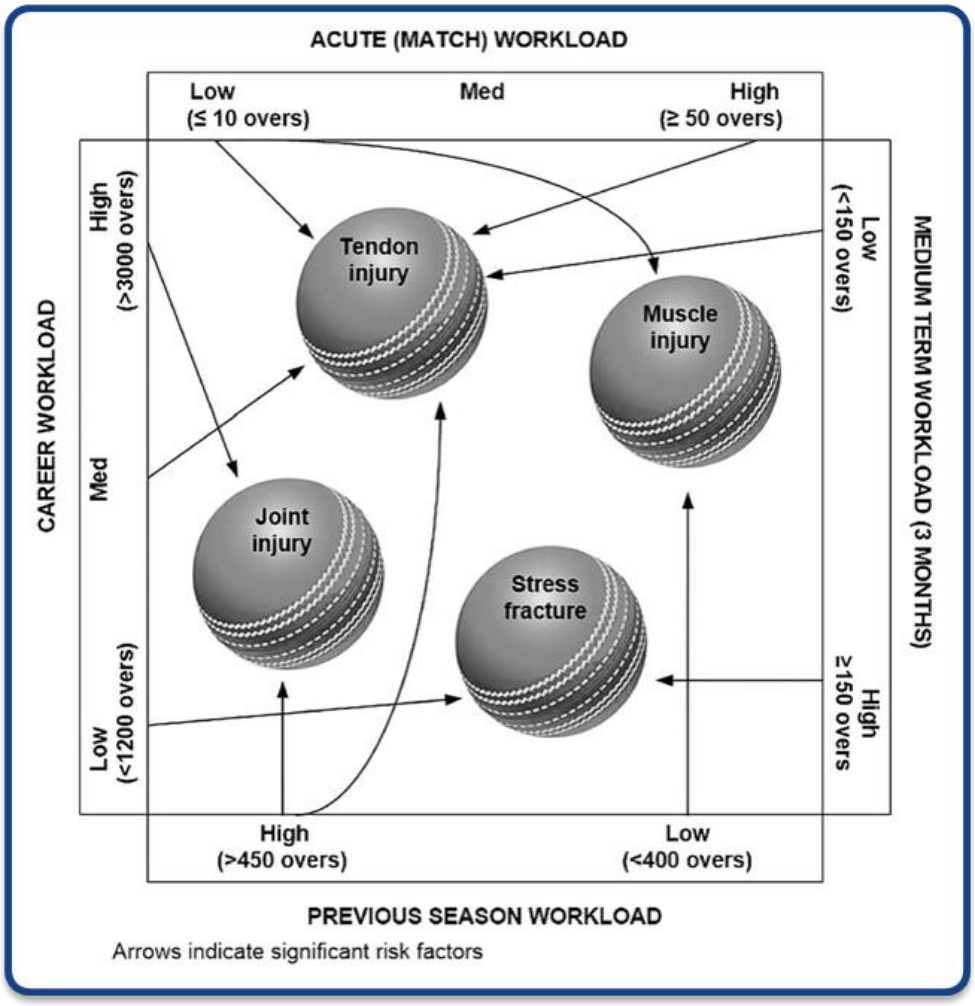
What we've done is over a four-year period we tracked our players. The first 3 years we didn't do much with the data at all, we just recorded it. But the last year what we tried to do was minimize the number of spikes in load and build high chronic loads. We measured injury rate and spikes in load as well. Chronic loads are building over time. It was only in the last year when we started to act on the data, spikes in workload decreased, where we actively tried to reduce the number of spikes. We get a massive reduction in injury rates. Now, I can't tell you whether it's by chance, maybe there's a little bit of luck in here, maybe if we come back the next year loads are high, spikes are low and our injury rates go to the roofs, maybe, maybe not.

The other thing I can't tell you is what's more important, the building of high chronic load or the reduction in spikes. What I can tell you is when we did this kind of program and this is the first kind of intervention that's look at it, when we reduce the number of spikes and build to high chronic loads in a safe way, we kept our injury rates pretty low.

We look at chronic load and acute chronic ratio together. We can try to get an idea of what's happened in those years. We tended to spike our workloads, and those injuries tended to occur at really low chronic loads. When we have really low chronic loads and then we spike them, that's when they've got injured. When you keep your spikes to a minimum and you build your chronic loads, you actually get no injuries. Nevertheless, sometimes it's due to low loads and spikes, sometimes it's due to moderate loads and spikes. Sometimes, we've been almost in the sweet spot for acute chronic ratio ad we've got higher loads, so sometimes it doesn't work as planned, so it could be a little chaotic sometimes.

