



# *PERIODISATION AND MONITORING OF OVERTRAINING IN RUGBY PLAYERS*

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*Providing coaches, referees, players, and administrators with the  
knowledge, skills, and leadership abilities to ensure that safety and best  
practice principles are incorporated into all aspects of contact rugby.*

## **INTRODUCTION**

It has been known for a long time that it is not possible to maintain a physical and mental peak for more than a few weeks at a time. Some sporting codes, such as athletics and swimming, have tournaments at specific times during the year, making it easier for the athletes to plan their training to peak at the time coinciding with when they are expected to deliver their best performances. Because the year is structured, they are able to plan their training with a carefully designed, periodised training programme. This type of training programme is systematic and gradually prepares the athlete for the rigours of competition. A periodised training programme also considers recovery and ensures that there is an optimum balance between training load and rest and recovery. This approach results in predictable performances and a minimal risk of injury. With team sports, however, it is impractical to apply this systematic approach to training as the demands of the competition or season requires that the players are at a heightened level of performance throughout the competition or season, which may last for several months. Rugby players, in particular, are faced with very specific challenges as invariably they are expected to peak several times a year, coinciding with the playoffs of the different tournaments. Most rugby players competing at the top level complete in at least three tournaments during the year. For example, consider that the Super 14 tournament begins in February and continues into May, followed by a series of Test matches in preparation for the Tri-Nations tournament, which runs from July until September. Thereafter there is an end-of-year tour to the northern hemisphere, usually ending in the first week in December. The players who do not make the national team are required to play in the Currie Cup tournament, which runs in parallel to the Tri-nations tournament and continues until mid-October. The demands on the players are therefore enormous. Any deviation from peak performance will result in them losing their place in the team and for professional players this has financial implications.

In the foreseeable future these demands on the players are going to get even more excessive as the Super 14 tournament is expanded to include more teams. The organisers of the tournament are clearly being driven by financial forces and are planning to have six teams in the playoffs in the 2009 tournament, compared to four teams that made it to the playoffs from 1996 to 2008. The increased demands and expectations on the players are unreasonable and will lead to shortened careers and an increased risk of injury if the players are not managed properly. Whilst anyone who knows something about exercise science and physiology would advocate a rest period of at least four months to allow the players to recover and have a systematic period of base training in preparation for the next tournament, this is unlikely to happen in the foreseeable future. The complexities of rugby, with competitions in the northern and southern hemispheres, make the synchronisation of seasons difficult. Unlike the American football players of the NFL, who have a mandatory off-season period of four months, rugby players are at the behest of their administrators, who are obliged to ensure that the rugby calendar is full. Indeed, Percy

Montgomery, in 11 years of playing professional rugby, has only had two four-month periods of pre-season training (in 1996 and 2007). It is not surprising that the seasons which followed these two four-month periods of pre-season training were rated as his best as a professional player ([www.keo.co.za](http://www.keo.co.za), accessed 24/7/2008).

However, until such time as the season is regulated, considering both the northern and southern hemispheres and the season has a structure with a well-defined off season/pre-season period, strength and conditioning trainers will have to apply themselves even more to avoiding the risks associated with overtraining. Whilst much is known about the physiology of overtraining, this knowledge has to be used in a pragmatic way, considering that the rugby seasons are unlikely to change in the foreseeable future. This really leaves two options open to the staff managing the players: (i) monitor symptoms of fatigue very precisely so that players succumbing to chronic fatigue can be identified and managed, and (ii) coaches will have to learn how to rotate players more efficiently, without detracting from the strength and momentum of the team. The next section will discuss the symptoms of overtraining, the principles of periodisation, and suggest a monitoring program that detects subtle symptoms of fatigue, which may be used strategically to manage the players. It is logical to assume that if the training is adjusted when symptoms of fatigue manifest, that the full-blown symptoms of overtraining will be curtailed.

## **DEFINITIONS**

To have a “meeting of minds” it is important that all the terminology is used consistently and in the same context. For this purpose, “periodisation” and “overtraining” will be defined, particularly in the context of rugby.

