Can we think about training loads differently?

Executive Summary, 21 December 2015

Background

Most high performance coaches would agree that optimal athletic performance requires adequate quality preparation as well as athletes remaining injury and illness free. Renewed scientific enquiry is providing a clearer understanding of the link between preparation (training), injury and success.

Can training loads protect or lead to injury?

Training loads have the potential to **protect** from or **increase risk** of injury/illness in athletes.[1, 2] Both low and high training loads are associated with increased likelihood of injury when compared to moderate chronic loads, which can protect athletes from injury.[3]

What might we need to know about 'training load errors'?

Training load errors are known to expose athletes to increased risk of injury.[4] It is acknowledged that errors might occur as the boundaries are pushed to reach peak athletic performance. Acceptance of some risk is part of high performance sport. However, athletes can avoid known training load errors associated with injury risk such as under-loading or over-loading. For more detail regarding known training load errors, please refer to the attached document.

What might we need to know about injuries and illnesses, and their relationship to performance and success?

Most coaches acknowledge that injuries or illnesses are detrimental to performance. Evidence links a lack of injury and illness to athletic success[5] and links increased injury burden to sporting failure.[6-8]

What are the key principles of training load management to reduce the risk of injury and illness?

1. **Establish moderate chronic training loads and ensure these are maintained**

Moderate to high training loads protect from injury if achieved in a safe manner.[2, 3, 9-11]

2. **Be aware that injuries can be latent following increased training loads**

Injury risk may be elevated for up to four weeks after an acute spike in training load.[10]

3. **Minimise large week-to-week fluctuations**

Large changes (acute spikes) in training load increase injury risk for up to one month after the spike.[2, 12]

4. **Establish a floor and ceiling of safety**

Establishing a floor (minimum training load) ensures that minimum training standards are achieved and risk of injury is reduced. Establishing a ceiling (maximum training load) ensures that risk of injury is reduced.

5. **Ensure training loads are appropriate for your athlete and their current situation**

In team sports it has been shown that younger athletes are less able to tolerate high training loads,[10, 13] and require longer periods to achieve these loads safely. Training load prescriptions must consider athlete age, skeletal maturity and training history.[13, 14]

The appropriate management of athlete training load is recommended as a crucial step to optimise performance by increasing an athlete's ability to train uninterrupted.

Can we think about training loads differently?

Version 1, 21 December 2015

Introduction

Coaches in the modern high performance environment face a variety of solutions to performance issues. One way of looking at this dynamic is to view the coach as an artist whose colour palette is the different scientific and clinical disciplines available to them. The more extensive the colour palette, the more vibrant a picture the artist can paint.

This document provides some detail of an approach to training load management using renewed and emerging information to help keep our athletes healthy and prepared for competition success. The focus of this document is on how training loads relate to injuries, illnesses and performance. In proposing this approach, we acknowledge the complex interactions between many other factors that contribute to injury, illness and performance. We wish to work with coaches to create an environment whereby athletes have the greatest probability of reaching their performance goals. We seek feedback from the high performance coaching community as to the effectiveness of this approach.

Background

In our experience, most coaches agree there are fundamental elements to achieving optimal sporting performance and success. First, an athlete must complete an adequate amount of quality preparation. Second, an athlete must be able to undertake this preparation unimpeded by injury and illness. Ongoing scientific enquiry is now providing a better understanding of the link between these fundamental elements, however we acknowledge that high performance coaches have recognised these principles for years. The association between training loads and injury incidence has been established in a number of sports and is considered a risk factor for injury.[1, 15] Furthermore, injury and illness affect both team and individual sporting success.[5, 6, 16]

While high performance coaches have understood these issues for many years, they might not have had all the tools for acquiring information to create solutions. In the past, coaches may have made decisions based on intuition or ad-hoc information. However, in light of the published scientific literature, supported by data from the AIS Athlete Management System (AMS), we are now able to offer support to coaches in their decision-making processes.

Can training loads protect or lead to injury?

Training loads have the potential to **protect** an athlete from injury, and to **increase risk** of injury.[1, 2] The level of training *already undertaken* is an important consideration in determining whether an athlete is at risk or protected.