Typically what happens is we have to take this information from single teams. There's no a lot of sharing of data, because of there's this feeling that if we give out our training load information, our injury information then we are lending out our deepest darkest secrets, and potentially our competitive advantage. A limitation of the research that has been performed in team sports is that the majority of studies have been performed on single teams. A limitation of single team studies is that there is typically few injuries. As a result the majority of workload-injury studies have pooled "workload related" injuries together, combining bone stress, joint, tendon and muscle injuries. Multi team studies can overcome this limitation, but with studies from single teams we have a small number of specific injuries to specific tissue types. However, it should be recognized that different loading patterns will lead to different injury patterns. The loading pattern for tendons will differ from bones, joints and muscles. Figure 5 shows the different load-injury interactions in cricket fast bowlers.

Figure 5: Different Loading Patterns Result in Different Risks to Different Tissue Types



Source: Orchard, Blanch, Paolini, Kountouris, Sims, Orchard, Brukner,2015.p.4.

I use cricket as an example because we've been able to get multi-years studies, around 15-20-years,and multiple players from multiple teams. So we can start looking at individual injuries to different tissue types, and you can see that muscle injury is tended to come on the back of low workloads. So if we use tendons as an example, tendons tend to respond really well to consistent loading, consistent surfaces of training. Constantly changing surfaces is thought to 'flare up' the tendon. They like these sort of fluctuations in load and they like it consistently rather than big spikes and big drops.

Bone stress injuries tend to 'creep up' on athletes over a longer period of time. If an athlete has a low career workload and then spike that workload over a three-month period, then it will increase their risk of bone stress injuries. That

typically happens in younger athletes, up to around 23-25 years of age before the bone has completely formed.

For muscle injuries, if you can build high chronic workloads in your players then the beauty of that it decreases your risk of muscle injuries.

But the trade-off is if you have high career workloads, you have never missed a training session, never missed a game, you've been a great contributor to the team, at some point in time you're probably going to have joint injuries. Unfortunately, high chronic loads have been associated with a greater risk of joint injuries.

Figure 6: Moderators of the Workload—Injury Relationship

Source: Gabbett 2018. p.4.

I would like to emphasize again that an ACWR of 1.5 is not a magic number. If we have two players who have the exact same ACWR of 1.5, what is it that allows one athlete to keep training, while the other player breaks? What is it that separates "robust" from "fragile" athletes? The differences in these athletes can largely be explained by moderators of the workload-injury relationship.

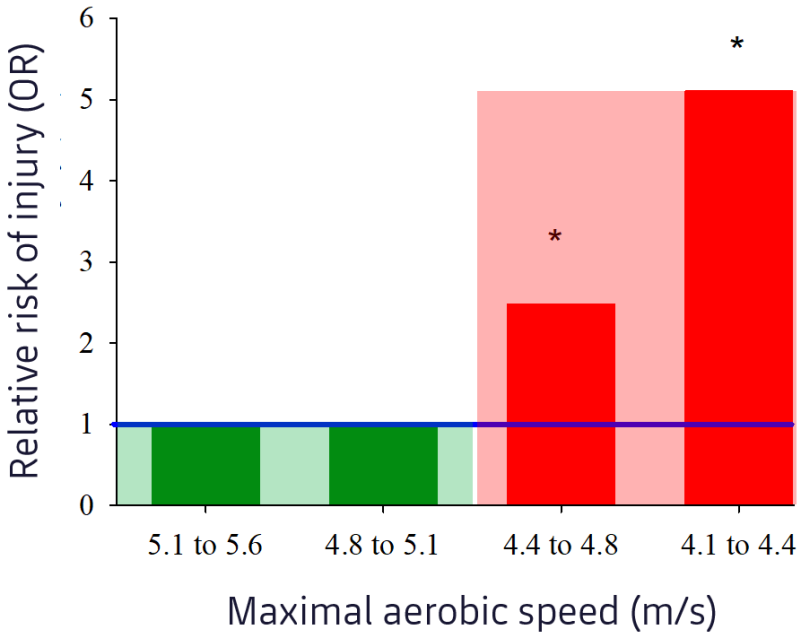
A mediator is where we have a direct 'flow on' effect. For example, when we spike workloads, there is a decrease in neuromuscular control, which in turn increases my risk of injury. Therefore, a decrease in neuromuscular control acts as a mediator of the workload-injury relationship.