### **Periodisation**

Periodisation is defined as the process of systematic planning of a short- and long-term training programme, by varying training loads and incorporating adequate rest and recovery. The concept of “periodisation” suggests that training loads should be applied in carefully planned and regulated amounts (29;30;79). The plan serves as a template for the player and fitness coach, and provides a structure for controlling the stress and recovery needed for inducing training adaptations (79). The terminology for dividing the cycles within a periodised plan are referred to as;

- macrocycles (long-term plan, usually one year),
- mesocycles (shorter plan, from about 2 weeks to several months), and
- microcycles (short plan of about 7 days) (83)

## **Overtraining**

Many terms have been used to describe the fatigue associated with training and in particular underperformance. Terms such as the “overtraining syndrome”<sup>(6)</sup>, “staleness”<sup>(62)</sup>, “chronic fatigue”<sup>(22)</sup>, “unexplained underperformance syndrome”<sup>(14)</sup>, and “burnout”<sup>(19;37)</sup> have all been used. The lack of consistency in terminology describing the condition has constrained the development of understanding of what causes the symptoms of fatigue and the associated impaired performance. This point has been discussed in a paper which attempted to reach some consensus and consistency in the definitions<sup>(58)</sup>. The paper suggests that overtraining should be used as a verb, and that a consequence of short-term overtraining is functional overreaching. This describes the normal fatigue associated with a hard training session and which dissipates during the recovery period, usually lasting a few days. Often there is a rebound to a heightened state of function and performance (supercompensation) once the symptoms of fatigue disappear. Non-functional overreaching is the condition that arises from more prolonged overtraining, and may take more rest (weeks) and reduced training loads for recovery. The overtraining syndrome, in contrast, suggests that there is multifactorial aetiology causing a situation where performance is impaired, accompanied by an increased risk of injury and illness. Stressors other than exercise may exacerbate this condition. Recovery from the overtraining syndrome may take several months<sup>(58)</sup>.

Concern about adopting imprecise terminology for use in the management of South African rugby players, prompted a workshop in November 2005. The goal of the workshop was to probe this condition and derive a working definition to be used in the management of rugby players in South Africa. Most of the support staff associated with professional rugby teams ( $\pm 100$ ) were at the meeting and agreed on the following definition to describe the symptoms of chronic fatigue that occurs in rugby players:

*“A syndrome in rugby players caused by continuous exposure to a rugby environment and which is associated with underperformance and increased risk of injury and or illness” (SA Rugby, unpublished internal report, 2005). The term “rugby environment” includes training, matches, travel and all other activities associated with rugby, and underperformance was defined as impaired performance related to training and matches, and includes decreased psycho-social functioning. This is the definition which will be adopted for the remaining section.*

## **PERIODISATION**

Whilst it is important to have a long-term plan, the day-to-day implementation of the plan should not be rigid, but rather should be modifiable based on the symptoms of the player<sup>(46;65)</sup>. Symptoms of the players can be assessed subjectively, but a more objective approach will be proposed later in this section.

The basis of periodised training is to distinguish between high-volume, low-intensity training designed to develop aerobic capacity, usually in the early part of the season, and high-intensity training designed to develop qualities linked to performance, as the season progresses <sup>(36)</sup>. This approach to training reduces the risk of overtraining, while the athlete is more likely to peak at a predictable time, usually coinciding with an important competition <sup>(36;83)</sup>. Another reason for this systematic approach to training is that different physiological systems vary in their retention rate after training <sup>(36)</sup>. Therefore, by varying the training loads as the season progresses, the desired adaptations, which are associated with peak performance, are achieved. The off-season period is where the most resistance training is performed and therefore also has the greatest application and manipulation of periodisation <sup>(32)</sup>. As mentioned earlier, the off-season is usually very short for the elite rugby player and therefore it is difficult to implement a comprehensive resistance training programme. At the rugby workshop in 2005, it was agreed that players need at least eight weeks of recuperation during the off-season, which includes one week at the end of the season for medical assessments, followed by two weeks of complete rest and at least four weeks of rehabilitation and individual conditioning away from the rugby environment (SA Rugby, unpublished internal report, 2005). At this stage, particularly for the national players, it is difficult to meet these minimum guidelines.

There are two main models of periodisation <sup>(33;67)</sup>: (i) the linear or classic model of periodisation, and ii) the non-linear or undulating model of periodisation. Classic periodisation programmes are divided into different training epochs: a macrocycle, which is subdivided into smaller epochs called mesocycles (e.g. 4 - 6 week blocks), and which are further subdivided into even smaller units called microcycles (e.g. 1-week blocks) <sup>(33)</sup>. This highly structured approach does not lend itself to a team sport where players are required to achieve higher levels of performance regularly during the season.

The non-linear model appears to benefit sports that have a long competitive season without requiring a concentrated build-up towards one specific event and is therefore more suited to rugby <sup>(33;67)</sup>. The main feature of this model is that the non-linear variation is more dramatic during the individual microcycles than the more traditional linear model <sup>(33)</sup>. The non-linear model caters for variation in training focus, i.e. changes in volume and intensity within a smaller time-period (e.g. a 10-day training cycle <sup>(67)</sup>). As with the linear model, this model also assumes that the player performs some form of base training before embarking on this undulating periodised training model.

A common feature of all periodised training programmes is that they share a common principle in having phases of general preparation, specific preparation, competition preparation and competition, transition or active rest <sup>(7)</sup>. