TITLE: Monitoring Training in Soccer: Measuring and Periodising Training

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Introduction

It is widely recognised that appropriate periodisation of training is fundamental for optimal performance in sport. Until recently, it has been very difficult to quantify the training loads (TLs) completed by football players due to difficulty in measuring the various types of stress encountered during training. Fortunately however, in the last decade the session-RPE method for quantifying training has become popular tool for monitoring training periodisation in various sports, and several football teams have adopted this approach. This method allows coaches to monitor individual player's perception of TLs and follow its periodisation. In this chapter, we will examine how this methods works, the validity of the session–RPE method, present ways that you can use session-RPE data to improve the training process for soccer. Finally, we also present examples of periodisation for various football teams around the world, but where possible we have placed particular emphasis on case studies from soccer.

Existing Periodisation Models

There is a large amount of coaching literature on periodisation strategies for various sports (Woodman & Pyke, 1991; Kibler & Chandler, 1994; Jenkins, 1995; 1996; Dawson, 1996; Martin & Coe, 1997; Daniels, 1998; Rowbottom, 2000; Norris & Smith, 2002; Noakes, 2003; Gamble, 2006), however, most of the models presented in the literature is based on informal experimentation by coaches. Traditional literature examining periodisation describes it as a framework for planned and systematic variation of training parameters with the goal of optimising training adaptation to a particular sport (Martveyev, 1982; Bompa, 1996). For some team sports, the typical model of periodisation usually includes the following phases: general preparation, specific preparation, pre-competition and competition (Woodman

& Pyke, 1991; Dawson, 1996; Kelly & Coutts, 2007). However, not all team sports follow this classic model. Indeed, many top level team sports do not follow this classical periodisation model due to factors such as the long duration of the competition season, the regular competition, climatic interferences and religious practices (e.g. Ramadan). It is because of these factors it can be very difficult to distinguish between specific training phases in some soccer teams that compete in top level professional leagues. More commonly, these professional teams usually complete about 3-5 weeks of preparation training following by a longer competition period. Additionally, in the south of Europe, there is another break of about 3 weeks in duration to allow for a mid-season winter break, whilst in northern Europe, this mid-season break is longer due to the more severe winter weather.

Regardless of the model adopted for periodisation in a sport, the effectiveness of the training programs depends on the successful manipulation of the total training stress which is a product of the training volume and intensity. At present, there is little empirical evidence to support any single approach to manipulating these variables in football, and the existing knowledge is mostly based on experiential learning from high level coaches.

Scientific Rationale for Periodisation

The rationale for periodisation are based on the effects that an increase in stress (i.e. a training bout) and a regeneration period can have on an athlete (Selye, 1956). When homeostasis is disrupted through exercise overload (Martveyev, 1982), a number catabolic events occur resulting in a breakdown of structural proteins and a depletion of energy stores (Viru & Viru, 2000). As a consequence of the catabolism, performance temporarily decreases and the body works to re-establish energy stores and increase protein synthesis in a process called regeneration. It is suggested that there is a supercompensation in performance as the athlete adapts to the stress imposed by the training bout (Bompa, 1996). Periodisation is based on this principle, and it is commonly thought that a cumulative overload of training will result in a more powerful stimulus for adaptation if appropriate recovery periods are planned (Martveyev, 1982; Bompa, 1996).

There are three important assumptions that arise from the scientific rationale of periodisation (Rowbottom, 2000). These are:

1. An increase in TL will produce an adaptation in performance (Foster, Daines, Hector, Snyder, & Welsh, 1996; Rowbottom, Keast, Garcia Webb, & Morton, 1997),
2. There is a saturation point at which increases in TLs will no longer be tolerated and adaptations in performance do not occur at this point (Coutts, Reaburn, Piva, & Murphy, 2007b; Coutts, Reaburn, Piva, & Rowsell, 2007c); and,
3. A recovery period of low TL should result in a transient increase in performance (Mujika, Padilla, Pyne, & Busso, 2004; Bishop & Edge, 2005; Coutts et al., 2007c; Coutts, Slattery, & Wallace, 2007d).

On the basis of these assumptions, it is now commonly accepted that training programs be systematically periodised with cycles of overload and recovery training. Specific terminology has been developed to describe each training cycle to assist coaches to develop periodised training plans. Training plans are usually in described in 12-month cycles (annual plan) which are broken down into smaller cycles. Larger training cycles (i.e. several months in duration) are commonly referred to as macrocycles, these are then divided in medium sized training (i.e. several weeks) cycles called mesocycles. Finally, the mesocycles can divided into smaller subunits, usually one week in duration called microcycles. To simplify planning, training plans are usually broken down into these smaller discrete cycles. Each cycle usually has specific training goals that ultimately relate to the final performance goal. A well designed training plan has these cycles systematically planned to develop the physiological and performance capacities of an athlete that allows them to best achieve their performance goals. However, despite this systematic planning many football coaches have been unable to check if they effectively implemented their plan as they were unable to measure the training completed by their athletes.

Periodising Training Loads for Football

It is widely recognised that the key to success for most athletes is a long-term training plan with carefully periodised cycles (Fry, Morton, & Keast, 1992; Foster, Daniels, & Seiler, 1999). For example, previous studies have clearly shown that training should be periodised to alternate hard-easy sessions on a daily basis (Bruin, Kuipers, Keizer, & Vander Vusse, 1994; Foster & Lehmann, 1997), TL should be gradually progressive throughout the preparatory period (Dawson, 1996; Rowbottom, 2000) and athletes should undertake a period of rest or taper prior to competition (Mujika & Padilla, 2003; Coutts et al., 2007c). It is widely thought that these fundamental principles of periodisation should be applied to both endurance and team sports. However, it is disappointing that to date, relatively few studies have examined or described periodisation strategies for team sports such as football (Dawson, 1996; Filaire, Bernain, Sagnol, & Lac, 2001; Foster, Florhaug, Franklin, Gottschall, Hrovatin, Parker, Doleshal, & Dodge, 2001; Andersen, Triplett-McBride, Foster, Doberstein, & Brice, 2003; Coutts, Reaburn, Murphy, Watsford, & Spurrs, 2003; Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004; Putlur, Foster, Miskowski, Kane, Burton, Scheet, & McGuigan, 2004).

Most of the published studies that have described periodisation in team sports such as football have only examined the influence of periodisation over 1-2 mesocycles (<12 weeks) on subsequent performance and physiological measures. For example, Putlur et al., (2004) reported that the incidence of illness and reduction in salivary immunoglobulin levels were associated with increased workloads over a nine week training period in a group of trained collegiate female soccer players. Additionally, others have also reported on changes in measures of muscular strength, power, speed and aerobic capacity during a 6-8 week mesocycle during the preparation and competition period of a semi-professional rugby league team (Coutts et al., 2007b). It has also been shown that a reduction in pre-season TLs of semi-professional rugby league players between seasons caused a reduction in training injuries and a meaningful increase in physical performance tests (Gabbett, 2004b). To our knowledge, only one study has accurately described periodisation strategies in a football team over the course of an entire season (Coutts, Sirotic, Catterick, & Knowles, 2008).

The periodisation of TLs during weekly competition is arguably of greatest importance to the team sport coach and athlete. In contrast to most endurance sports, team sport athletes usually compete every 4-9 days for 6-8 months of the year. In some cases, they may play even three games within seven days. These competitive demands place significant physiological and psychological stress on the athlete. This is of considerable concern, since it has widely been demonstrated that an imbalance in stress and recovery leads to reduced athletic performance in strength, power and team sport athletes alike (Elloumi, Maso, Michaux, Robert, & Lac, 2003; Kraemer, French, Paxton, Häkkinen, Volek, Sebastianelli, Putukian, Newton, Rubin, Gómez, Vescovi, Ratamess, Fleck, Lynch, & Knuttgen, 2004; Maso, Lac, Filaire, Michaux, & Robert, 2004; Coutts et al., 2007b; Coutts et al., 2007c). The findings of these previous studies suggest that appropriate periodisation to allow for removal of fatigue and maintenance of fitness during the competition period of professional team sport athletes is a difficult task. In support, Dawson (1996) suggested that coaches have difficulty in providing the appropriate training structures that allow team sport athletes to recover from a game, complete mid-week fitness training and then complete a brief pre-game taper in the 4-9 days between games. However, there is little research evidence available that either describes or compares real periodisation strategies in high level team sports (Coutts et al., 2008).