A moderator can increase or decrease the risk of injuries. If we have a player with poor aerobic fitness and expose that player to a spike in workload, then that will increase his/her risk of injury. If we take a player with good aerobic fitness, and expose them to the exact same spike in workload then that will decrease their risk of injury. Therefore, aerobic fitness is a moderator of the workload-injury relationship. There are some other moderators that we know are important. For example, age strength, training history, and injury history are all important. Along with aerobic fitness, this makes five moderators that we are aware of (at this point in time). It is highly likely that different

moderators will have greater or lesser importance for different sports, and that more moderators will be uncovered over time.

Mediation and moderation allow practitioners to gain a better understanding of the mechanisms behind injury. It allows us to identify factors that moderate the workload-injury relationship. So, if we know that aerobic fitness and strength moderate the risk of injury at a given workload, then we can develop these qualities to modify injury risk. It allows us to train our athletes smarter and harder.

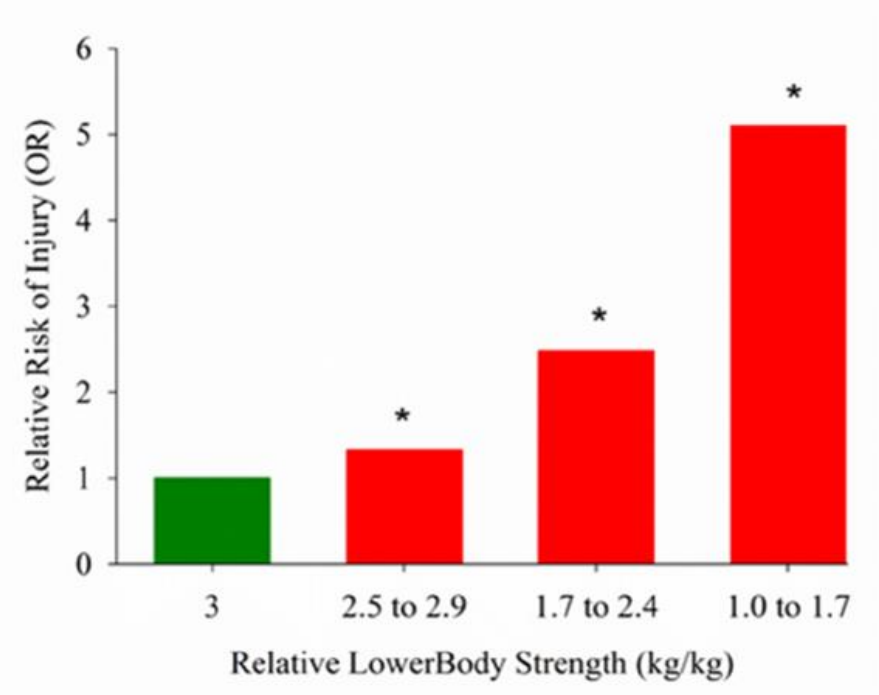
Figure 7: Does "Fitness" Protect Against Spikes in Load?



Source: Gabbett 2018. p.5.

So, the first we've done is we've taken a group of 40 players, who have different physical qualities. Every player is different and we wanted to know what is it about aerobic fitness, can it actually protect players against workloads spikes. So we looked at all the workload spikes, ratios of 1.5 we defined as spikes. Figure 7 shows the risk of injury at a given spike in workload in players with different aerobic capacities. The results show that at a given spike in workload, players with higher aerobic fitness had a lower risk of injury. However, when aerobic fitness was low, the risk of injury was 5 times greater. Aerobic fitness moderates the workload-injury relationship.

