Module 1. Weekly changes

1.1 Introduction to studying weekly changes

Human beings, and therefore athletes, adapt quickly. Training loads that differ from week to week cause changes in the body's homeostasis. Significant weekly changes appear to increase the athlete's probability of injury.

Based on existing studies, coaches and physical trainers must be aware that high loads increase injury risk (Gabbett, 2016), but that substantial modifications in the training load from microcycle to microcycle are also worth paying attention to (Cross, Williams, Trewartha, Kemp, & Stokes, 2016; Piggott, Newton, & McGuigan, 2009; Rogalski, Dawson, Heasman, & Gabbett, 2013).

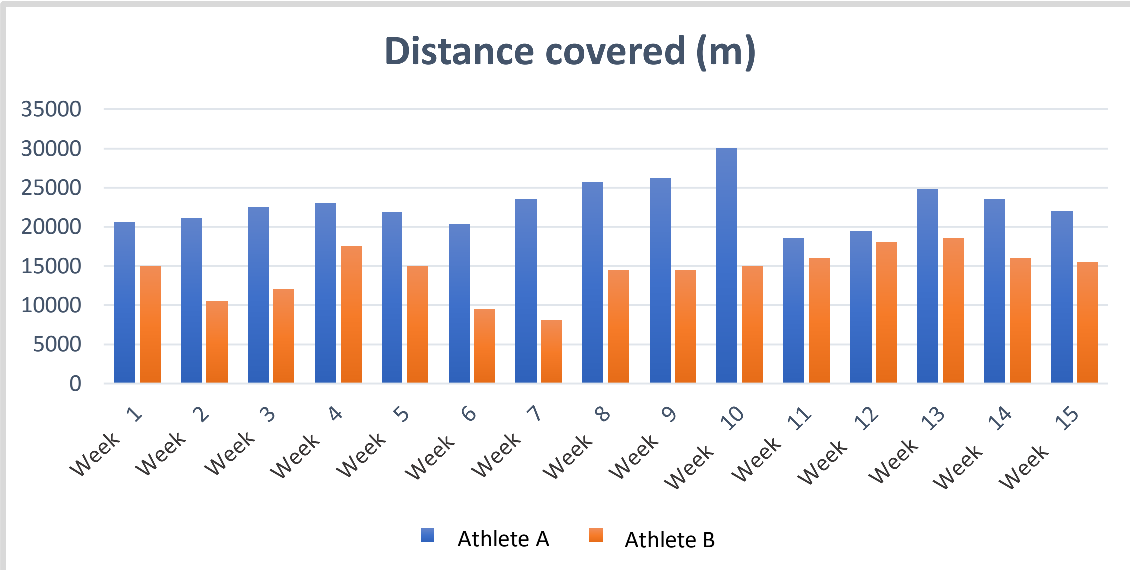
Recent literature (Gabbett, 2016) has discussed the need to not only quantify the load in absolute terms (or in time), but also to measure the percentage of change. When there is sufficient information about what the team is doing from week to week (or what was done in previous years), and what they usually do, a baseline can be established to then assess the % of change that the team is experiencing from week to week or over the established time period.

1.2 Procedures for calculating weekly changes

When evaluating making changes, there are several options. It all comes down to trying to measure how much change occurs in the player's load. For this, both the average training load from recent weeks (usually the last 3 or 4 weeks) and the base load (the load performed during the season, or earlier) can be compared with the current load, the microcycle load or that performed in a specific period (Coutts & Reaburn, 2008).

An example can be seen in Figure 1 which shows the distance covered weekly over 15 weeks for two specific players. It illustrates there is a certain amount of variation in the weekly loads.

Figure 1: Weekly distance covered by two players over 15 weeks of training



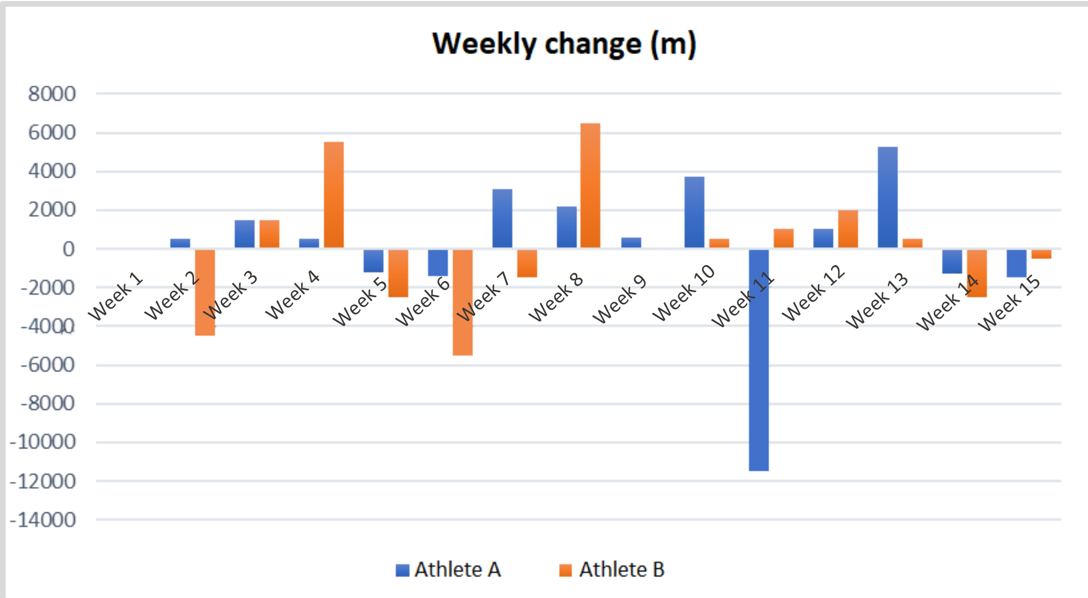
Source: Prepared by the author.

These same values will be used for the following calculations.