Methods Used to Quantify Training in Football

A major reason for the little of information available on optimal periodisation strategies for team sports such as football is that there are few valid and reliable methods for quantifying training that can be practically implemented in the team environment. There are several methods that now can be used to quantify training in the team environment and these can be used to measure either the external work completed by the athlete (e.g. distance travelled) or the internal work completed by the athlete (e.g. heart rate or perception of effort).

Some of the techniques that are now used to quantify TLs in team sports require heart rate (HR) monitors and/or Global Positioning Satellite (GPS) units. Whilst these methods can provide very detailed information on the training stress experienced by athletes, they have several limiting factors which can prohibit them from wide use in football clubs. In particular these devices can be expensive, require a high level of technical expertise to operate, and data analysis can be time consuming. Additionally, these methods can not be easily used to compare the training stress imposed from various forms of training that are common in team sports (e.g. aerobic training vs. power training). Combined, these factors limit the practical usefulness of these techniques for monitoring the TL periodisation in teams. Fortunately, the session-RPE method for quantifying TLs has been developed (Foster, Hector, Welsh, Schrager, Green, & Snyder, 1995). The session-RPE method now allows coaches of football teams to measure the training that their players complete and consequently better control the periodisation of training.

Explaining the session-RPE Method

The session-RPE method of monitoring TL in team players requires each athlete to provide a Rating of Perceived Exertion (RPE) for each exercise session (see Table 1) along with a measure of training time (Foster et al., 2001). To calculate a measure of session intensity, athletes are asked within 30-minutes of finishing their workout a simple question like "How was your workout?" A single number representing the magnitude of TL for each session is then calculated by the multiplication of training intensity (RPE from Table 1) by the training session duration (mins).

TL = Session RPE x duration (mins)

For example, to calculate the TL for a training session 40-minutes in duration with the athletes RPE being 5, the following calculation would be made:

TL = 5 x 40 = 200 AU (arbitrary units)

Table 1: The modified rating of perceived exertion (RPE) scale used for athletes to classify their perceived intensity of each training session (Foster et al., 2001).

Rating	Descriptor
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	
7	Very Hard
8	
9	
10	Maximal

Further simple calculations of training '*monotony*' and '*strain*' can also be made from session-RPE variables. *Training monotony* is a measure of day-to-day training variability that has been found to be related to the onset of overtraining when monotonous training is combined with high TLs (Foster, 1998). Indeed, it has previously been shown in racehorses, that a constancy in TL is important as the total TL (Bruin et al., 1994). It was observed that horses could tolerate progressive increases in TLs as long as a light training day separated each heavy training day, however, once the TL on the recovery day was increased the horses performance decreased and they demonstrated symptoms of overreaching. These findings can have important implications for football teams and suggest that training with lower monotony (i.e. greater variation in TLs) may prevent injury, illness and improve performance. Training monotony is calculated from the average daily TL divided by the standard deviation of the daily TL calculated over a week. We have shown how to determine training monotony below.

TRAINING MONOTONY = mean daily TL / standard deviation

For example, to calculate the TL for the training scheduled shown in table 2, the following calculation would be made:

Step 1: Calculate the mean daily load for the weeks training:
Sum (Σ) all the daily load scores and divide by number of days
Σ (0, 244, 240, 210, 315, 100, 135, 540)/7 = 223 AU

Step 2: Calculate the standard deviation of the mean daily TL over the week:
Standard Deviation (SD) = $\sqrt{((\Sigma d^2)/N-1))}$

Daily Load Score **X**	**Daily load – Mean weekly load** ***(X - 223)***	**Difference^2** **d^2 (d x d)**	
0	0-223 = -223	$(-223)^2$ =	49715
244	244-223 = 21	$(21)^2$ =	432
240	240-223= 17	$(17)^2$ =	290
315	315-223 = 92	$(92)^2$ =	8470
100	100-223 = -123	$(-123)^2$ =	15121
135	135-223 = -88	$(-88)^2$ =	7739
540	540-223 = 317	$(317)^2$ =	100509
		Σ	182275

N = number of days (7),
$\therefore$ N-1 = 7-1 = 6
$\therefore$ SD = $\sqrt{(182275/6)}$ = $\sqrt{(30379)}$ = 174.

Step 3: Training Monotony = 223/174 = 1.58 AU

Table 2: An example of the typical weekly load, monotony and strain associated with the 'in season' training program of a professional soccer player.

Day	Training Activity	Session RPE	Duration (min)	Daily Load
Monday	Rest	0	0	0
Tuesday	Skills & Aerobic Conditioning	3.25	75	244
Wednesday	Strength and Aerobic Training	4	60	240
	Skills	3	70	210
Thursday	Speed and training game	3.5	90	315
Friday	Skills Training and Coordination	2	50	100
Saturday	Skills and Agility/Short Sprints	2.25	60	135
Sunday	Game	6	90	540
	Weekly load			**1784**
	Monotony ([mean weekly load / SD])			1.58
	Strain ([load x monotony] = 1784 x 1.58)			2815

A global measure of *Training Strain* can also be calculated from TL and monotony scores. Training Stain is a useful method for monitoring training when players are undertaking high TLs. In football, high levels of training strain are usually only reached during the preparation period of training when there is not regular competition. The advantage of monitoring training strain for football players is that recovery only becomes fundamental to training when high TLs are being undertaken. For example, when TLs are high and there has been inadequate time for recovery between sessions, the training strain is high. This type of training has been associated with incidence of illness and poor performance (Putlur et al., 2004). Conversely, training strain is low when players complete either high or low TLs with regular recovery periods between high load sessions (i.e. low monotony). We have shown how to calculate training strain below.

TRAINING STRAIN = weekly TL x monotony

An example of how to calculate the weekly training strain for the training scheduled shown in table 2, the following calculation would be made:

$$(\Sigma(0, 244, 240, 210, 315, 100, 135, 540)/7) \times 1.58 = 2815$$

$$\text{Training Strain} = 1784 \times 1.58 = 2815 \text{ AU}$$

Although these calculations may appear at first to be complicated, with the assistance of a spreadsheet or on-line monitoring software (www.trainingload.com, Acceleration Australia, Brisbane) calculations can be made simple. Moreover, by recording your data in a spreadsheet or database, the trends for the whole team, groups of players within a team or individual players of can be easily graphed to determine if training strain reflects planned training strain from your season plan (see Figure 1).

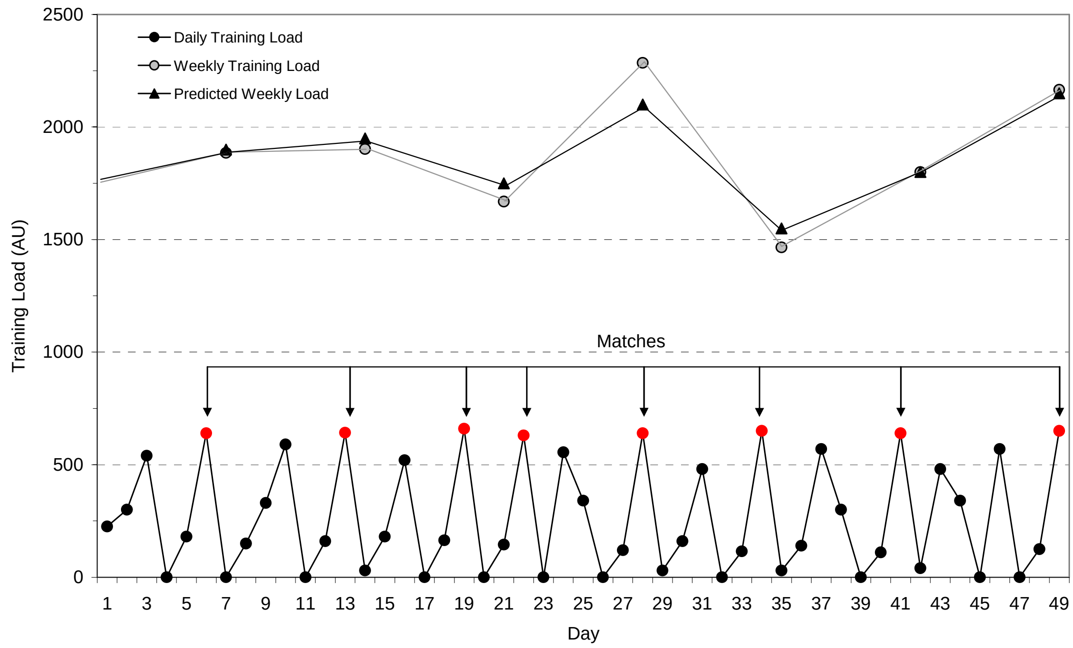

Figure 1: An example of Actual versus Planned TL for a professional football team during a competition period.