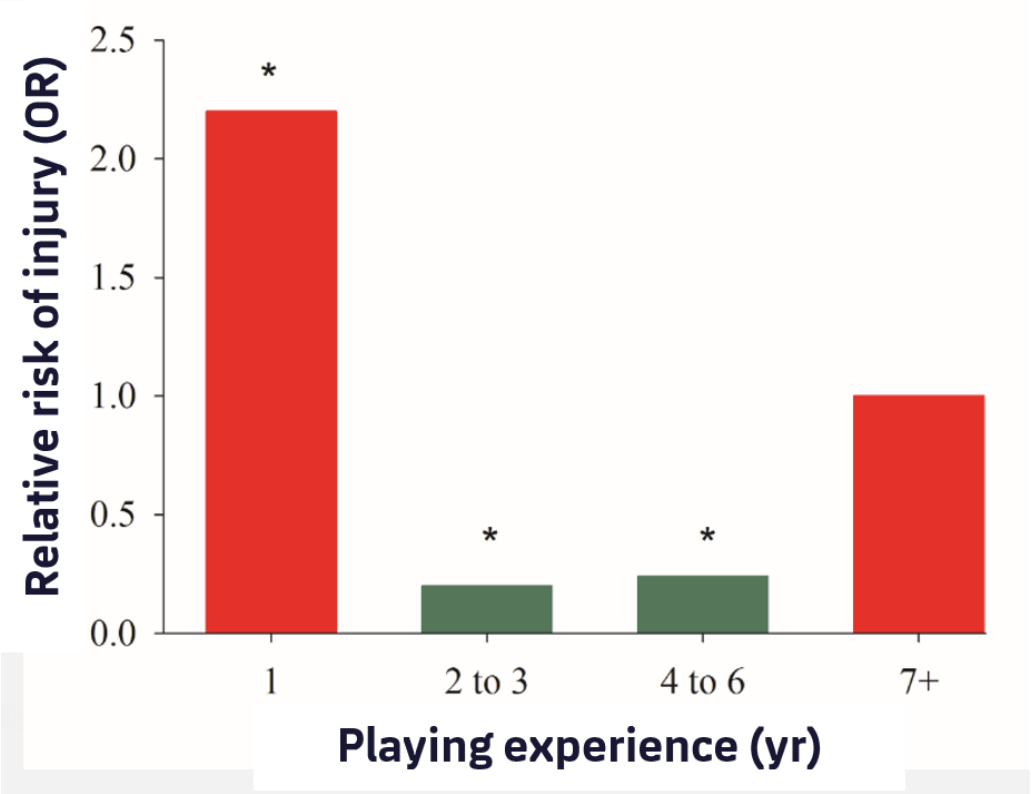
Figure 8: Effect of lower body strength on tolerance to “spikes” in load



Source: Gabbett 2018. p.5.

Figure 8 shows relative lower body strength as a moderator of the workload—injury relationship. Lower body strength was measured using a trap bar deadlift. When athletes are relatively stronger and they are exposed to a spike in worklolad, their risk of injury is low. However, when an athlete is relatively weak, you’re their risk of injury at the same spike in workload is 6 to 7 times greater. Lower body strength moderates the workload-injury relationship.

Figure 9: How do we ensure our adolescents become senior athletes?



Source: Gabbett 2018. p.5.