There is a 'U-shaped' relationship between historical training loads and risk of injury (Figure 1). Both low and high training loads are associated with increased likelihood of injury when compared to moderate training load achieved across a month. This region is represented by the bottom of the U where a zone of training loads actually provides the athlete with protection from injury.[3] It is important to understand the athlete's ability to achieve large week-to-week changes safely is reduced when an athlete is in a moderate to high load zone.

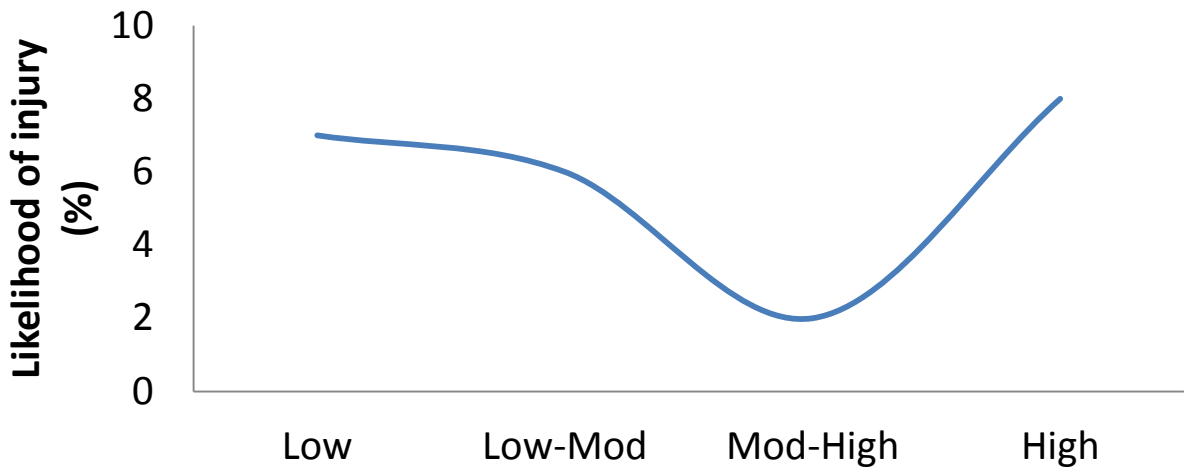


Figure 1: Moderate levels of training are associated with the lowest risk of injury. Moving into the high or low training zones increases the risk of injury (adapted from Cross et al, 2015).[3]

What might we need to know about 'training load errors'?

While unforeseen errors may pose an opportunity to learn, training load errors expose athletes to an increased risk of injury.[4] For example, in basketball an error may be a turnover in possession. This can occur for various reasons and may not be the fault of the player.[17] A mistake would then be to not defend the turnover.[17] In the case of training loads, errors will occur as the boundaries are pushed to reach peak athletic performance and accepting the risk of these errors occurring is a part of high performance sport. The mistake would be not to adjust training load prescription in light of the known risks. Training load errors, caused by lack of good information, typically follow periods of **under-loading** or **over-loading**.

Under-loading presents in two common forms:

1. An athlete has not completed sufficient training to meet the current training and/or competition demands. In this instance, an athlete's chronic training load (or training base) is not enough to protect them from injury. This leads to a spike in training load.
2. An athlete has undergone a period of tapering, rehabilitation or programmed rest (holidays) and then resumed training at a level greater than their capacity to safely undertake the planned training load. This is the 'too much, too soon' phenomenon.

Both these scenarios demonstrate an acute increase (or spike) in training and the absolute load exceeded the athlete's current capacity.[18] 'Overuse injury' has been the common diagnosis for injuries occurring as a result, however when placed in the context of the complete training history these incidences can now be attributed to low chronic training[4] loads or high acute training loads.

Over-loading presents in two common forms**:**

1. An athlete combines large spikes in workloads with already high chronic workloads.[2, 19] For example during camps[20] and intensified training weeks sometimes labelled 'shock weeks' in many sports. With the available data, caution is recommended when planning these high-risk activity periods to ensure that these planned training loads are achieved safely. This is particularly important if contemplating a camp or high-intensity training after any planned rest, such as Christmas, competition and tapering periods.