We will outline the different ways to study weekly change using the values from this example. The first approximation can be made by looking at the differences across the absolute values for the variable (in this specific case, meters covered weekly). The change will be calculated as the difference between the value obtained in the current week minus the value obtained in the previous week.

Weekly change in absolute values = current weekly load - previous weekly load.

Figure 2: Weekly change expressed in absolute values (distance covered in meters)



Source: Prepared by the author.

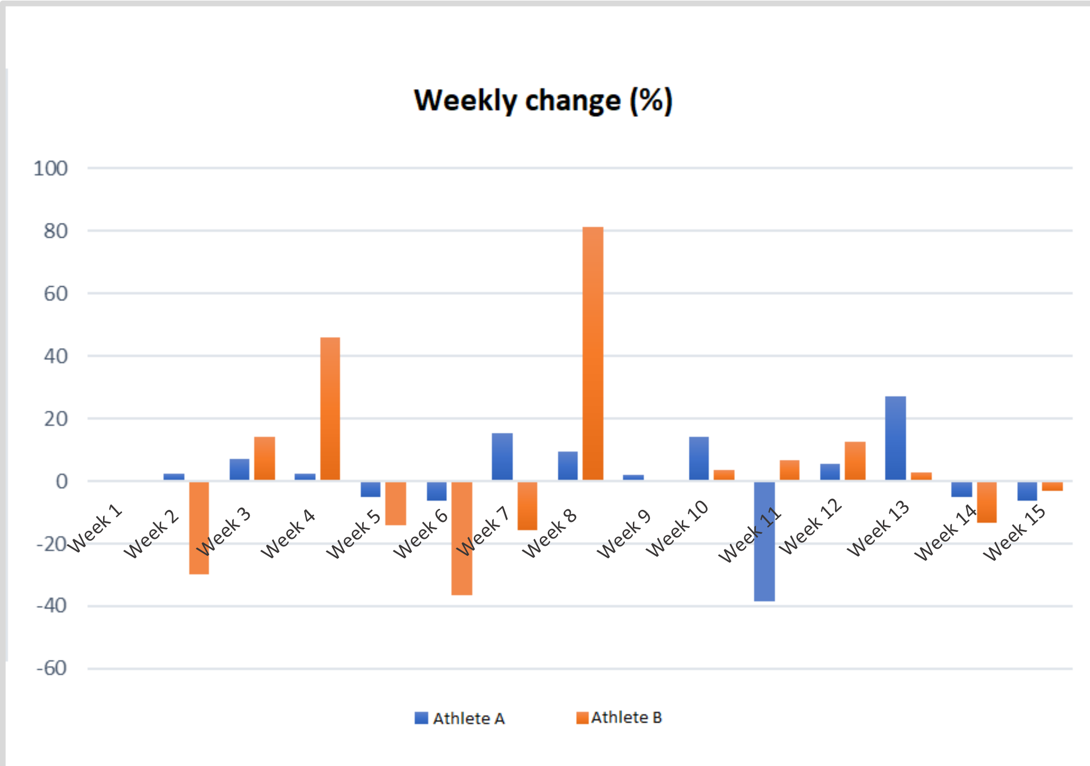
As can be seen with Athlete A, week 5, week 6, especially week 11 and also week 14 and 15 show negative values. In this case, the negative values mean that the load for the week being studied is lower than the load in the preceding weeks. Furthermore, using absolute values allows us to see exactly how many more meters or how many less meters the athlete covered compared to the previous week. We can see that Athlete A in week 10 covered 4,000 m more than in week 9, or that in week 13 the athlete covered 5 meters more than in week 12.

However, this method may not be valid for inter-player comparisons. If we have athletes who cover significantly different distances weekly, studying the differences in meters between weeks does not provide information that will help us manage training loads. For example, the change experienced by Athletes A and B are the same in week 3. In both cases, the athletes covered 1500 m more than the previous week. However, Athlete A covered 22,500 m in week 3 whilst Athlete B covered 12,000 m. So, is the change in load experienced by the athletes the same? Another hypothetical example helps us to understand the importance of making the changes relative. Athlete X covers 26,250 m in week 9, which is 550 m more than the distance covered in week 8. However, Athlete Y might usually only cover half that distance, making a change of 550 m significant for that athlete. Thus, if the distance traveled by the new athlete is 10,000 m in week 9 and 9500 m in week 8, his weekly change will only be 500 m. But does this mean then that the load change for Athlete Y is less than the change experienced by Athlete X?

The answer is no, and in order to study the magnitude of the changes in load between different athletes, it is necessary to relativize those changes. Thus, the % of change will be calculated using the formula:

Weekly change (%) = ((current weekly load - previous weekly load) / previous weekly load) * 100

Figure 3: Weekly change in the distance covered variable, expressed as a percentage (%)

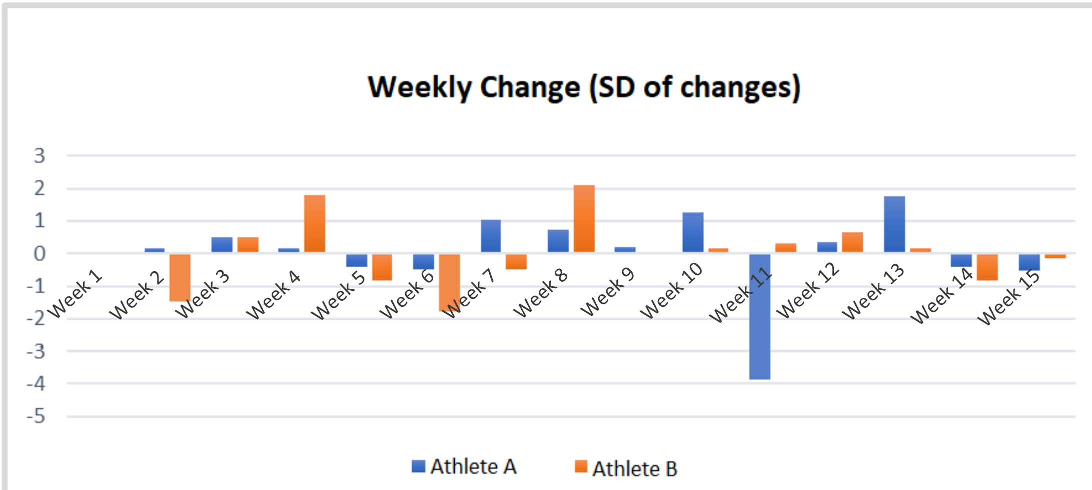


Source: Prepared by the author.

Continuing with the previous example, we can now see how week 3 shows a different change (%) between Athlete A and Athlete B. We could therefore conclude that percentage is the ideal method for studying and comparing weekly changes, however, using percentages does not take into account the variability of the measurements.

There are different statistical methods for studying change, taking into account the dispersion of the measurements. For all methods the objective is to measure how many deviations have changed. This is of particular interest when studying athletes with different levels of variability (for example, athletes with very stable or highly variable demands) or when studying change in very stable variables (such as distance covered) or variables with broad dispersion (e.g.: distance covered at high speed). A 15% weekly change can represent a significant change for a "very stable" athlete, while it may be within the normal limits for another athlete with more dispersion in their measurements. This also applies for the load variables. Accumulated data is needed to apply this type of calculation, therefore it cannot be applied immediately (or based on known dispersions, which would limits its application).

Figure 4: Weekly change in the distance covered variable expressed as a number of standard deviations for each athlete



Source: Prepared by the author.

In the example we have been using, for total distance covered, Athlete A has a standard deviation of 2,955.9 m, while Athlete B has a standard deviation of 3,079.1 m. In Figure 4 the weekly change is represented in relation to the number of standard deviations. Thus, we can observe how in week 8 Athlete A experienced a change of 9% while Athlete B experienced a change of more than 80% (Figure 3) – a change which is 9 times higher than that experienced by Athlete A. However, when these changes are expressed in relation to the deviations, the differences between the athletes decreases, since Athlete B has broader dispersion of load level. Thus, Athlete A increases by 0.7 deviations while Athlete B increases by 2.1 deviations, so the change experienced by Athlete B is only 3 times greater than that of Athlete A (Figure 4).

In addition, we can modify the reference points for the change. So far we have only looked at change by comparing the current week's load with the previous week's load, expressing the results in different ways. However, changes can also be studied in terms of the following:

- The previous week (already completed).
- In terms of the season average.
- The average of the previous weeks.

However, depending on whether these reference values are calculated using the player's individual values, the average for the playing position, or the team's average, the validity and therefore practical application will be lost as we move away from the specific athlete being studied.

Of course, this comparison can be made using any of the variables that have been selected to assess the training load. The variables can range from the load indicator obtained through to the session-rating of perceived exertion method or RPE (example shown in Table 1), or even variables related to heart rate, distance covered (including the different speed ranges) or accelerations and decelerations.

Table 1: Load values obtained using the Session-Rating of Perceived Exertion Method for a specific microcycle, compared with the average of the previous four microcycles. The individual % corresponds to the comparison made with the player's baseline and the team % corresponds to the comparison made with the team's average.

RPE			
Player	**Change %**	**Individual %**	**Team %**
1	-32%	78%	61%
2	-33%	111%	84%
3	17%	110%	114%
4	38%	132%	139%
5	-15%	122%	116%
6	13%	100%	68%
7	26%	127%	140%
8	-12%	103%	122%
9	-57%	65%	63%
10	1%	100%	92%

Source: Castellano & Casamichana, 2016 p. 93.

As shown in Table 1, each player has a particular training load that differs by a certain percentage (% of change) from the average of the last four microcycles. The formula:

(current microcycle - (average of last 4 microcycles))/(average of last 4 microcycles)

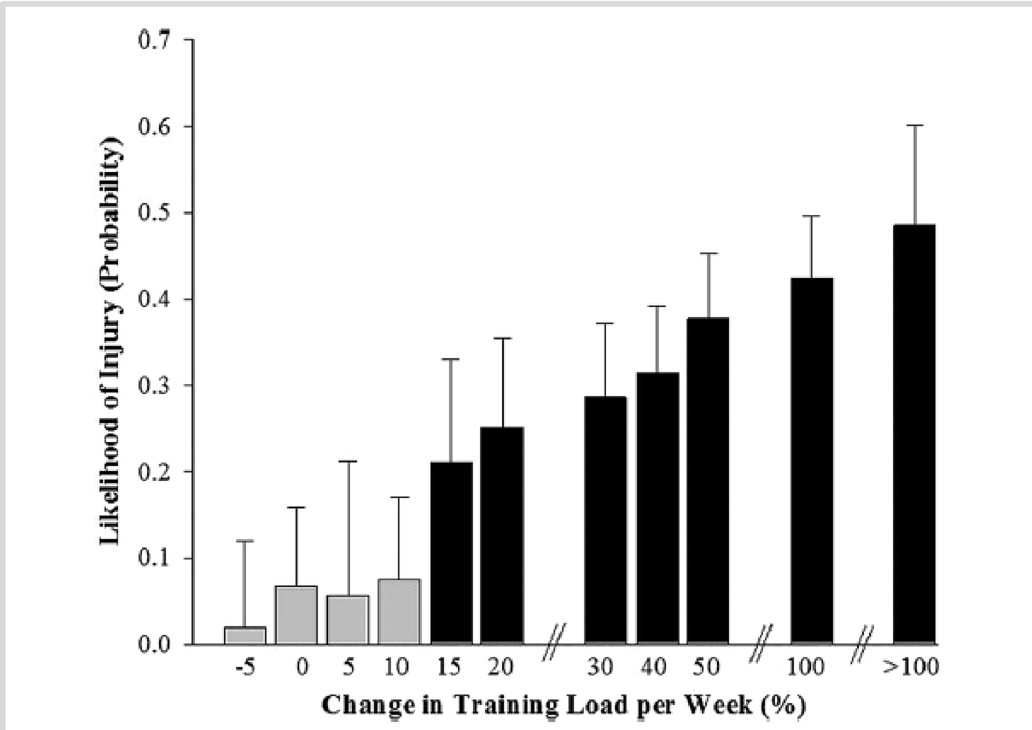
In this way we can assess the % of change that the player experiences. As can be seen, some players have negative values (they had a lower training load in this microcycle) and some have positive values (those who perceived that they trained more compared to previous weeks). Values above 20-30% or below 20-30% (Gabbett, 2016) can alert us to assess for overloading or lack of stimulus, respectively. The second column (Individual %) is a more stable value, providing information based on the comparison of the player with their own baseline or average accumulated throughout the season. Values above 100% indicate that the player is increasing the training load, the opposite applies if they are below 100%. Finally, the Team % corresponds to the comparison between the player's activity versus the team's average. Here we can detect differences between the players. The values collated in Table 1 for the load indicator obtained through the session-rating of perceived exertion method or RPE can be applied for any of the variables considered appropriate to monitor, such as time >90% of maximum heart rate, distance covered at more than 21 $km \cdot h^{-1}$, etc. (Castellano & Casamichana, 2016).

Furthermore, with this information, it is possible to evaluate how load progresses from week to week or whether tapering (or a decreased training load) has been correctly implemented at specific moments of the season.

1.3 Weekly changes and injury risk

Figure 5 illustrates the relationship between increases in the weekly workload and the probability of injury (Gabbett, 2016). Taking all of this into account and in order to minimize injury risk, weekly workload increases should not exceed 10% (Gabbett, 2016). Moreover, preventing fatigue and overtraining is fundamental when monitoring and quantifying workloads. Although there is a relationship between high loads, which produce a state of fatigue or overtraining for the athlete, and injuries, the problem is not only with the training itself, but the inappropriate ways that the load is managed or prescribed (Gabbett, 2016). In this way, the use of specific fatigue recovery strategies depending on the type of fatigue, together with a suitable distribution of training loads, are determining factors when it comes to preventing injury risk.

Figure 5. Likelihood of injury in relation to changes in training load



Source: Taken from Gabbett (2016), p. 5.

Figure 5 brings together data based on different findings from a various studies performed across different sports. Cross et al. (2016), for rugby union players, used the rating of perceived exertion method as an indicator of load measurement and found that a change of 2 deviations between weeks substantially increased the probability of injury. Therefore, injury probability when the change is greater than 1069 AU with between 1 to 2.5 standard deviations when the change is less than this cut-off value.

Table 2: Identifying training load as a risk factor in professional rugby union players

95% Confidence interval							
Load calculation	2 SDs	Effect of 2-SD increase (odds ratio)	Lower	Upper	P	Inference	% likelihood effect is beneficial/ trivial/harmful
1-wk cumulative load	1245 AU	1.68	1.05	2.68	.003	Very likely harmful	0/1/99%
Absolute change (±)	1069 AU	1.58	0.98	2.54	.06	Likely harmful	1/6/93%

Monotony	0.39	1.22	0.84	1.78	.29	Unclear	5/26/69%
Training-stress balance	172%	1.41	0.60	2.80	.42	Unclear	15/14/71%
4-wk cumulative load							
<3684 AU (reference)		1.00					
3684-<5932 AU		0.79	0.48	1.29	.34	Unclear	70/21/9%
5932-<8651 AU		0.55	0.22	1.38	.20	Likely beneficial	85/8/7%
→ 8651 AU		1.39	0.98	1.98	.06	Likely harmful	1/9/90%

Source: Taken from Cross et al. (2016), p. 20.

Similar studies have been undertaken in other sports. For example, in the study by Rogalski et al. (2016), looking at Australian Rules Football, the findings (as shown in Table 3) demonstrate that an increase in the weekly load by more than 1250 AU increases the likelihood of injury for an athlete by 2.58 times.

Table 3: Training load during the competitive season and factors for injury risk in elite Australian Rules Football players

Load calculation	In-season			
	OR	95% CI		*p*-Value
	Exp(B)	Lower	Upper	Sign.
Cumulative load (sum)				
1 week				
<1250 AU (reference)	1.00			
1250 AU to <1750 AU	1.95	0.98	3.85	0.056
1750 AU to <2250 AU	2.44	1.28	4.66	0.007
>2250 AU	3.38	1.69	6.75	0.001
2 weeks				
<2000 AU (reference)	1.00			
2000 AU to <3000 AU	2.98	0.70	12.66	0.138
3000 AU to <4000 AU	4.03	0.98	16.53	0.053
>4000 AU	4.74	1.14	19.76	0.033
Absolute change (±)				
Previous to current week				
<250 AU (reference)	1.00			
250 AU to <750 AU	1.34	0.90	2.01	0.148
750 AU to <1250 AU	0.89	0.50	1.58	0.680
>1250 AU	2.58	1.43	4.66	0.002

Note: No significant odds ratios were calculated in the pre-season phase.
OR, odds ratio; CI, confidence intervals.

Source: Rogalski et. al., 2016, p. 501.

Malone, Owen, Newton, Mendes, Collins, & Gabbett, studying soccer players, found that for significant changes (between 351-455 m for distance covered at high speed or 75-105 m for the distance covered at sprint) the likelihood of injury increased by 3 and 5 times, respectively. In this sense, it appears that avoiding significant increases, especially in distanced covered at a sprint (avoiding changes of more than 50 m), from week to week, may be key to reducing the likelihood of injury.

Table 4: Change in weekly load and acute:chronic load ratio of the distance covered at high speed and sprint as an injury risk for elite soccer players. The data is presented as OR (90% CI) when they are compared with the reference group.

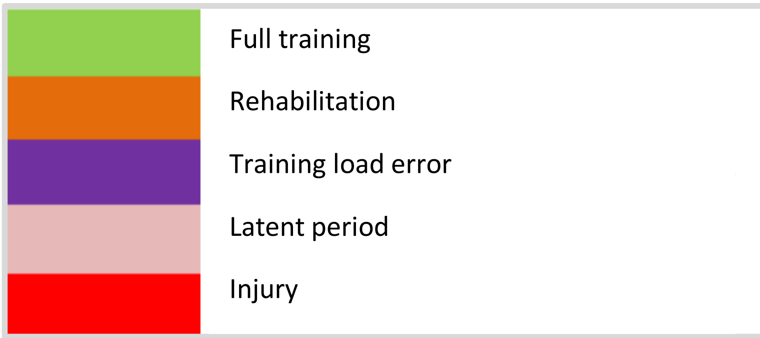
External Load Calculation	In-Season	90% Interval	Confidence	*p*- Value
	Odds Risk (OR) of Lower Limb Injury	Lower	Upper	
Absolute weekly change in high-speed distance (m)				
(←) 100 -m	1.00			
Between 101 – 205 -m	1.20	1.05	3.93	0.034
Between 206 – 350 -m	2.27	1.93	4.44	0.002
Between 351 – 455 -m	3.02	2.03	5.18	0.011
Absolute weekly change in sprint distance (m)				
(←) 50 -m	1.00			
Between 51 – 64 -m	3.12	2.86	6.13	0.033
Between 65 – 75 -m	4.12	3.86	7.84	0.002
Between 75 – 105 -m	6.12	4.66	8.29	0.001

Source: Malone, 2017, p. 3.

1.4 Practical examples

Next, we will examine a series of practical examples that were described by Charlton & Drew (2015). We will first outline the meaning of the bar colors used in the examples to better understand the load dynamics discussed.

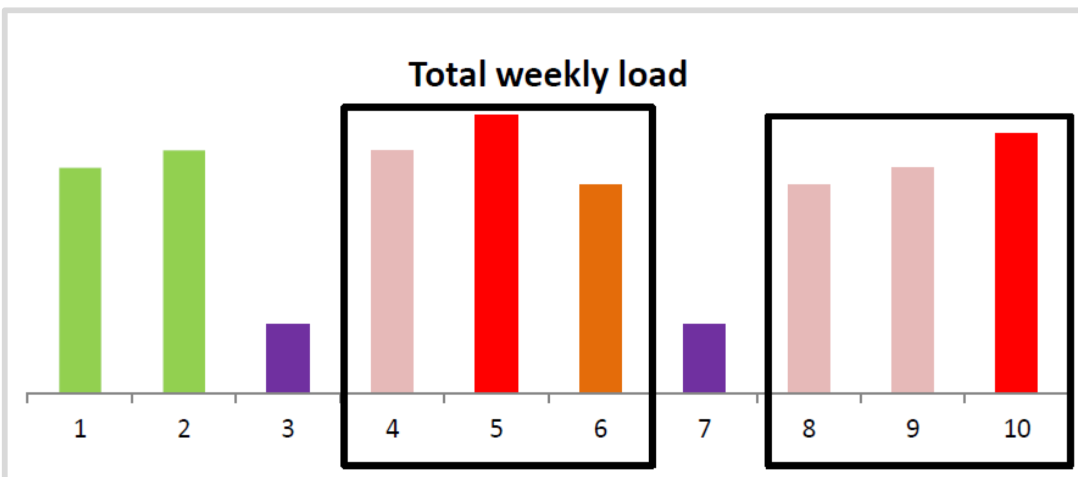
Figure 6: Meaning of the bar colors used in the following examples



Source: Charlton & Drew, 2015, p. 7.

In Figure 7, Situation 1 provides an example of periodization with recovery weeks (the purple bars). These recovery weeks can increase the likelihood of injury when the athlete returns to the normal training load the following week.

Figure 7: Weekly load over a 10-week period including two recovery weeks (purple)



Source: Charlton & Drew, 2015, p. 8.

We may find situations like this in soccer, for example in the weeks prior to the competitive season when there are training "vacations", such as the Christmas period. In order to avoid errors in training load management, it is important to:

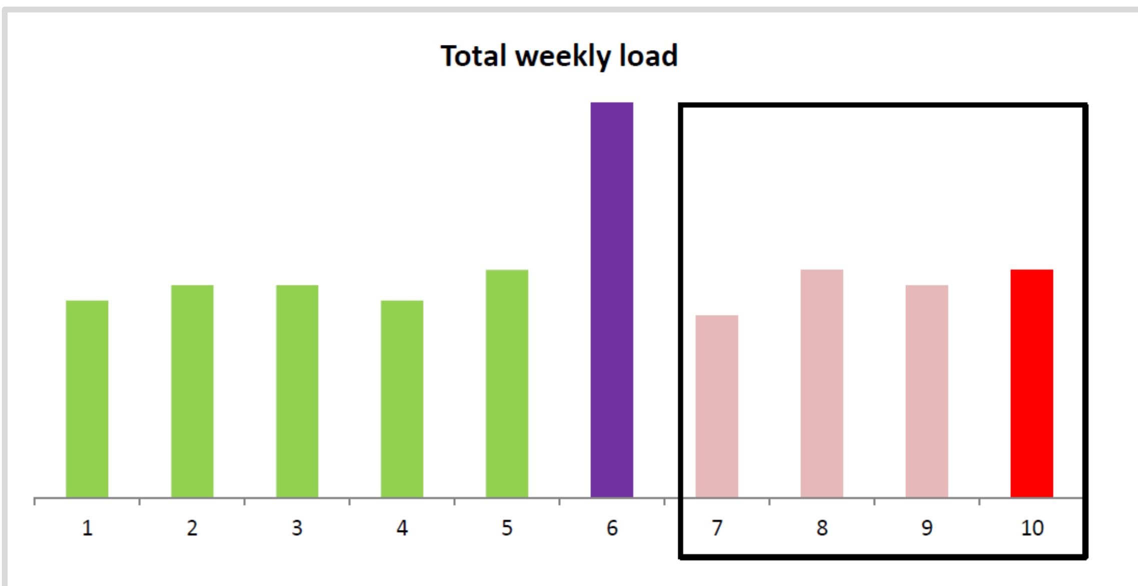
1. Avoid significant decreases in training load levels. Reducing volume, maintaining intensity, and modifying (slightly) the level of specificity can all be helpful in this regard.
2. Monitor the training load in these weeks. In spite of the difficulties associated with monitoring an athlete's training load when they are not physically with a

coach/physical trainer, it is important to know what the players have and have not done.

3. Be aware of a decrease in activity, avoiding a significant increase in the % of weekly change. Use the strategy of reduced or moderate changes between training weeks to minimize the risk of injury.

Figure 8 shows an athlete or group of athletes performing moderate to high weekly training loads, followed by a very large spike in the weekly training load (week 6), which substantially increases the likelihood of the athlete being injured.

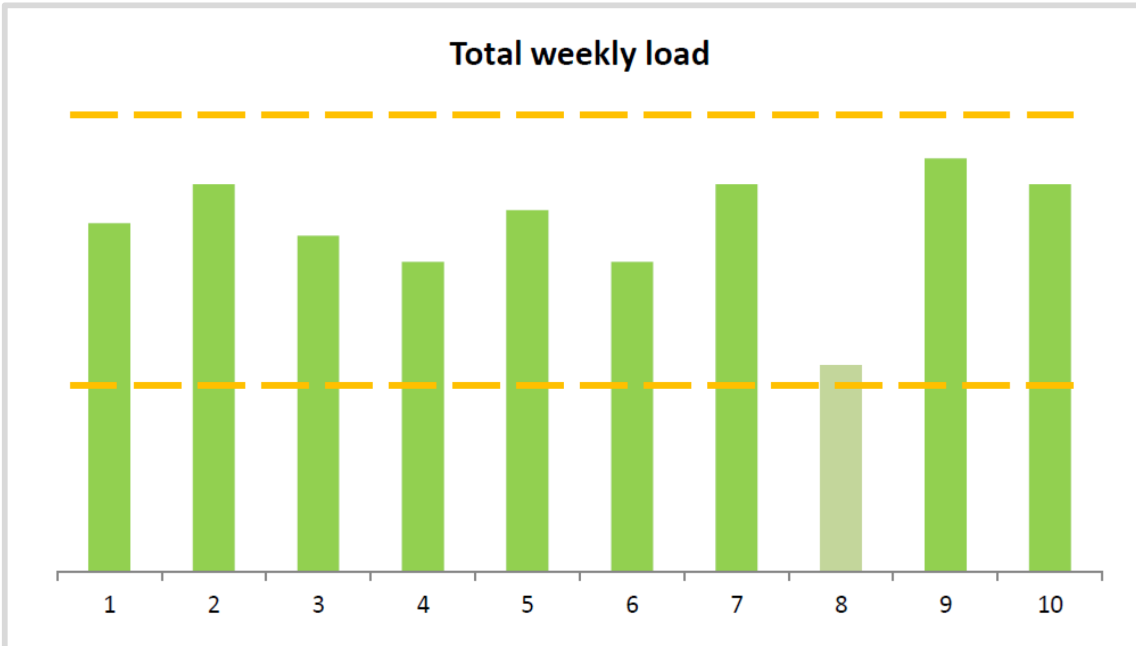
Figure 8: Weekly load over a 10-week period where the weekly load in the first 5 weeks is moderate, the load in week 6 is increased, with a significant spike compared to the week before



Source: Charlton & Drew, 2015, p. 8.

Situation 3 depicts an athlete performing moderate to high weekly loads, with an adequate load during the recovery week (vacations) to avoid increasing their likelihood of injury. The goal is to have safe fluctuations in training load.

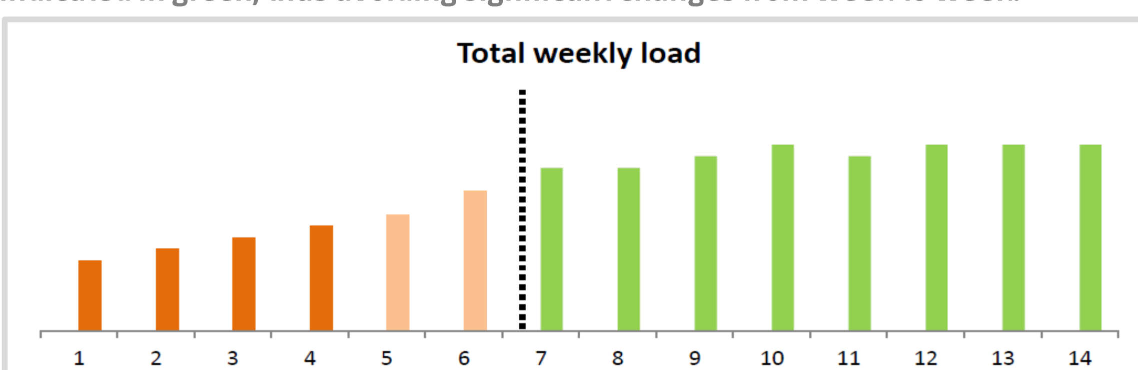
Figure 9: Weekly load over a 10-week period where there is a minimal load in week 8 (vacations or recovery week), and the weekly training load never exceeds a safe level in any week



Source: Charlton & Drew, 2015, p. 9.

Thus we understand that variation is an important factor when managing training load. However, the fluctuation of loads is decisive when establishing the relationship with the injury or illness rate. To date there is no evidence to support or contradict the **10% rule** when managing our athlete's training loads.

Figure 10: Weekly load over a 10-week period with a progressive increase in the load. There is progressive increase in the weekly load until the athletes reach the "usual" load, as indicated in green, thus avoiding significant changes from week to week.



Source: Charlton & Drew, 2015, p. 7.

In this sense, they are critical moments where many training load errors are made during tapering or refinement, recovery periods or when an athlete is injured or ill. At such times, the athlete's training load is decreased, and this needs to be taken into account when planning the training load in the following weeks. Based on a database of 3500 injury/illness events registered across 27 sports, the Australian Institute of Sport highlights a number of aspects that should be considered:

- Injuries and/or illnesses frequently occur after periods of rest in training.

A considerable number of injury/illness episodes occur in the "return to training" period after a break, such as after a planned break or vacation, after refinement or tapering, an illness or a rehabilitation/recovery period.

- The loss of training time puts the training objectives at risk:

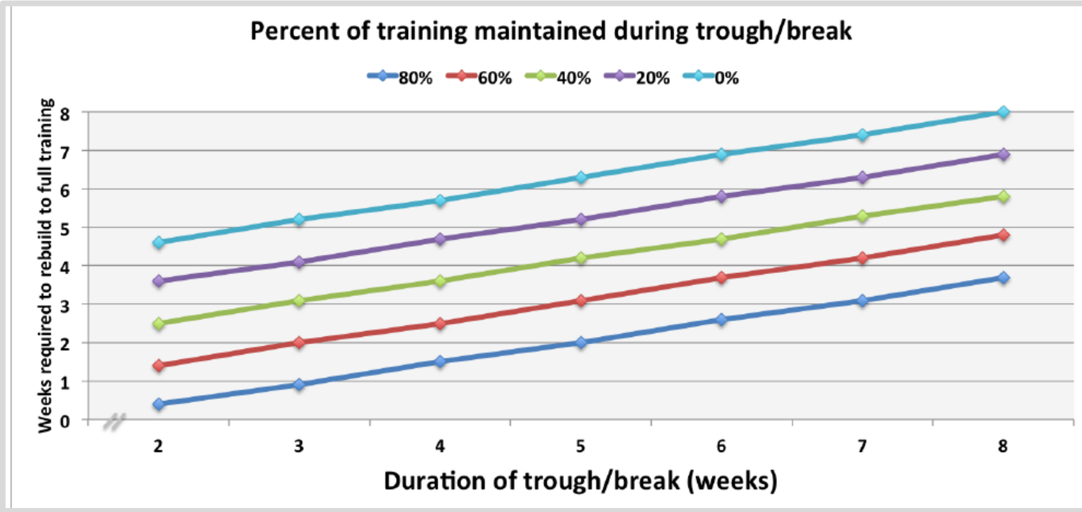
If an athlete completes more than 80% of the planned training weeks in the 6 months prior to a championship, their chances of reaching their performance goal increases 7 times (Raysmith & Drew, 2016).

A similar relationship has been observed between injuries and performance in individual sports when analyzing internal load for athletes who reported injuries in the month prior to a world championship and injury risk during the world championship (Alonso JM, Jacobsson J, Timpka T, Ronsen O, Kajenienne A, Dahlström Ö, Pascoual E, 2015).

Team sport performance improves with player availability (Hägglund M, Waldén M, Magnusson H, Kristenson K, Brengtsson H, Ekstrand J, 2013, Podlog L, Buhler CF, Pollack H, Hopskins PN, Burgess PR, 2014).

- Training load monitoring provides the platform to plan the return from a training trough. Planning training load is crucial to maximizing exposure to planned training sessions, which in turn allows the athlete to adapt and develop the capacities/skills they need to perform at their best.
  All sports are unique, thus each sport has different associated risks. An appropriate system for monitoring internal load and external load will optimize safety when a player is returning to training load periods.

Figure 11: Time required to rebuild to the full training load without increasing the risk of injury, in relation to the duration of the reduced load period, and the load imposed on the athlete during this time.



Source: Taken from https://bit.ly/36pwa08

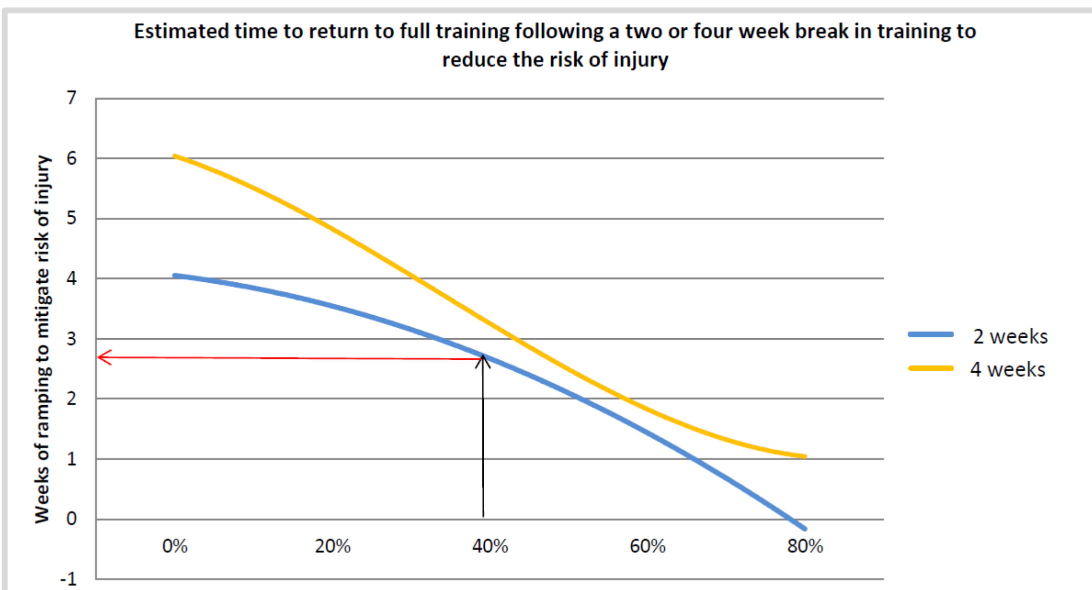
We must keep in mind that any recovery period implies a substantial decrease in training load, when compared with normal levels. A decrease in the training load level may be absolute (no training) or relative (significant decrease in the normal training load level, for example 30%). For an elite athlete, long periods of absolute rest can reduce physical capacity. There is a corresponding increased injury risk and illness when the athlete returns to training, if the volume, intensity and frequency of training is not managed properly. Data from Australian athletes indicate that after a pronounced reduction in the training load, through a planned rest period, tapering period or due to injury/illness, abruptly returning to usual load levels increases the risk of injury. The time taken to return to normal load levels must be proportionate to the duration of the "rest" period, as well as the percentage of training maintained during the rest period.