Scientific Basis of the session-RPE Method

The session-RPE method has been shown to be a simple and valid technique quantifying whole training session intensity in endurance (Foster et al., 1995; Foster et al., 2001), intermittent-aerobic (Foster et al., 2001; Impellizzeri et al., 2004) and strength training (Day, McGuigan, Brice, & Foster, 2004; Sweet, Foster, McGuigan, & Brice, 2004). Indeed, recent research compared the session-RPE method with heart rate (HR) methods that have been previously suggested to be precise methods for quantifying training stress (Banister, 1991). This original study that assessed the validity of session-RPE for monitoring TL was divided into two parts. The first part compared these two methods of quantifying training during eight laboratory controlled interval-training sessions in 12 well-trained cyclists. In the second part of this study, 14 university college basketball players were assessed during normal court training using both the session-RPE method and HR recordings. The results showed that there was a highly consistent relationship between these two methods of monitoring training, although the session-RPE method did provide higher absolute scores for both interval training and team based field training. More recently, Impellizzeri et al., (2004) reported a moderate correlation between (from r = 0.50 to 0.91) HR-based TRIMP measures and session-RPE in 19 young soccer players in 479 sessions. Combined, these results provide support for the use of this method in monitoring training for team sports.

Other recent research has also shown a good correlation between TL measures taken through HR-monitoring and the session-RPE in elite level female soccer players in 623 training sessions (Alexiou, 2007). It was interesting that this study with elite female soccer players showed a lower correlation between session-RPE for more intermittent activities such as resistance training ($r = 0.25$, $p < 0.001$) or competitive matches ($r = 0.49$, $p < 0.001$) rather than tactical-technical training ($r = 0.68$, $p < 0.001$) or aerobic conditioning exercise ($r = 0.74$, $p < 0.001$) (Alexiou, 2007). The lower relationship between these measures is most likely due to the contribution of muscular acidosis associated with high-intensity exercise to the perception of effort. To test this theory, we recently conducted a study to determine if RPE was a more accurate global measure of exercise intensity than HR or blood lactate concentration ([BLa^-]) measures. To do this, we recently measured heart rate and blood lactate and RPE from 20 soccer players during 67 small sided-games soccer training sessions (Coutts, Rampinini, Castagna, Marcora, & Impellizzeri, 2007a). Our results demonstrated that the combination of [BLa^-] and HR measures during small-sided games were better related to RPE than HR or [BLa^-] measures alone suggesting that RPE as valid method of estimating global training intensity in soccer than either HR or [BLa^-] independently. Because it is a valid measure of TL in various types of training, session-RPE is now widely used by many top level football teams to monitor their player training.

Why is the session-RPE method Useful for Monitoring Football Training?

A training session for team sport athletes may involve any or many of the following components: warm-up, speed and agility training, skill development, endurance development, lactate tolerance development, development of aerobic power, muscular strength, power development and warm down. Additionally, many different activities can be completed within these components further increasing the variability of training stressors. The complex physiological interactions of the development of all the physical capacities in these sessions makes it difficult for a coach or conditioner to accurately quantify TL using measures of time, heart rate, blood lactate or distance using Global Positioning Systems (GPS) units. Fortunately, by using the athletes RPE for each session method, a global score for the total stress of each session can be calculated.

The session-RPE method of monitoring training stress is also suitable for monitoring team sports as it enables the coach to accurately combine TLs from different training modalities to give an accurate estimation of overall TL. Previously, using other monitoring methods such as HR-based TRIMPS (Banister, Calvert, Savage, & Bach, 1975) or training duration, it has been difficult for the coach to accurately quantify and compare the stress from different modes of physical training within a single session or between training sessions (e.g. skills session vs. resistance training session). Fortunately, the session-RPE method allows for different training activities to be measured in the same units, thus allow activities to be combined to give a score for total TL.

Using the session-RPE method to Monitor Soccer Training

By adopting an approach of regularly monitoring training stress in training, it is now possible to gain a better understanding of the physiological stress your athletes are experiencing. With time, practice and a little experimentation individuals' tolerance to training may be tracked and a greater understanding of optimal TLs will be developed, ending in greater performance. Using the indices of training described by Foster (1998) (see Table 2), the likelihood of excessive TLs is reduced, thereby reducing the chances of overtraining or injury. By completing this practical assessment of the TL, a greater understanding of optimal training will be developed, ultimately delivering optimal competitive performance on the field.

Another benefit of monitoring TLs with this method is that when combined with a regular sport specific performance test (e.g. Yo-Yo Intermittent Recovery Test), you can accurately track the performance responses to TLs. For example, at the completion of each planned training macrocycle the performance test can be completed to determine if your prescribed TLs are eliciting an adaptive or positive training effect (i.e. increased performance). With time, practice and a little experimentation individuals' tolerance to training may be tracked and a greater understanding of optimal TLs will be developed. This will enable you as a coach to accurately prescribe optimal loading and tapering TLs when required, resulting in greater performance.

For a coach, the real value of monitoring TLs in athletes comes with tracking individuals rather than group or team scores. Close monitoring of an individuals TL may provide a greater understanding of his/her tolerance to training allowing coaches to modify future loads that best suit individual athletes. We have listed below a number of ways in which the session-RPE method can be used to improve the training of athletes.

Monitoring player loads compared to intended loads

Valuable information can be obtained from monitoring training of individual players and the intended loads prescribed by the coach. Through monitoring the level of agreement between the planned load of the coach and the actual load of the athletes, the coach can determine if training has been implemented correctly, if the athletes are tired or adapting to training. For example, if a player begins to report higher perception of loads than the main group despite no apparent increased in training completed, then this dissociation between planned and actual TLs may be an early indicator that the player is not coping with the demands of training (Figure 2). This may suggest that the player has not adequately recovered from the previous training due to increases in muscle damage (Marcora & Bosio, 2007) or decreased carbohydrate stores in the muscle (Jeukendrup, Hesselink, Snyder, Kuipers, & Keizer, 1992; Snyder, 1998). Well-controlled scientific studies have shown that these physiological changes can cause an increase in perception of effort at standard workloads (Jeukendrup et al., 1992; Marcora & Bosio, 2007).

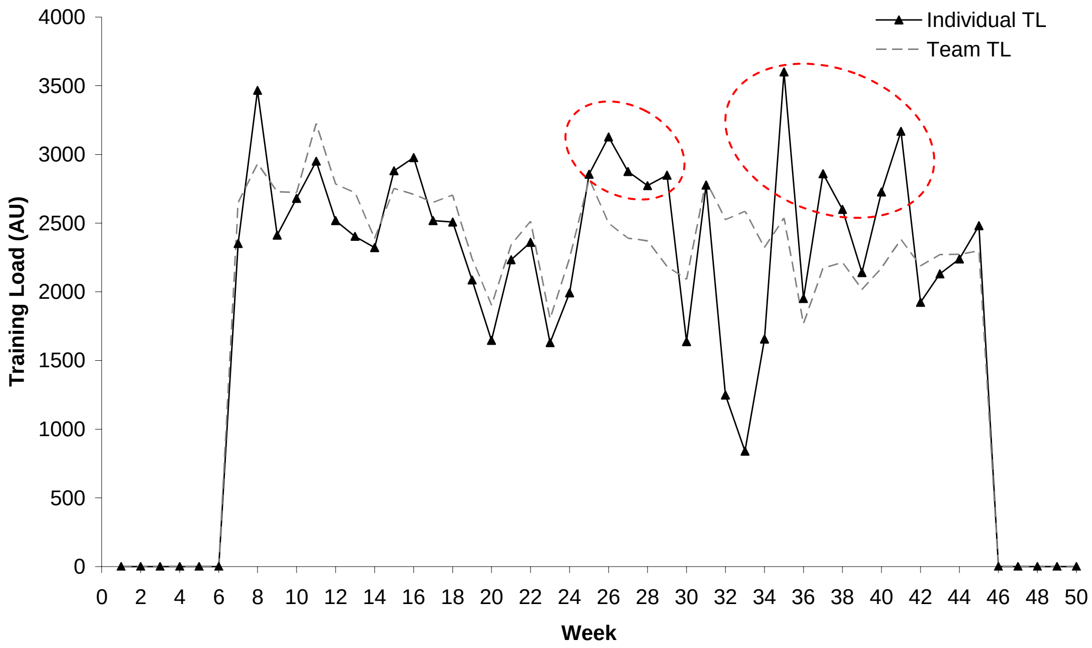

Figure 2: The dissociation between planned and actual TLs for an individual player may show when a player is not coping with training.