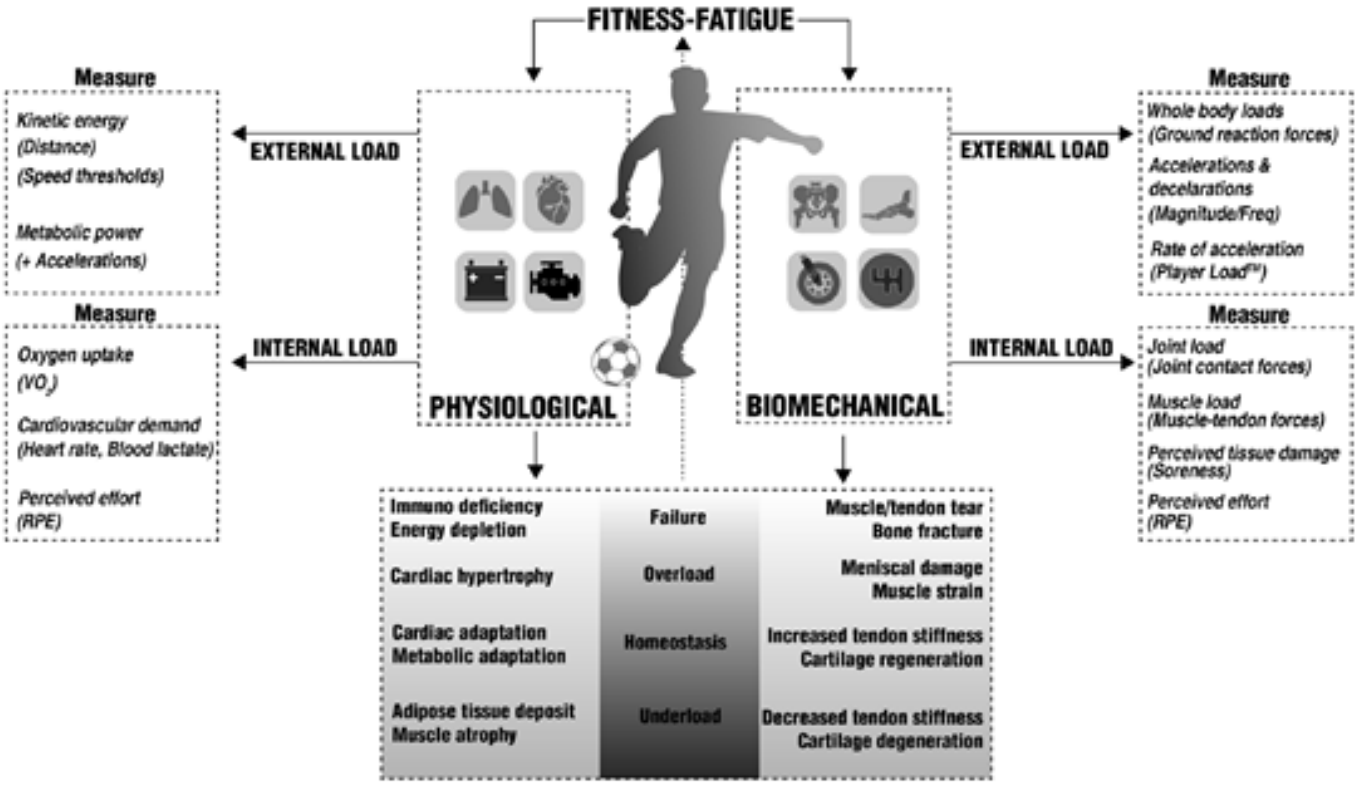
What about our younger players? Does age and playing experience influence the workload—injury relationship? Playing experience is closely related to age. Young players have an increased risk of injury at a given workload in spike. Older players are also at risk. I've noticed with players in the middle of their career they just tend to string a whole heap of training sessions and games together, they never seem to get injured. It's almost like a perfect age to be playing football With younger players, these individuals are susceptible to bone stress injuries. In older athletes, we tend to see more joint and potentially muscle injuries. Now that we've discussed a number of different moderators of the workload-injury relationship, it is clear to see that the ACWR should not be interpreted in isolation! As a practitioner, if you identify a spike in acute:chronic workload ratio, interpret this data in combination with the chronic load. It is also advisable to identify the relevant moderators of the workload—injury relationship; age, training history (i.e. chronic load), injury history, aerobic fitness, and lower body strength.

Let me provide an example of two players who have both had a rapid spike in workload. If player A is not "too young" or "too old", has a short injury history, and good training history, and well-developed aerobic fitness and

lower-body strength, these are five moderators that can work in that athlete's favor.

On the other hand, let's take a second player (player B) who has also been exposed to a spike in workload. Unlike player A, this player is young (or old), has had a lot of recent injuries, and because he has all of these injuries has not been able to perform consistent training. Because of his low training loads, his aerobic fitness and strength are poorly developed. In this case, we have five moderators working against that player. It is likely that the way he is managed his different from the player with five moderators that protect against injury.

Figure 10: Interaction between biomechanical and physiological load



Source: Vanrenterghem, Nedergaard, Robinson, Drust, 2017. p.2136.

The majority of studies have focused on the physiological aspects of workload monitoring, but of course, athlete monitoring involves more than physiology – we also can study biomechanical 'loads'. External loads from a biomechanical viewpoint relates to whole body loads, accelerations, decelerations, changes in load or body load. Internal load can also be assessed by measuring joint and muscle loads. When the load that we apply

on a tissue exceeds the capacity of that tissue to handle the load, it results in a breakdown of the tissue (e.g. a tendon rupture, a muscle strain, or a meniscal tear). If the load is great enough that it exceeds the capacity of the tissue to adapt then it can also result in breakdown of other tissues as well (e.g. a bone a fracture).

It is important to consider that biomechanical deficiencies may influence the ability of an athlete to tolerate load.

The other thing to keep in mind with training is every time we train, we are training the body, and we know that. But we are not actually training players to look good in the mirror, every time we train, we are training the brain. And if you don't consider the brain in the training that you do then, is sort of a mindless conditioning. Yes, we are getting them fit but we are not actually working on the things that they need to work on.

When athletes perform several high performance plays during games (repeated effort bouts) it does not happen by accident. We actually have to create situations for players where they learn how to handle those situations. With physically demanding activities, it's not only the body that has to cope with them. At any point of the task athlete could say, this is too hard I'll opt out. Nevertheless, we are training the brain to go to those places and accept the fact that it might hurt a little bit, but it's going to worth the effort.

We are in the moments and memories' games, so as coaches, as medical staff, as fitness coaches, we are trying to create moments for our players. So when things go hard during competition they can find inside themselves something that they didn't realize they had. As coaches we have to help them when we expose them to that moment, we've got to help them to try and win that moment so that they becomes memory. The more often we can expose them to that moment with enough recovery of course, the more likely it is that it'll become a memory.

So that when athletes go into a game and they have to go through a hard situation, and they try to fight their way out of it that they've actually been there before. They know exactly what it's like, they don't have to panic.

So, this is a quote that I borrowed from Dr. Seuss: "Sometimes you don't know the value of a moment until it becomes a memory". That's what our game is about, moments and memories.

4.1 Pain and Injury are Not the Same!

Pain does not mean that injury has occurred. Sensations of pain can arise for multiple reasons other than tissue damage. In addition, fatigue does not always mean that a catastrophic event (e.g. injury) will occur. In the following section, I will discuss the similarities in the way athletes process pain and fatigue.

Figure 11: Parallels between the interpretation of pain and fatigue

Source: O'Sullivan, O'Sullivan, Gabbett, 2017. p. 1.

Pain can be a physical sensation but it can also arise from biopsychosocial sources. Similarly, fatigue may not always occur as a result of physiological limitations. On occasions we see athletes with well-developed physical qualities that still fatigue quickly in training or competition. In these cases, it is unlikely that the fatigue is arising from physical sources. Figure 11 demonstrates 3 different pathways to interpreting – and more importantly,

understanding pain. Let's say we have an athlete who has pain sensations, and our belief is that pain indicates damage to the body. Our response is a fear-driven avoidance of those sensations.

When we have that fear-driven response, we reduce training loads, because our belief is that if we don't reduce training loads, our vulnerable athlete will 'break'. In this example, the consequence is that the athlete has a reduction in physiological and psychological resilience, and are left vulnerable and/or deconditioned.

When you have that fear-driven response, you back off training. You wrap your players in cotton wool or you shut them down completely. You don't want them to experience that sensation, and the mentality is that if you don't back off training your vulnerable athlete would break. Nevertheless the consequence of that is, you end up with a situation where the athlete has a reduction in physiological and psychological resilience. They are left vulnerable and his ability deconditioned.

There is also another way of interpreting pain and fatigue. Our second example (far right of the figure) can involve a practitioner who believes that those sensations of pain or fatigue are signs of physical or psychological weakness. He then ignores those sensations and punishes the athlete, with harder training. The consequence is an exacerbation of those sensations or the athlete sustains an injury.

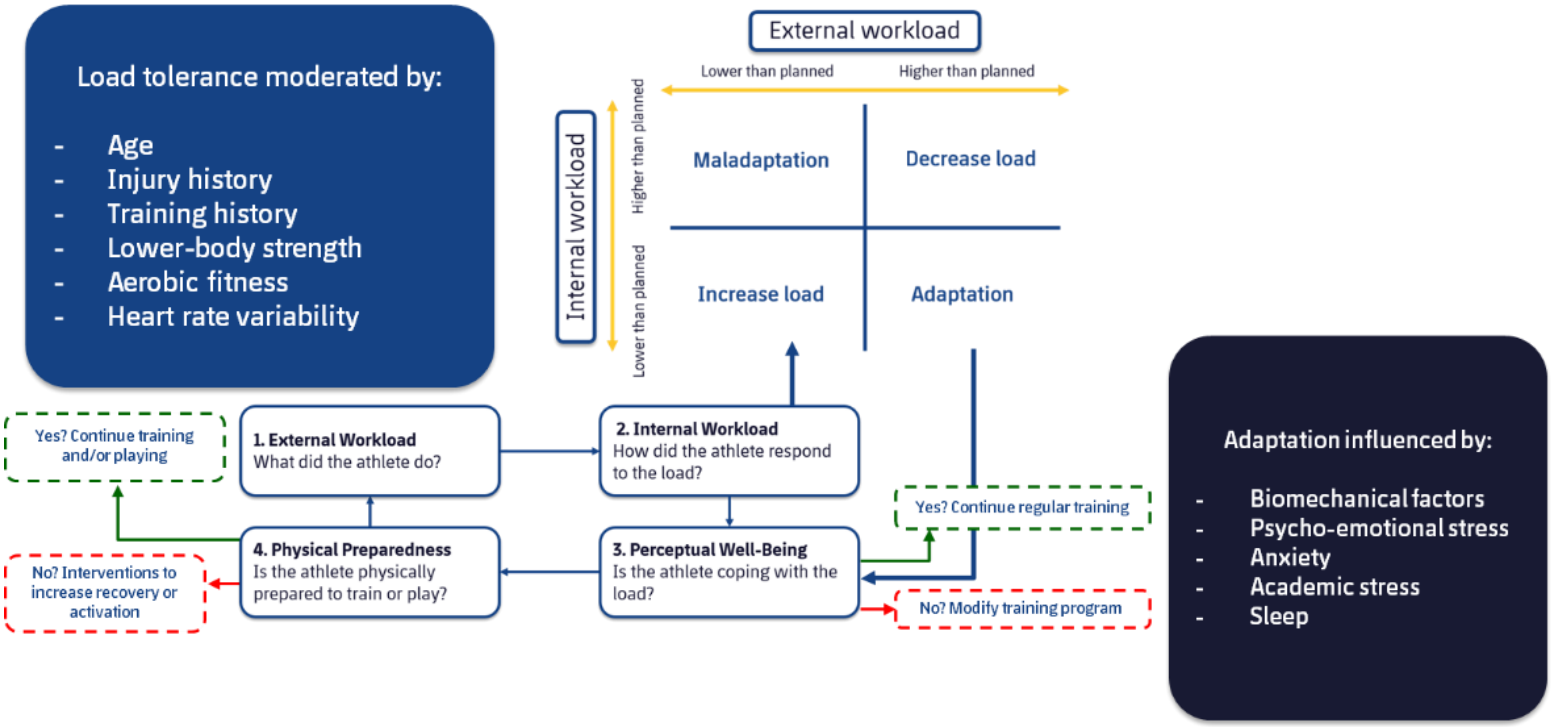
However, there is a third and final pathway that we can use to interpret this pain and fatigue sensations. When we choose the middle pathway we give our athletes the best chance of success. Pain could be due to tissue damage but there could be multiple of other reasons why our athletes are experiencing these sensations. The response involves identifying the factors responsible for those sensations. Pain does not always arise from tissue damage. Furthermore, rapid fatigue experienced by a very fit athlete, has to be driven by factors other than simply physical. In this example, educating the athlete is the way to follow through. We can adjust the program to maintain the maximum training load that the athlete can tolerate. Physical and psychological resilience is enhanced, resulting in athlete who is ready to contribute to the team.

The key point is that pain and fatigue are not simply physical issues - there are also psychological and social factors, and all of these lifestyle stresses can contribute to an athlete's ability to tolerate load.

4.2 The athlete monitoring cycle

Athlete monitoring is not just about "load". Figure 12 shows the process of applying load (i.e. applying external workload). We then need to examine the internal response to that load (e.g. perception of effort, blood lactate concentration or heart rate). An athlete's ability to tolerate load is influenced by external stresses. We can capture the effect of these external stresses through perception wellbeing questionnaires - "is the athlete coping with the load?" Finally, we can perform physical readiness tests (e.g. countermovement jump tests, Wattbike tests, or heart rate variability). These 4 steps completes the athlete monitoring cycle.

Figure 12: Relationship between workload, perceptual well-being and physical preparedness.



Source: Gabbett 2018.p.6

If you don't have expensive equipment to monitor physical readiness it's ok, you can actually go through the first three steps, and still monitor your athlete well. If you don't have expensive equipment, you don't have GPS and micro sensors then you can still monitor your athletes, you can get internal workload and wellbeing just from pen and paper.

What I do next is combined pieces of information. I've never interpreted any piece of information on its own, I always tried and take at least two bits of information. I combined external and internal workload to try to make conclusions. That allows me to find out whether my athlete needs decreases or increases in load, whether they are maladapting or whether they are adapting to the training.

Once you have the load information you look at wellbeing and if the wellbeing is good, even if the training load is high, you continue regular training. However if wellbeing is poor then you modify the training program. This doesn't mean stop training all together, it means, let's see if we can keep loading, but using a physical demand that they can tolerate.

When we look at our physical readiness test, if the results say they are in good shape, then just continue training and playing. If not, you just combine this data, to either work out whether they need extra activation to get them ready to train. They might nead extra recovery just to get them away from training, before they come back and train again. So, this is your athlete monitoring cycle and this allows you to join up the pieces of information that you collect on your athletes.

Let's say you've got a player who believes that when he trains hard he breaks. So, he comes to you and that's going to impact the type of training you can do. You have to work with his beliefs. Firstly to try to adjust that belief. Maybe it wasn't that he trained hard, t was that he was training inappropriately. Maybe he's had a big injury history or there's some things that you don't know about that. So when the medical reviews come up maybe you can try and get some of these moderators. You can test some of the moderators a little bit to see whether it's likely to handle load.

Does change in teams increase or decrease your risk? And does going up and down from first team to second team, within the same club increase your risk? I think you would look at the injury risk of players who have been in the same club for a long period, and then what's the injury risk of the players that are coming in their first year. Do they have higher risks? If they've been here two years, does that risk reduces? If they've been here three years, does it reduce further? So, that's one question and then you can do the exact same design but moving from first team to second team, second team to first team, you could say: does going down from first to second, does that change the

risk? Does going up change the risk? You can almost go, if I'm changing 15 times in a year does that increase risks more than if I'm going to change it five times.

What happens when you don't have your best players available, and therefore you can't perform as well. so you lose or do you stay injury free and win games and the more you win the better you play so the better you perform, the fitter you are.

I've talked about like a concentric and eccentric football and it's easy to, it's probably easier to see it from a rugby or a handball point of view with these collisions. So, in rugby, when you are playing concentrically, when you are rolling over the top of teams, you never seem to get injured. But when you are playing eccentrically when teams are rolling over the top and you are getting bend back, you lose and you always seem to get injured.

In FC Barceona have two experiences. When the load is normal and everybody wins, the injury is lower down. Nevertheless in basketball the data after many seasons, says that when the team wins, the team train more and that's why they injure more. There's no standard that says that when you win more you have less injuries. Because if you win more you go further during the tournaments, and then you have to train more. Therefore you have to compete more, so you are going to get more injured.

You can use different load, you can have analyzers, load analyzers but you cannot analyze performance, you cannot load performance. In basketball is easier than in soccer because you have the performance index of the players given in stat. But in soccer you cannot do that so you have to develop a way and the experience is that when you win in football the same load less injuries, and in basketball more wins, more injuries.

Nevertheless, you can have one good season when everybody is healthy and you win everything like first Pep Guardiola season. But in basketball the data we are talking about took 9 years on a roll, where they got the results, when you win more, you get injured more.

When young people come to the FC Barcelona, during to their adaptation to the Barca system, they tend to injure, because they are more immature. In a training way, in their training history, most of them have suffered big injuries on their adaptation process to the club.

Also a player can change inside the same club, change teams, you know he goes from Junior team to the first team that load improvement or decrease will necessarily interact with his performance and his injury risk.

What is the best way to load during off-season when you don't have the same monitoring data of the player? When players go away for five weeks, if they haven't done anything they'll risk. In international breaks or if they go away in off-season if we usually monitor GPS, you don't let players take GPS away.

In order to minimize the risk when they return following off-season break, they need to be doing something but, so we can give them programs to go away with, but we also need to give them some education around the importance of doing the training program. Even the best training programs will not save you if it never is taken out of their bag. And you don't necessarily want them to be training at a high levels, like they normally train at. But if you say to them, let's only do half of what you normally do, if you say that then there's a certain risk that would come with that, but it will be much lower risk if they don't do anything.

The biggest problem we have got in sport with injury is when players come back from off-season break, with returning players from injury. So, whenever we want to put together a program, we need three factors, we need to know the time we've got, we need to know the starting point and we need to know what the end point is.

So, let's look at the end point, when you bring a player back for day one of pre-season you have a program emplaced that with the time frame you've got, this is the minimum starting point they need to be at with that amount of time to get to this level for the first game of the season. Now, if instead of coming back at this level, they come back at a lower, you can't change the time unless you extend it out because the demands aren't changing, they're always going to be high. So, it's going to be a much deeper increase. So, you've got one of two options, you can't change the demands of the game, they are what they are. So you can either increase time, so take longer to get them fit, which the coach may not be too happy about. Or raise the starting point and the way you raise the starting point is through them, doing the program when they go away.

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