Figure 11 illustrates the relationship between the trough (horizontal axis) with the number of training weeks needed to reach the athlete's training load, in relation to the % of training maintained during the trough or break. Thus we can see how if the athlete has a tough that lasts for 3 weeks, with a training load that is 20% of their habitual load, it will take 4 weeks to reach habitual training load levels, increasing load progressively, avoiding significant spikes from week to week, in order to control the athlete's likelihood of injury. This chart simply provides useful guidelines on how to manage training load after a tough or break from training.

- The longer the trough lasts, the more time is required to progressively rebuild the training load.
- The percentage of load maintained for the athlete during these troughs is a key factor, as the lower the load experienced in these periods the longer it will take to rebuild to full training levels.
- If an athlete trains at 60% of their normal training load for a period of two weeks, they will need a period of 10 days to progressively return to their habitual training load, without significantly increasing their probability of injury.
- Longer periods of reduced load and more significant reductions in volume and intensity require longer periods to progressively rebuild to full training load levels without significantly increasing the risk of injury.

In addition, the authors of the Australian Institute of Sport report indicate that a longer period rebuilding load is necessary if this is not the athlete's first injury/illness. In this case, we must rebuild the load even more progressively, increasing the duration of this period.

Figure 12: Time required to rebuild to the full training load without increasing the risk of injury, in relation to the duration of the reduced load period (2 and 4 weeks), and the load imposed on the athlete during this time (40% of the load in the example highlighted).



Source: Taken from https://bit.ly/2LFCup9

To use Figure 12, the length of the intended rest period must be established (in this case there is a 2-week trough, as represented by the blue line, while the yellow line represents a 4-week rest period). As can be seen in this graph, as the duration of the rest period increases, the lines are placed higher. Next, the percentage of the athlete's normal training load which will be maintained in this recovery period must be selected. In the example shown, it was decided that the athlete would perform 40% of their normal training load during the 2-week reduced load period. Using the graph, the recommended time to rebuild and ramp training is calculated so that the athlete returns to 100% of their normal load, minimizing the chances of injury and illness (red line). In other words, during this training ramping period, spikes are avoided when managing training load, controlling the % of weekly change in the training load. We must take into account that loads must be specific to the sport in question. For example, a runner should reduce volume but maintain intensity. This could help to reduce the likelihood of the athlete suffering a running-related injury. In this case, a runner who usually covers 100 km a week who then covers 40 km per week in the tough period, can expect a 2.5-week training ramping period after two weeks at 40% of their normal training load. Returning quickly to a full training load would increase the probability of injury. Therefore, two weeks of recovery would lead to a ramping period of 4.5 weeks until 100% of the weekly training load is reached (two weeks at 40% plus 2.5 weeks of ramping.)

Table 5: Weeks of modified training load required to return to full training and, in parenthesis, total weeks of modified training required in relation to the length of the reduced load period and the % of the habitual load completed during said period.

Weeks of training at a reduced load	Weeks of modified training required to return to full training (total weeks of modified training)				
8	8 (16)	6.9 (14.9)	5.8 (13.8)	4.8 (12.8)	3.7 (11.7)
7	7.4 (14.4)	6.3 (13.4)	5.3 (12.3)	4.2 (11.2)	3.1 (10.1)
6	6.9 (12.9)	5.8 (11.8)	4.7 (10.7)	3.7 (9.7)	2.6 (8.6)
5	6.3 (11.3)	5.2 (10.2)	4.2 (9.2)	3.1 (8.1)	2.0 (7.0)
4	5.7 (9.7)	4.7 (8.7)	3.6 (7.6)	2.5 (6.5)	1.5 (5.5)
3	5.2 (8.2)	4.1 (7.1)	3.1 (6.1)	2.0 (5.0)	0.9 (3.9)
2	4.6 (6.6)	3.6 (5.6)	2.5 (4.5)	1.4 (3.4)	0.4 (2.4)
	0%	20%	40%	60%	80%
	Percentage of training of normal training load completed				

Source: Taken from https://bit.ly/2LFCup9

This table displays the number of weeks of training at a reduced load and the % of training load during those weeks. Where these variables intersect represents the time in weeks of the ramping training period and in parenthesis the total length of time not training at normal training loads. For example, if our athlete spends 2 weeks training at 40% of the usual full load, they will need 2.5 weeks of ramping, which in total will be 4.5 weeks of training at less than 100%. Another example is if our athlete spends 4 weeks training at 60% of the usual full load, they will need 2.5 weeks of ramping, which in total will be 6.5 weeks of training at less than 100%.

The equation used to estimate the time needed to return to their normal full training load level is:

Weeks to return to training = 0.5533 x (length of reduced loading period in weeks) - 0.0587 x (percentage of full training load completed) + 3.533

If we use this equation to calculate the previous example we obtain the following values:

Weeks to return to training = 0.5533 x (2) - 0.0587 x (40) + 3.533
Weeks to return to training = 1.1066 - 2.348 + 3.533
Weeks to return to training = 2.2916

*Note that the calculations are not exactly the same as the values in the table. The adjustment for the equation is R^2 0.94.

References

Alonso J-M, Jacobsson J, Timpka T, Ronsen O, Kajenienne A, Dahlström Ö & Pascoual E. (2015) *Preparticipation injury complaint is a risk factor for injury: a prospective study of the Moscow 2013 IAAF Championships*. British Journal Sports Medicine. Vol. 49. No. 17 [pp.1118-1124].

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