Ensuring that you have appropriate periodisation

It has been suggested that alternating hard-easy, reduces training monotony and may assist in the prevention of overtraining and illness (Foster, 1998). By monitoring daily TLs you can keep a close monitor on the actual periodisation of training and ensure that you ovoid overtraining, illness or injury. For example, during the competition season with football teams we are careful to check the TL for each individual player each week prior to the main training session for the week and following each match. In addition, we are also take great care to ensure that players do not train too hard for two days successively and also place particular importance on ensuring that low daily TLs (usually <200 AU) are completed on the two days following a match.

Soccer coaches usually implement the largest TLs in the mid-week period (i.e. 3 and 4 days prior (Wednesday and Thursday) to a game played on Sunday). Indeed, a case study from a professional Tunisian soccer club has shown that if the sum of the TLs completed on the 3-4 days prior to the game is in the range of 500-600 AU, then a load reduction or a pre-game taper period during on the two games prior to a game allows for appropriate recovery and good physical performance on the Sunday match. However, caution should be taken if the TL exceeds 650-700 AU during the 3–4 days before a game, as even a sharp reduction of TLs prior to the game (e.g. TLs of < 150 AU on Friday and Saturday (easy sessions)), may leave the players feeling 'heavy and tired' during the Sunday game. In addition to this, we also check for weekly trends for each individual in comparison to other players and themselves. In particular, we carefully check for players whose TLs are greater than one standard deviation above the team average and investigate their individual program to see if they are perceiving training to be higher than most of their team mates. This could mean that players are not coping with training demands and may require additional recovery (e.g. see Figure 2).

Detecting players who are not coping with training

Our experience has shown that younger 'rookies' (i.e. first year players), older and less fit athletes tend to report higher RPE scores for similar sessions during periods of arduous training. By closely monitoring these athletes you may be able to detect if your athletes are not coping with their training. For example, we have found often that young first year 'rookie' players in top-level teams almost always perceive their loads to be ~10-15% greater than their more experienced team mates. This effect may be due to the younger players not having established a strong physiological base and obtained strong fundamental qualities such in the areas of strength and endurance. Additionally, it may require at least an entire training year for players to becoming accustomed to the training and playing demands of top level football. In addition to these, players with lower levels of aerobic fitness may perceive a standard training bout to be higher than their fitter team mates. Therefore, it appears that players reporting higher TLs may also be of lower aerobic fitness.

Monitoring loads of different groups within a football team

In some sports, different playing positions / types of players can either tolerate, or are required to complete different TLs. The session-RPEs method can allow you to accurately monitor TLs of different groups within a team. Additionally, with the increase in fitness and sport science support staff, the training programs for football players are now becoming highly individualised. For example, our data shows that soccer goal keepers experience different training programs/loads than field players. Nonetheless, it is also apparent that unless a special individual training is performed for specific positional groups (i.e. wings or forwards), then the TLs still tend to be relatively homogeneous amongst the players within the same soccer team. However, we still recommend that coaches monitor special players/groups of players TLs individually if necessary. This is certainly the case of other team sports as volleyball or basketball where the 'playmakers' can experience different TLs than their team mates. Therefore, we recommend a good database system that can provide reports for groups or players within a team, and also has the capacity to compare groups or players within particular groups.

Monitoring Training Loads during Rehabilitation After an Injury

Another advantage of the session-RPE system is that it can be used to ensure loads are not progressed too quickly and/or appropriate training has been completed prior to return to sport. For example, criteria for train loads that must be completed can be set for the coaching staff before injured players can return to the main training group or to play. Additionally, session-RPE TLs can be monitored for players in rehabilitation (from injury) training to ensure that they are completing training doses that are similar to the main training squad (see Figure 3).

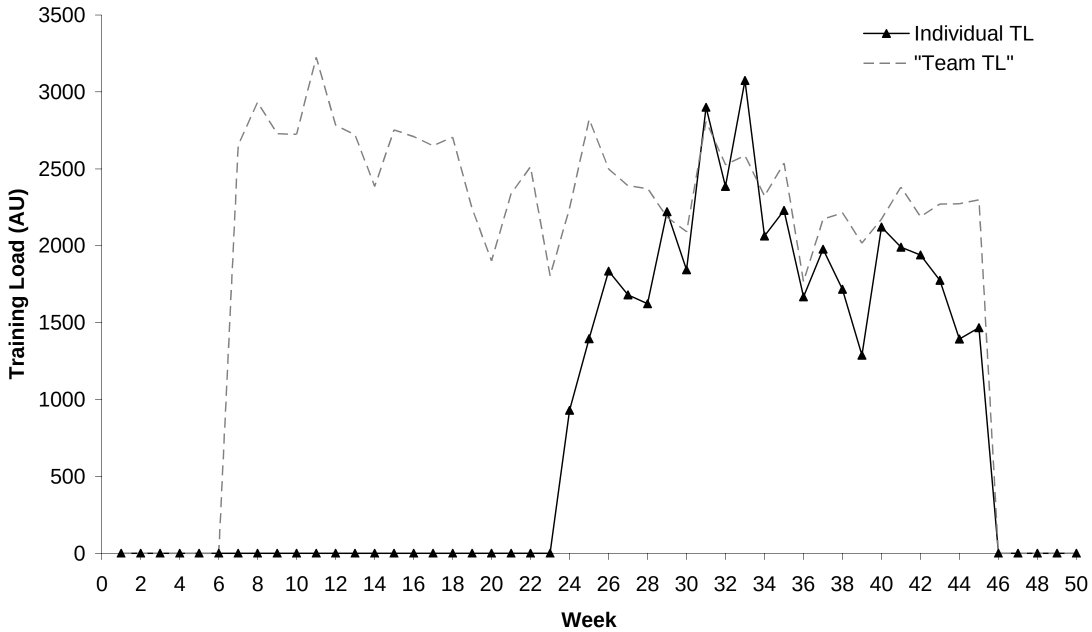

Figure 3: An example of how monitoring TLs can be used a safe and gradual return to training following a serious injury.

A System to Plan Training During the Competitive Phase

A common problem for coaches is determining the appropriate TLs to prescribe during the competition phase of the season. The simplicity of the session-RPE method allows it to be broadly applied to every player in a team. We have recently suggested a system using the session-RPE method where coaches can objectively plan TLs between matches during the competition season in football (Kelly & Coutts, 2007). This system was developed to account from the various factors that affect the amount of training that can be undertaken between games (Figure 4). These factors are the quality of the opposition, the number of training days between matches and any travel associated with playing away games. We suggested that a combination of these factors can be used to guide planning of the between-match weekly TLs. For example, a team preparing for a difficult match (i.e., strong opposition, little preparation time, and significant away travel) may plan a light training week so that any residual fatigue is minimized. Conversely, a home game against weaker opposition with a longer period between games may provide an opportunity to have an increased TL to improve the player's fitness levels.

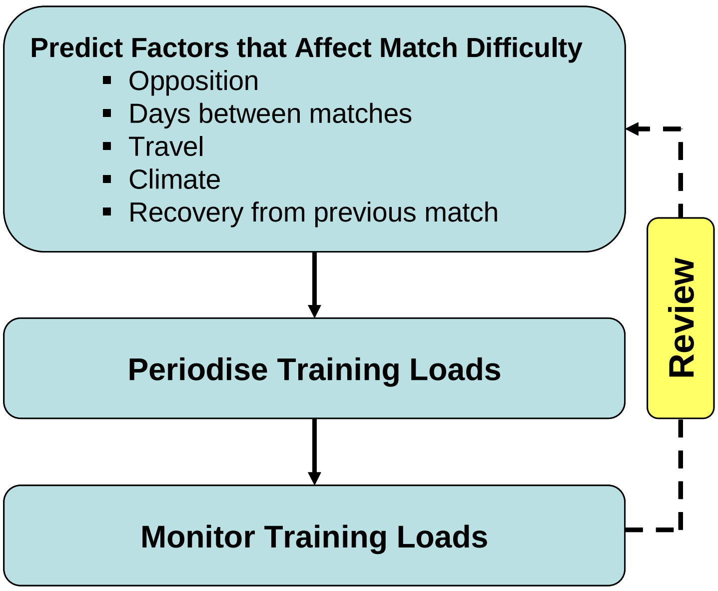

Figure 4: A schematic of a model suggested for planning training during the competition phase in football (Kelly & Coutts, 2007).