2. An athlete substantially increases training load from one week to the next. This is associated with increased injury risk in the following week.[1, 2, 15, 19, 21-23] Additionally, this phenomena may be sustained for up to a month[10] and this is referred to as a **latent period**. The latent period occurs in other scenarios as well, such as sitting next to someone on a plane that is sick; whereby the athlete may develop symptoms days later, as opposed to during the flight. This concept is discussed further in a later section.

As a real-world example, we now know that planning training loads during camps and heavy competition must account for both the athlete's recent training history (chronic load) and the magnitude of change expected in the next week. Therefore, we can provide coaches with three options for safely achieving the requisite training load:

1. Perform less during the camp/competition period (we acknowledge this is not always feasible).
2. Perform more training in the lead-up to the camp.
3. A combination of both the above.

What might we need to know about injuries and illnesses, and their relationship to performance and success?

Most coaches acknowledge that injuries or illnesses are detrimental to performance. Evidence links injury and illness to athletic success[5] and failure.[6-8] A lower injury burden resulting in increased player availability for matches has been associated with higher team success in soccer,[6] basketball,[7] and rugby union.[8] For track and field, injury or illness sustained in the six months preceding competition resulted in substantially reduced likelihood of achieving performance goals.[5] Conversely, athletes who completed more than 80 per cent of their planned training weeks were greater than seven times more likely to achieve their season goal. This explained 86 per cent of the successful seasons.[5]

<u>The appropriate management of athlete training load is recommended as a crucial step to optimising performance by increasing an athlete's ability to train uninterrupted.</u>

How do we engage around load management in rehabilitation?

Injuries come in packages. Emerging data highlights that an athlete is likely to sustain more than one injury or illness in a period.[5, 24-28] Once an athlete sustains a second injury in the preparation period, their chance of reaching their individual goal is reduced by 68 per cent in athletics.[5] Careful planning of the progression back to full training and competition is required. Athletes should aim to re-establish training in a moderate chronic load as a priority as this will protect against further injury. Importantly, the way the athlete gets to this level will influence the risk of subsequent injury.[18, 29] It is recommended that cross training alternatives are utilised to maintain activity levels while respecting the stage of tissue pathology healing. We believe that the coach and athlete's beliefs and experiences are imperative to the process and suggest that the coach and athlete should design the initial rehabilitation programme, followed by consultation with sports medicine and sports science staff with a strong understanding of the athlete's ability to achieve the planned training loads. This collaboration may enable initial and ongoing feedback based on early warning signs, which can be utilised to lower the risk of further injuries or illnesses.

The language of load

What is training load?

Load is a broad term describing the total volume, intensity and type of physical activity an athlete undertakes during both training and competition.[2, 30] We acknowledge that may be a simplistic view of training loads and there are many potential ways of quantifying this. The definitions used in this document have been utilised in published studies of training load and the relationship to injury and illness.

'Training load' is broadly separated into two categories: external and internal. These are detailed below, along with other relevant load-related concepts. It is important to understand how each of these might affect an athlete in a particular sport in order to monitor and manage load effectively. To be precise in prescriptions of training loads, a minimum of 28 days of data is recommended. Longer history of training load will assist planning around heavy training blocks such as camps and congested fixtures, which are known to be associated with increased injury incidence and severity.[16, 20, 31]

What are the methods of quantifying training load?

External load

This describes the work performed by an athlete that is quantified externally.[32] For example, the distance covered by a runner, the number of pitches thrown in baseball, gymnastics routines performed, or the number of jumps a volleyball athlete undertakes. This might also include knowledge of the duration, intensity and other available metrics.

Internal load

This describes measurements of the athlete's perception of effort for a given external stress.[32] The most common method of quantifying internal load is a rating of perceived exertion (RPE) or heart rate response to a stimulus (the training impulse score, TRIMP). Internal load measurements should include both exposure (for example, distance or time) and the athlete's effort (perceived or measured). The most commonly applied measure for this is multiplication of activity duration and sessional RPE.[33] Internal load quantification should include all activities that the athlete completes, not only sport-specific skill training. For example, capturing cross training and strength training sessions as well as sport-specific sessions will provide a more complete picture of the athlete's load.

Total load

It is important to quantify the entire workload an athlete performs by measuring both internal and external loads relevant to their sport, as each quantifies different parameters.[34] Partial capture of workload may lead to only partial quantification of injury risk.[19] Internal loads may be the only feasible method of total load in many sports.

Absolute and relative load

Absolute training load is the total of all training sessions performed within a specified period, such as a single day or one week. When this is totalled across a seven-day period, it is referred to as 'acute training load'.[2, 19] Both low and very high acute training loads have been associated with increased risk of injury in Australian football, rugby union and baseball.[3, 35, 36] However, moderate-to-high workloads can protect against injury.[2, 3, 11] Relative training load is the change in training load over a specified time frame relative to historical training load. This is expressed as a percentage, such as change from week-to-week or week-to-month. A widely accepted method of quantifying this is 'training stress balance' (TSB).[30, 37] This has now been renamed in the scientific literature as the 'acute to chronic workload ratio' (ACWR)[2] which indicates exactly what is being described: the ratio of the most recent week (acute load) and average of the previous four weeks (chronic load).[2, 19] It is important to quantify absolute and relative training load as together they determine both athlete capacity and injury risk.[2]

Are there steps to establishing a load-monitoring programme for injury and illness prevention?

What are the training and competition demands?

Establishing the training and competition demands over a season or multiple seasons of competition is already an essential part of coaching strategy.

The competition demands should include average demands as well as 'worst-case scenarios'.

For example in the case of a basketball, netball or volleyball tournament this would entail the maximum number of games required should the team progress to the final. This may be a series of eight games over a five-day or a two-week period.

Establish sport-appropriate measures of load

Include relevant measures of both internal and external load. For example:

Internal load:

Duration x RPE

External load:

Volleyball = number of landing impacts

Baseball = pitches thrown

Cricket = balls bowled

Swimming = distance (m)

Gymnastics = number of routines performed

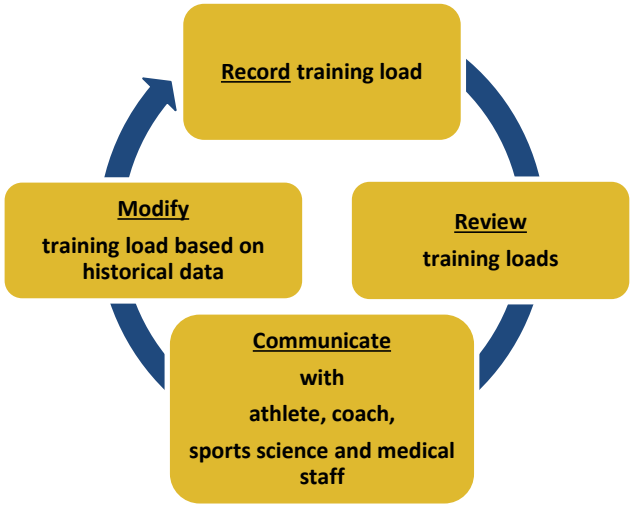
Establish a surveillance programme

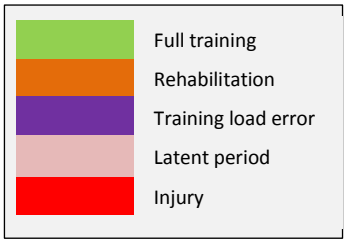
A surveillance program will regularly and consistently monitor the established load measures alongside injury/illness and performance data.

Consistency is very important as days of missing training load information leads to an inaccurate representation of risk/safety.

Ideally, before making definitive conclusions and recommendations regarding load-management strategies at least **one month** of consecutive daily load data should be collected.