Examples of Periodisation for Football

Determining optimal loads for your soccer players is a difficult task. We have provided examples of various periodisation strategies for football players. In particular we have provided examples of the amount and distribution of TLs completed during the various training cycles.

Weekly loads

Our data from top level professional football teams show that the mean weekly TLs are usually higher in the preparation phases of the training year (see Figures 5 and 6). It is interesting that many football teams seem to complete TLs that are higher than the values (> 3200 AU) that have been associated with decreased physical performance in team sport (overreaching) (Coutts et al., 2007b; Coutts et al., 2007c). However, our experience also shows that many individual players can tolerate loads well in excess of this value. Indeed, we commonly observe players with individual TLs > 4500 AU during the general preparation period in leagues that have a longer duration preparation training macrocycles (i.e. 8-14 weeks) without significant effect on their performance. In contrast however, recent case studies from an Italian professional league that had a shorter preparation training macrocycle (~3weeks) showed that when the TLs were very high during the brief preparation period (~3000-3200 AU) then performance was compromised at the start of the season. The decrease in performance following this brief, intensive training period may be due players accumulating high levels of fatigue prior to the season. Indeed, in support of this, previous research from soccer has shown that soccer players entering a competition season with symptoms of overreaching experienced performance reductions during the course of an 11 wk soccer season (Kraemer et al., 2004).

There have been a wide range of TLs reported in football players at various times of the training season from other codes of football. For example, Gabbett (2005b; 2005a; 2006a; 2006b) has reported very low mean weekly TLs in lower level rugby league season were ~200 – 450 AU. Of interest, this investigator also reported reduced training-related injuries have been reported in semi-professional rugby league players who completed lower TLs (Gabbett, 2003, 2004a). Moreover, Coutts et al., (2007b; 2007c) reported symptoms of overreaching with reduced endurance and strength performance in rugby league players who completed > 3200 AU in the final week of progressive overload preseason training in rugby league. Additionally, Putlur et al (2004) reported an increased incidence of illness and injury in college soccer players who reported a TL of 2000 – 3600 AU during a nine week period. Impellizzeri et al., (2004; 2005) also demonstrated that TLs for talented young soccer players was of approximately ~2400 AU. These research findings suggest that there may be a TL 'threshold' for football players beyond which the additive effect of extra session has a negative impact on their performance and health.

However, regardless of these values, we urge that coaches interpret the TLs only in comparison to their athletes with particular focus on individual changes in comparison to previous loads and other team members. In that regard, we suggest that accurately monitoring TLs for 2 to 3 months will provide insight to the coach of the range of TLs in which this team seems fit during the games and a threshold over which the team is tired or with 'heavy legs' on the field during the games.

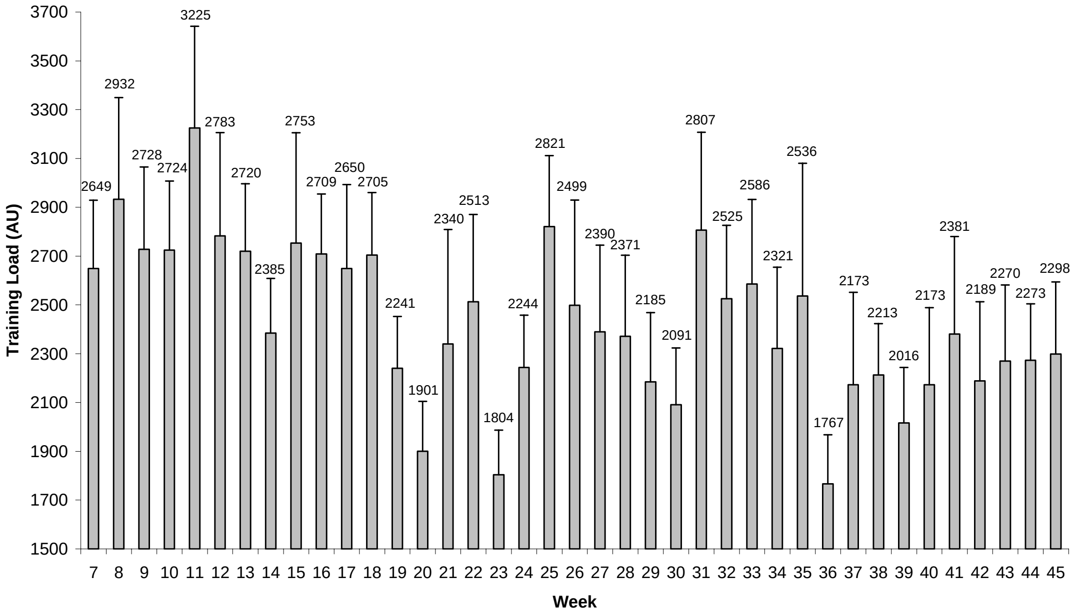

Figure 5: An example of the TLs (± SD) calculated by the session-RPE method for a professional Italian soccer team during an entire season.

It is also apparent that there is quite often large variation in TLs during the season, and therefore there are usually low monotony values for football players (see Figure 6 and 7). The training monotony values that are observed in most football teams are much lower than the values suggested to be of great concerns for athletes (> 2.0) (Foster & Lehmann, 1997). Indeed, since most football teams usually have 1 - 2 rest days that have no training during each week we suggest that high risk monotonous training is most likely to be observed during the off-season periods or for players who are in long-term rehabilitation programs.

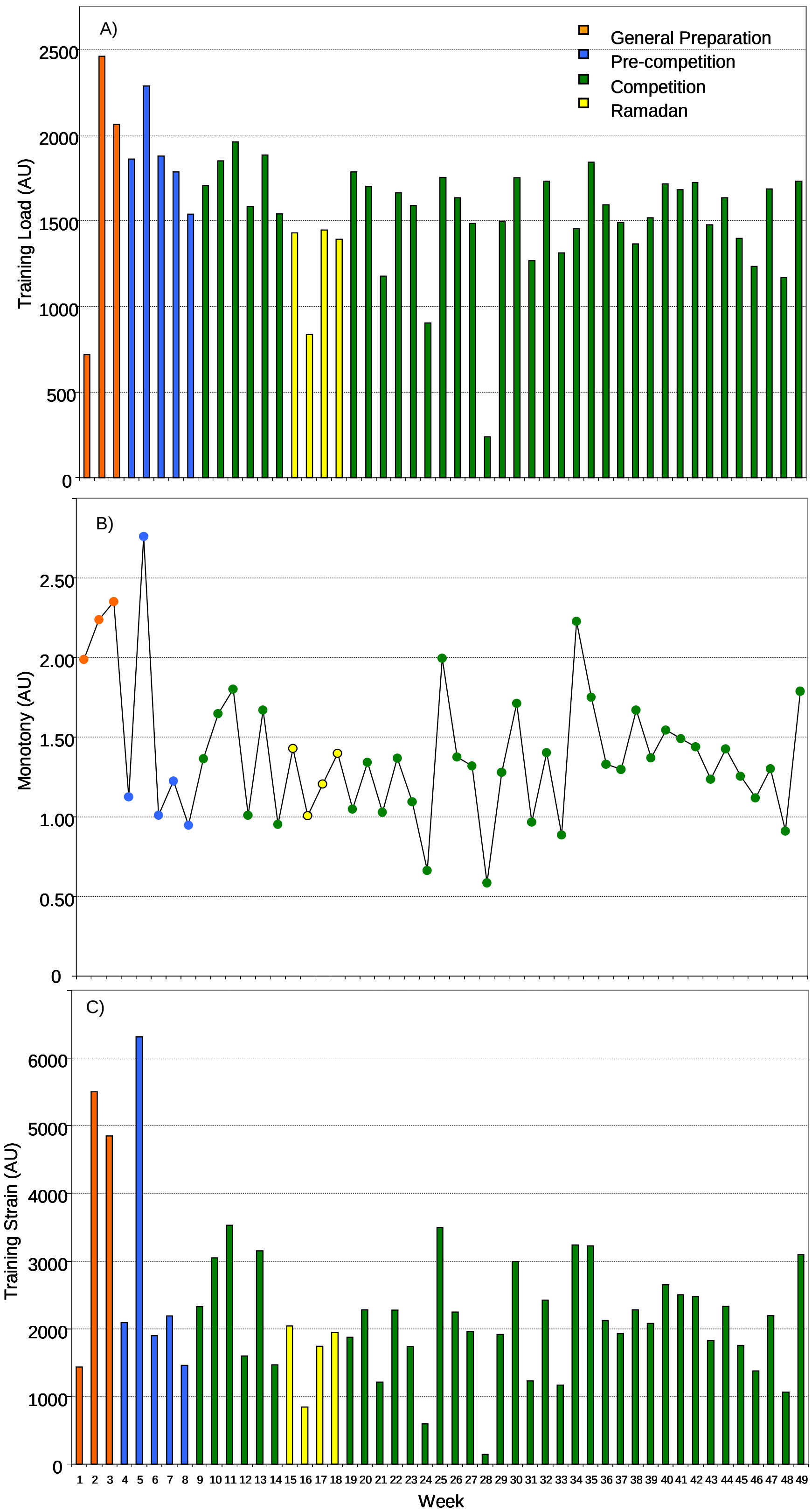

Figure 6: Weekly TL (A), monotony (B) and training strain (C) for a top-level professional Tunisian soccer team during an entire season.

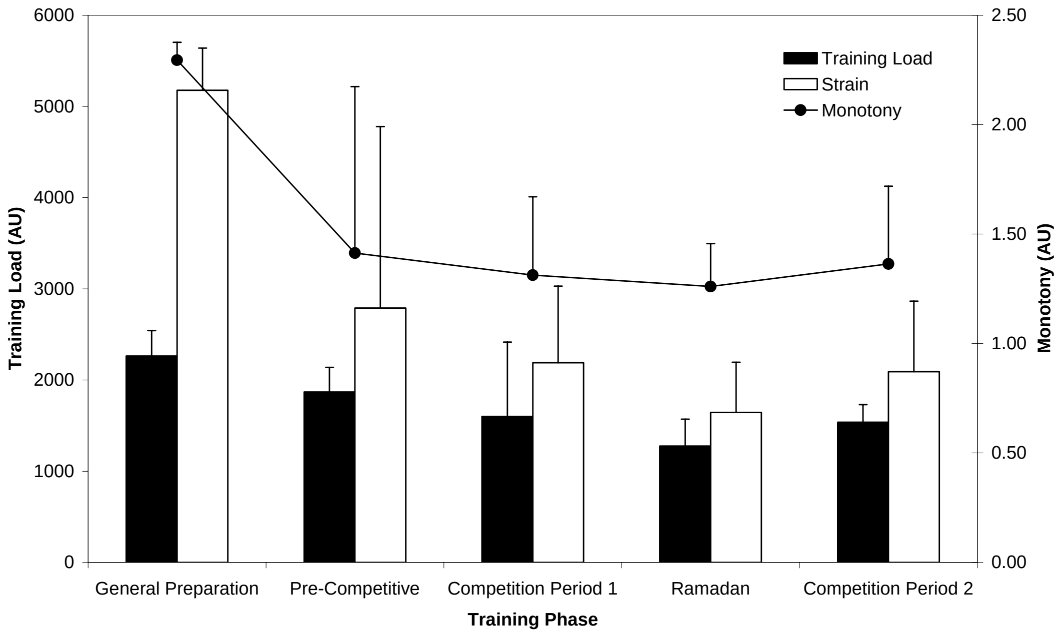

Figure 7: Mean (± SD) TL, training strain and monotony during the major macrocycle of a Tunisian professional soccer team.

Training Loads of the various types of training completed in football

Figure 8 shows the mean session TLs experienced by elite British women soccer players during a season. It is interesting to observe that the highest TLs come from matches and technical training sessions. This has previously been reported in other team sports such as professional rugby league (Coutts et al., 2008) and young male soccer players (Impellizzeri et al., 2005) and suggests that recovery practices should follow these higher doses of training.

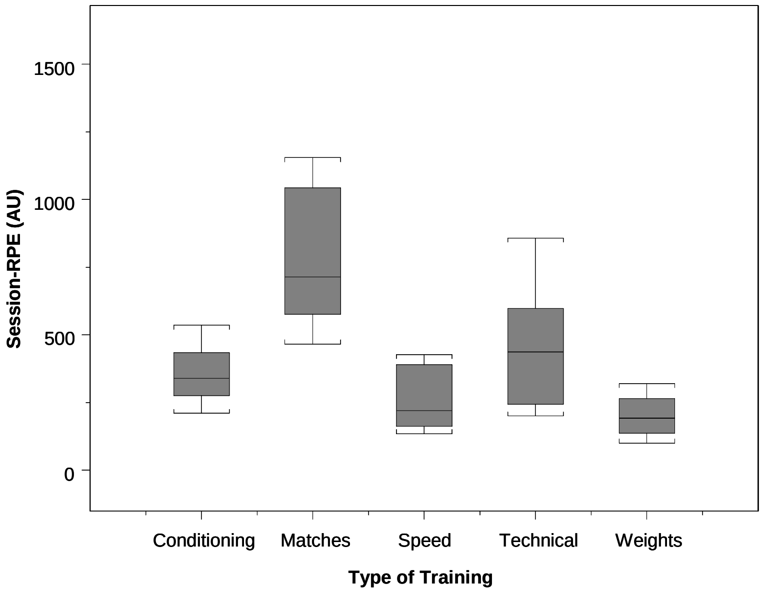

Figure 8: Boxplot of the session-RPE TLs (AU) for each of the common training modalities completed during an elite women's soccer team (Alexiou, 2007).

Additionally, it has been shown that there is periodisation in the various types of training in football teams (Gabbett, 2004b; Impellizzeri et al., 2004; Gabbett, 2005b; Impellizzeri et al., 2005; Coutts et al., 2007c; Coutts et al., 2008). For example, Figure 9 shows that a greater mean weekly TL for aerobic conditioning exercises and strength training are completed during the general preparation phase in football compared to the pre-competitive or competitive cycles of the year.

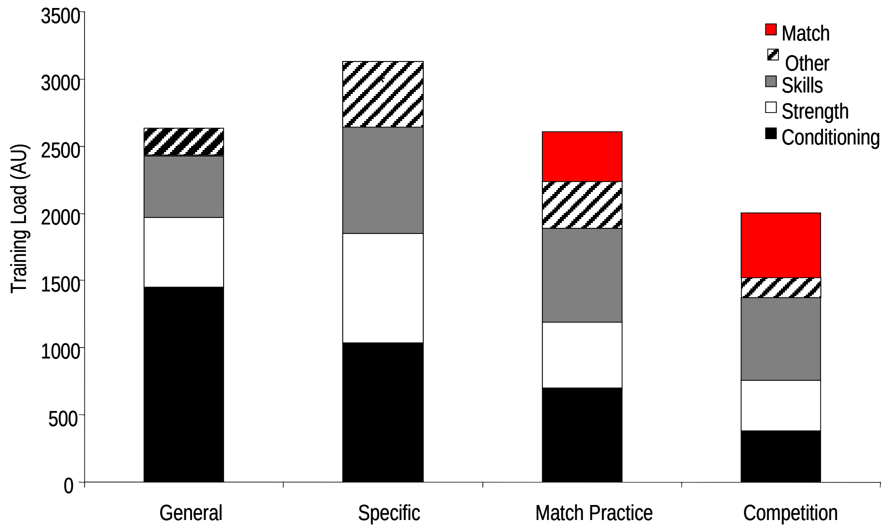

Figure 9: Distribution of training categories for a professional rugby league team during the various macrocycles of a training year (Coutts et al., 2008).

Between match periodisation

There have only been a few studies that have described the TLs completed between matches during a competitive season (Impellizzeri et al., 2004; Coutts et al., 2008). Figure 10 shows the typical daily TLs used by a professional rugby league team during a competitive season. It is interesting that the mean daily TLs are reduced when there is a very short break between matches (i.e. 5 day period). It is interesting that daily TLs were reduced for the 48 hr following to match, most likely to allow for physiological restoration (i.e. repletion of endogenous energy stores and synthesis of structural proteins). Indeed, we recommended that low TLs be completed during this period and that eccentric loading of the leg musculature be avoided to ensure best recovery from matches.

Our experience also leads us to recommend that a short intense, specific, skill-based training session either the day prior to, or on the morning of the match (depending on time of day for the match). We also recommend that players respond best to weekly TLs are on the < 2100 AU (including the match load). We have found that between 1800 - 2100 AU each week during the competition season is normal in elite Australian Football and Rugby league teams while normal values are around 1600 – 1900 AU in elite Tunisian soccer players. However, this recommendation must be interpreted with caution as continual low loads between matches may lead to decreases in fitness if sufficient training stimulus is not provided to the players. This is particularly true for the non-starters that every week experience lower TLs than starters and then, after some weeks/months may undergo a serious decrease in their levels of physical fitness. Conversely, if between match TLs are too high, the players may become ill, injured or show symptoms of overreaching (decreased performance) (Lehmann, Schnee, Scheu, Stockhausen, & Bachl, 1992; Filaire et al., 2001; Andersen et al., 2003; Filaire, Lac, & Pequignot, 2003; Putlur et al., 2004; Coutts et al., 2007b; Coutts et al., 2007c).

However, data obtained from professional Italian soccer clubs shows that the normal weekly TL during the competition period is about 2500-2600 AU (match included) with 600-700 AU derived from the match. Additional, analysis from the field-based performance test results also suggests that an excessive weekly TL during the competition season (match included) is >2800-2900 AU and at TL < 1900 is not sufficient to maintain performance during.

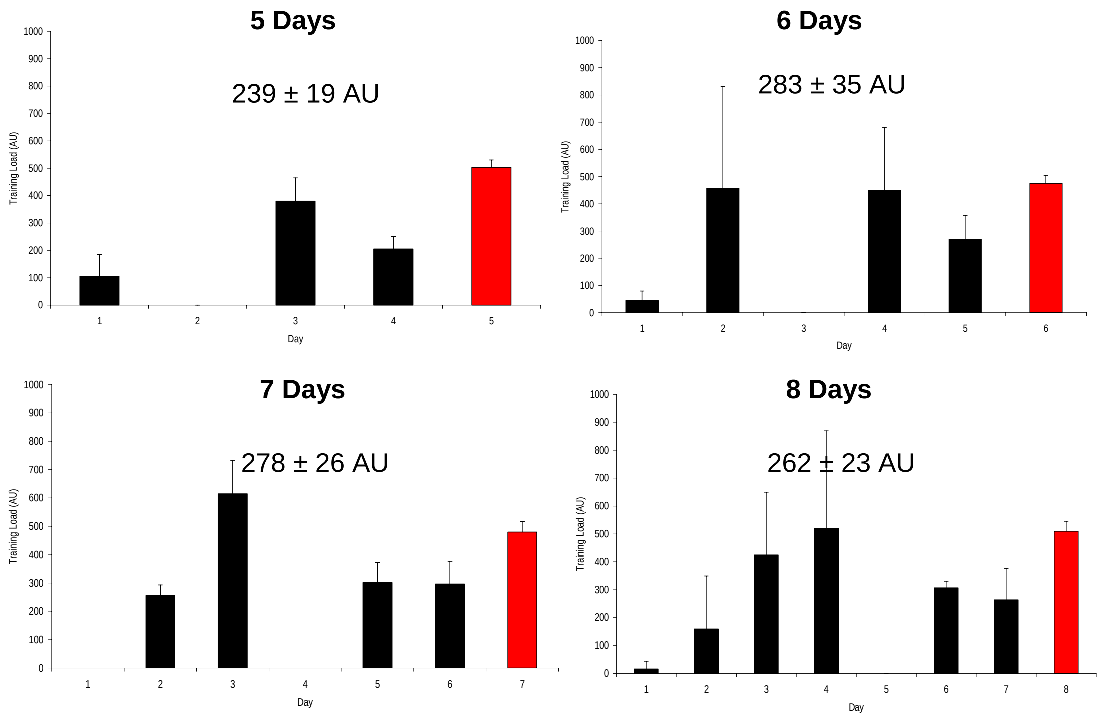

Figure 10: The mean daily TLs completed by a professional rugby league team during a season for a 5, 6, 7 and 8-day break between matches. The red columns represent match load.

Another important factor to consider when planning weekly training programs for football is amount of time available for training and recovery between games. In some competitions two or three games per week is not uncommon. During these periods, planning of ‘recovery’ training sessions is imperative. As an example, Impellizzeri et al. (2005) reported the weekly TLs of Italian professional soccer players during training weeks that consisted of either one or two games (Figure 11). It is interesting to note that even when games were scheduled, the rest day was not removed from the program. Indeed it is commonly believed that the day of rest following a game is fundamental for both physical and psychological recovery of players. It is also interesting to note the light session performed on Friday (for the one-game week) in order to recover from the peak TL accumulated during the Wednesday and Thursday double-session days.

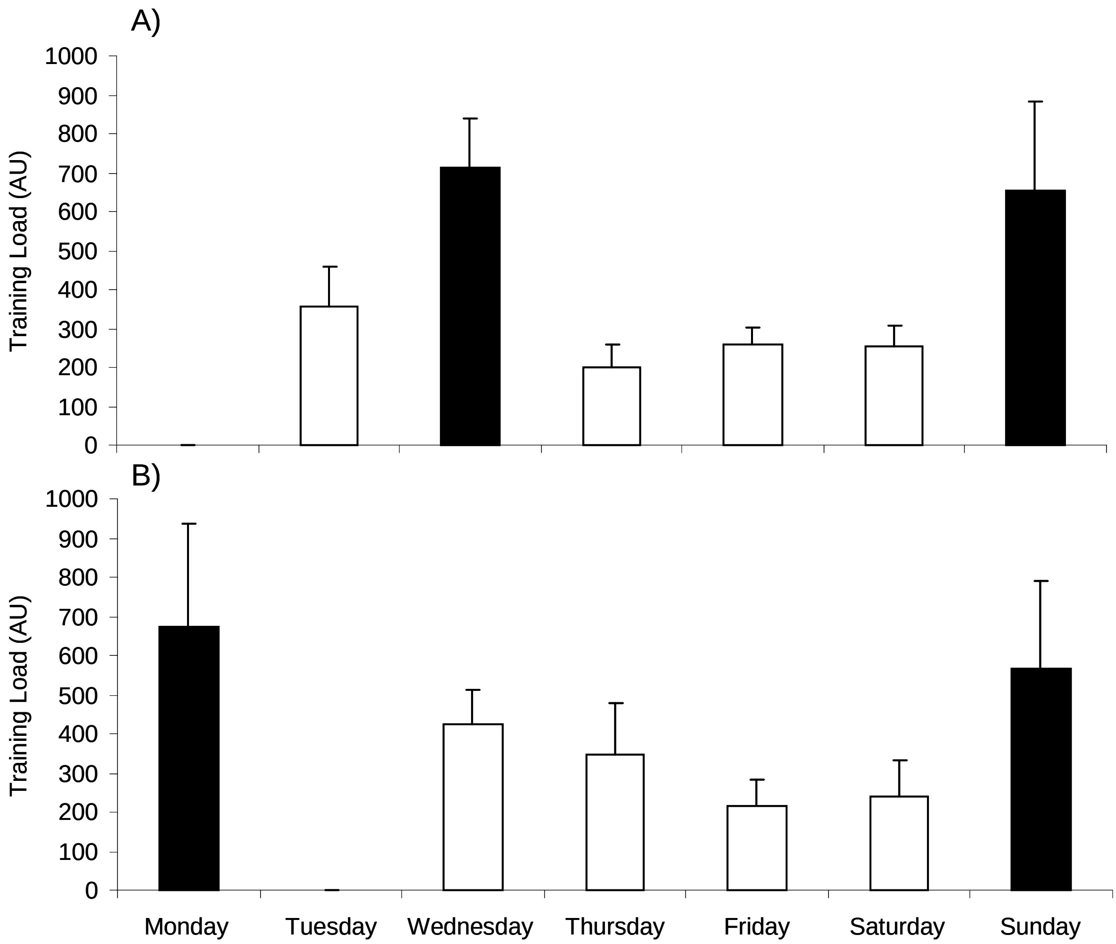

Figure 11: An example of placement of daily TLs during A) two games in a week, and B) one game in a week. Filled boxes (■) show games and open boxes (□) show games.

It is interesting to observe that the data obtained on this case study were collected in Italian third division professional players that are accustomed to high TLs. Indeed, the TL for the combined Wednesday and Thursday session is ~1200 AU, and the total weekly TLs are above 2400 AU. These TLs are higher than what is reported for professional soccer players from Tunisia. The most likely explanation for this is the different styles of play between these nations and also the coaching philosophy behind each teams training strategy. Rather than using these figures as a guide for all players, we suggest that the data present here be used to guide coaches and scientists in developing their own individual plans for their own players/teams.

It also appears that the TLs conducted prior to each match can affect the players match performance. Figure 12 shows a case study example of the relationship between the pre-match weekly TL (i.e. the weekly TL excluding the match) and physical performance (i.e. rate of skill involvement (per minute) during matches in Australian football shows that the higher the weekly TL, the lower the game involvement. Even, if the relationship is quite weak ($r = -0.61$), it is significant and consistently suggests that the week TL preceding a match seems to be inversely proportional to the physical outcome of the game. These data show that it is important to monitor the TLs completed by all players in a team on an individual basis to ensure that their between-match training programs may not be affecting their on-field performances.

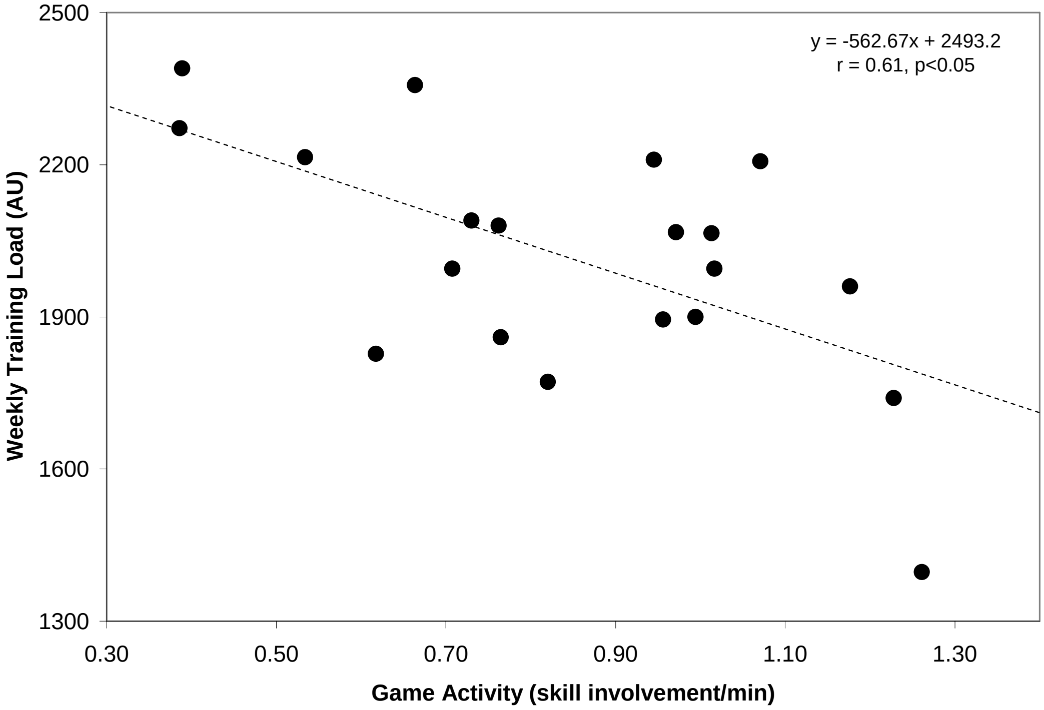

Figure 12: A case study showing the relationship measured between weekly pre-match TL and the player's rate of skill involvement (skill involvement per minute) in a game of professional Australian Rules Football.

One method that can be used to monitor TLs is to program the intended/planned TLs into on monitoring database/spreadsheet program and then follow-up the observed TLs daily to determine if training had been completed how it was intended. This system allows to the fitness coach and the coach to adjust daily training session and gain better control of the training process of the players. An example of TL monitoring on an Excel spreadsheet (Table 3) is provided for Tunisian professional soccer players below (Figure 13). Note that the sum until that day is provided for each day, this allows the coach to adjust following training according to the previous training session and training plan. In Table 3 below, the sum of TLs completed for the week (i.e. on the Saturday) is marked in yellow. This represents the goal TL for the individual to complete up until the day before the game. The example below demonstrates a week of good control of training periodisation, as the completed TLs are very close to the programmed ones.

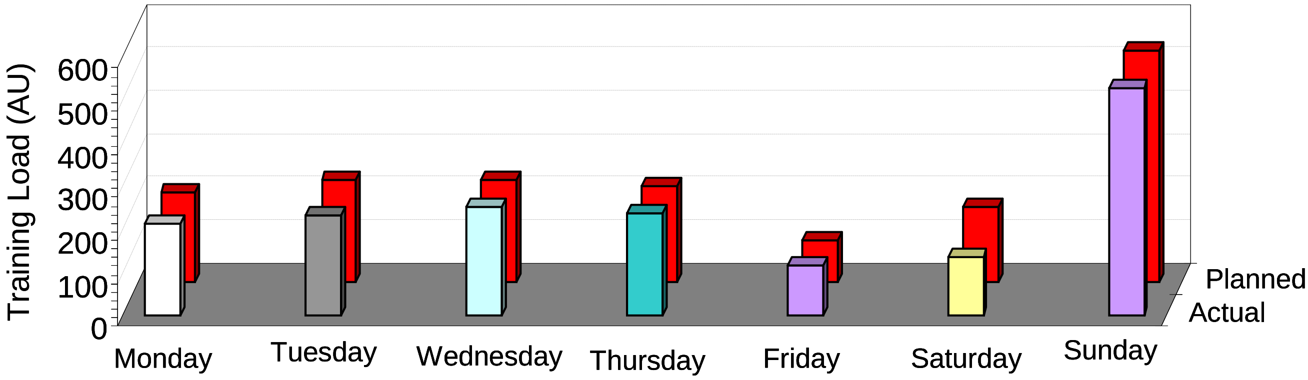

Figure 13: An example of a weekly TL monitoring with showing the planned versus actual TLs completed during a week of Inseason training in Tunisian Professional soccer. The red columns show the planned TLs and the coloured columns show the actual TLs in 10 starting players.

Table 3: An example of an Excel spreadsheet that can be used as a monitoring to check the agreement between the ‘planned’ versus ‘actual’ TLs in Tunisian professional soccer players.

Week 49

TL Planned	Vol	RPE	TL	Daily TL	
Monday	70	3	210	210	210
Tuesday	80	3	240	240	450
Wednesday	60	4	240	240	690
Thursday	75	3	225	225	915
Friday	50	2	100	100	1015
Saturday	70	2.5	175	175	1190
Sunday	90	6	540	540	1730
Σ Planned TL		Total	1730		
Monotony	1.79	SD	138		

	Player														
Actual TL	1	2	3	4	5	6	7	8	9	10	RPE	Vol	TL	Daily TL	Cumulative
Monday	2.75	2	3	3.25	3.5	2	2.75	3	3	3.5	2.88	74	213	213	213
Tuesday	3.5	2	4	3	3.5	3		2.5		4	3.19	72	230	230	442
Wednesday	4		4	5	3.5	3	4	3.5	3.5	4.3	3.86	65	251	251	693
Thursday	2.75	2	3.5	5	3	3	2.5	2.75	3.25	3	3.08	76	234	234	927
Friday	3	2	2.5	2	2.5	3	2.5	2		2.5	2.44	47	115	115	1042
Saturday	3	3	2.5	3.25	2	2.5	2.75	2	3	2.5	2.65	51	135	135	1177
Sunday	5.5	5	5.5	5	6.5	6		5	5		5.44	97	527	527	1704
							Σ Actual TL					Total	1704		
Week Sess	7						Monotony				1.80	SD	136		

Summary

A structured approach to planning and monitoring training offers many advantages for long-term development of football players and may assist in optimising performance of the team and individual players. The TL experienced by players is influenced by both training volume and training intensity. A precise understanding of TLs completed during training can be beneficial for both the coach and the player. The coach can use feedback from training to systematically modify future training so that future performances can be improved. Players can use this feedback for motivation for future training. TL can be monitored in many different ways, however, we recommend that the session-RPE method for quantifying training because it is simple to use, easy to understand and easy to implement. From a sports science perspective, a valid and reliable record of TL allows the effectiveness of different training to be assessed. It can be used to ensure that both sufficient TLs are implemented and that excessive loads are not too hard. Finally, overtime and with some practice accurate monitoring of TL will enable the coach to better understand the best training methods for individual players. Ultimately this may lead to improved football performance on the pitch.

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