Once a load-monitoring strategy is established, the following should occur:



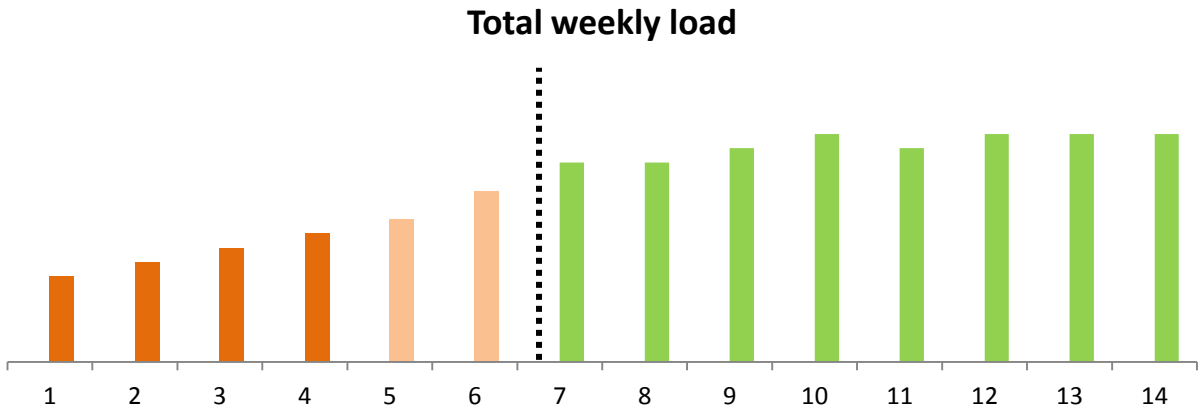


Key principles of load management:

1. Establish moderate chronic training loads and ensure these are maintained

Why?
Moderate to high training loads protect from injury if achieved in a safe manner. [2, 3, 9-11]

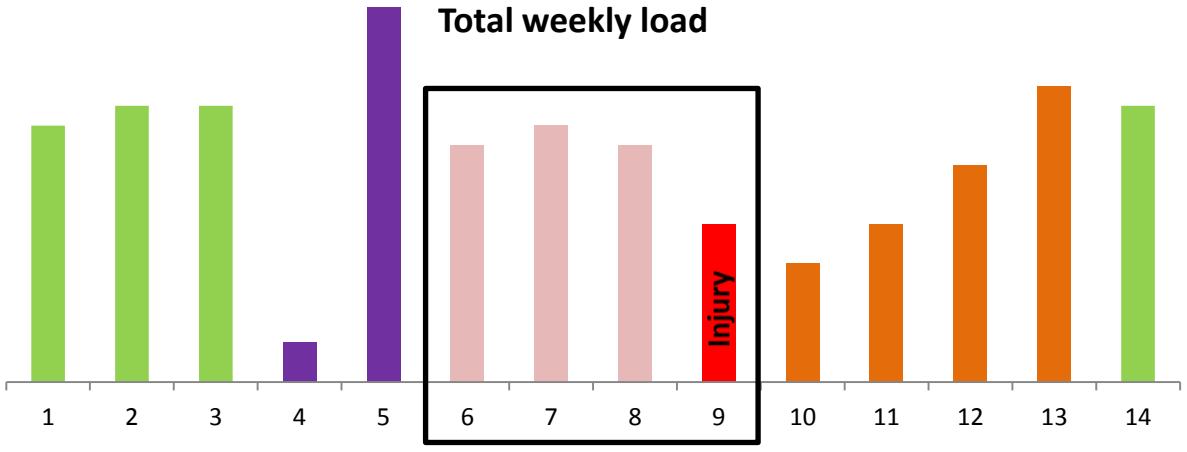
The second half of the graph below is a good example of an athlete maintaining a moderate to high training load from weeks 7-14 (green bars). There is a linear pattern in weeks 1-6 to increase the volume of load safely and may represent situations such as an athlete returning from injury or a planned rest (such as a holiday). More information can be found on the 'Prescription of training load in relation to loading and unloading phases of training' document[29] and other resources at the end of this document.



2. Be aware that injuries can occur up to one month later

Why?
Injury risk may be elevated for up to four weeks after an acute spike in training load, in a latent period.[10] Generally speaking muscle injuries occur one to two weeks after training load errors, [15, 35] for tendons within three weeks [10] and bone between three and four weeks.[10]

This means we must be aware of what athletes have completed in the previous four weeks and the likely outcome in the subsequent four-week period. The purple bars below depict a large week-to-week change. The boxed region represents the period after this training load error where injury risk is heightened (latent period). The red bar represents injury. The orange bars represent rehabilitation and return to training following injury.



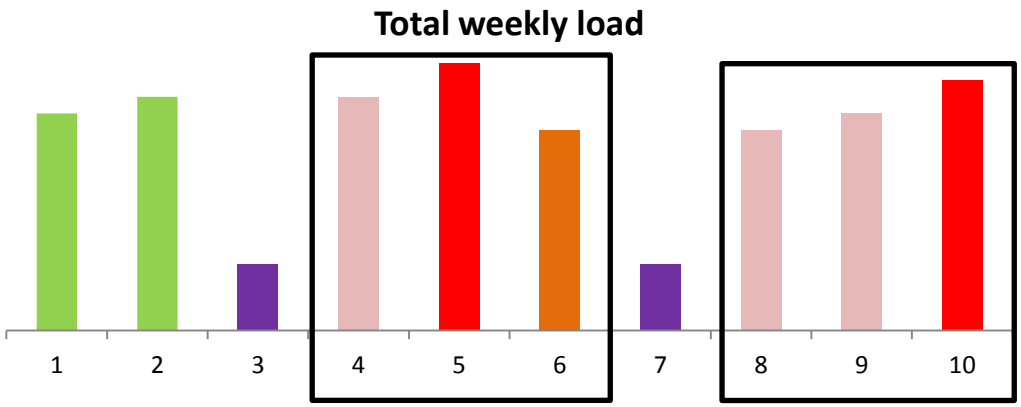
3. Minimise large week-to-week fluctuations

Why?

Large changes (acute spikes) in training load increase injury risk for up to one month after the spike.[2, 12] Three situations highlighting this principle are described below.

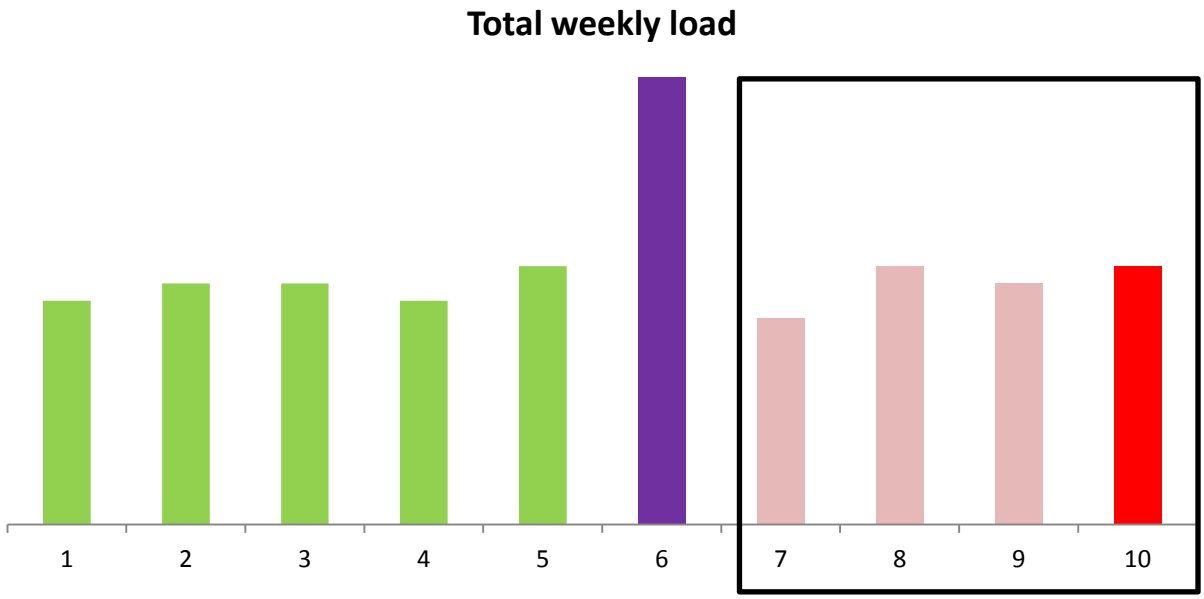
Situation 1:

Recovery weeks are important, however if the recovery week training load is too low (purple bars) it may expose the athlete to increased risk of injury on returning to normal training (pink bars).[15]

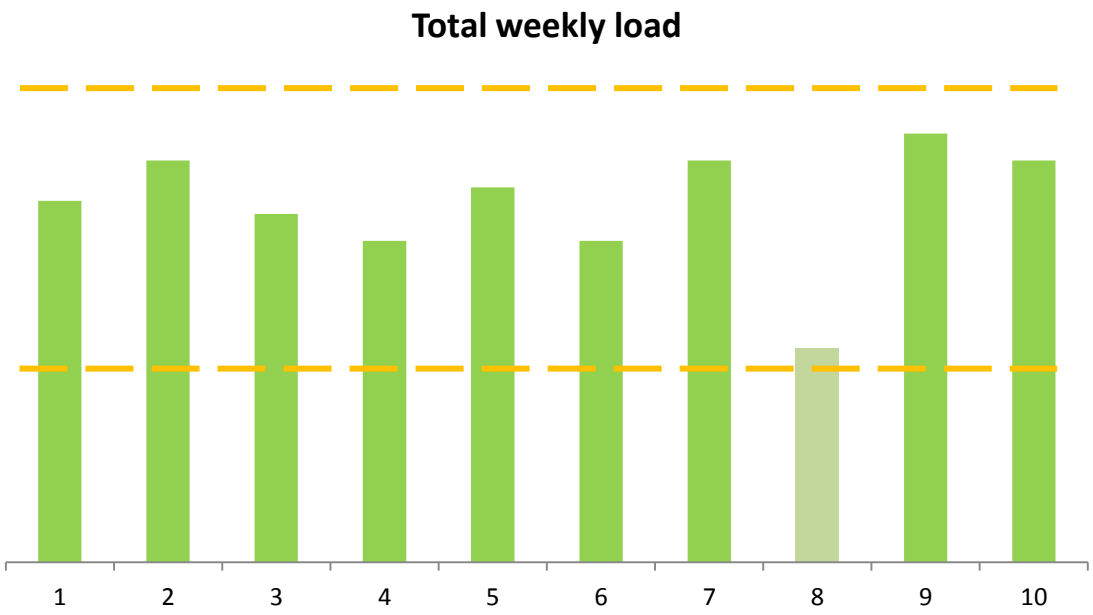


Situation 2:

If an athlete is already performing moderate to high training loads (green bars), a large spike in load (purple bar) presents a substantial risk for injury (red bar).



Situation 3:
If an athlete is performing moderate to high loads (green bars) they are protected from injury in the case of safe fluctuations in training load for events such as recovery weeks and holidays (light green bar).[2]

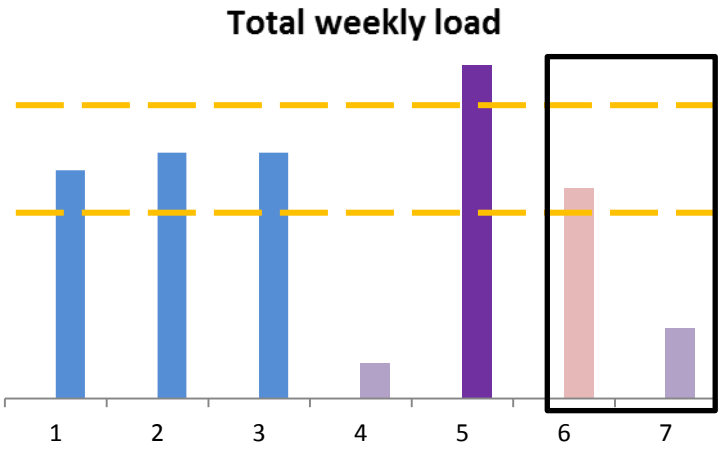


4. Establish a floor and ceiling of safety

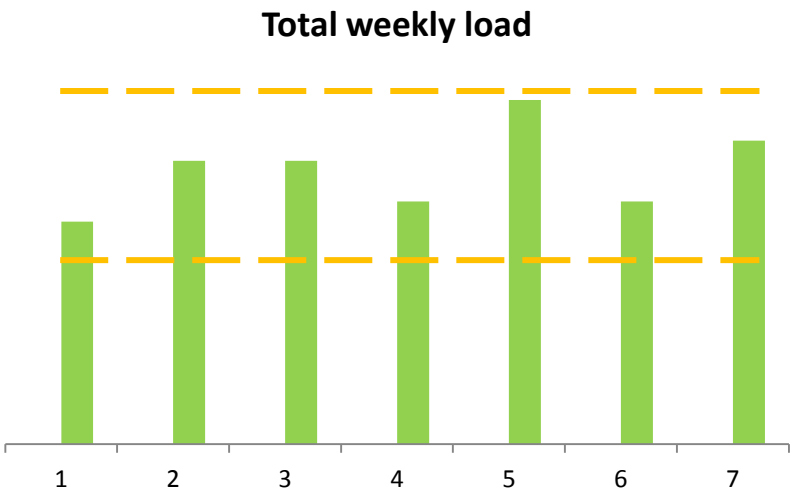
Why?
Establishing a floor (minimum training load) ensures the achievement of minimum training standards and reduced risk of injury. Establishing a ceiling (maximum training load) also reduces risk of injury. Please note that these are specific to each sport[10, 15, 35, 38] and to each athlete within the sport. The ceiling may be raised gradually over time.

The orange dotted lines on the two graphs below depict a low risk floor and ceiling for an athlete.

The graph below demonstrates high variation of training loads that are above and below the floor (light purple) and ceiling (dark purple bars).



The graph below depicts consistent training loads (green bars) within safe limits (orange dotted lines).



Note: variation in training loads from week-to-week is important. However, the magnitude of variation is what is important when determining injury and illness risks.[2] There is no evidence to support or refute 10 per cent weekly increases in training load for athletes.[39]

5. Ensure applied training loads are appropriate for your athlete and their current situation

Why?

In team sports it has been shown that younger athletes are less able to tolerate high training loads,[10, 13] and require longer periods to achieve these loads safely. Training load prescriptions must consider athlete age, skeletal maturity and training history.[13, 14]

Summary

This document aims to provide a summary of the key concepts and principles of load monitoring, load management and explain how these activities might be integrated into an athlete's training and competition plan. This is to reduce the risk of injury and illness and subsequently improve performance outcomes. We welcome feedback, particularly regarding providing improved ways to describe concepts of training load. We wish to collaborate further with the coaching community to achieve a mutual understanding of the challenges of keeping athletes healthy and performing at the highest level. We encourage you to discuss the concepts among your colleagues and to decide whether the suggested approach is appropriate for your sport and athletes.

When designing a load-monitoring strategy for athletes, consider sport-specific measures of both internal and external load. Ideally, these would be monitored throughout an athlete's training and competition period to support you in the planning process.

Implementing load-management strategies may help avoid injuries and illnesses. These strategies include:

1. Establishing and maintaining adequate training loads.
2. Avoiding (large) acute spikes and troughs in load.
3. Heightened awareness of latent periods following any increase or decrease in load.

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The document has been peer reviewed internally by Dr David Hughes (AIS Chief Medical Officer), Dr Philo Saunders (AIS Physiology), Jamie Youngson (AIS Strength and Conditioning), Matt Lyon (Coaching and Leadership), Dr Dale Chapman (AIS Physiology), Dr Wayne Spratford (AIS Biomechanics), Dr Marc Portus (AIS Movement Science), Dr Tony Rice (AIS Physiology), Tim Kelly (AIS Performance Innovation and Science), and Professor David Pyne (AIS Physiology).

Recommended reading and further information:

Presentations:

'Load, Injury and Success: Current Directions from the AIS Physical Therapies Department', 2014, World Class to World's Best – Ben Raysmith and Phil Cossens

'Load Management – What is the evidence?' 2015, Athlete Management System Symposium – Mick Drew

'Injury Prevention in Pre-elite Athletes', Winning Pathways Conference, 2015, Mick Drew

'Prescription of training load in relation to loading and unloading phases of training', 2015, David Hughes, Craig Purdam and Dale Chapman

Documents:

'Prescription of training load in relation to loading and unloading phases of training'

Journal articles:

Halson SL. Monitoring training load to understand fatigue in athletes. *Sports Med.* 2014; 44(2):139-147.

Saw AE, Main LC, Gastin PB. Monitoring the athlete training response: subjective self-reported measures trump commonly used objective measures: a systematic review. *Br. J. Sports Med.* 2015.

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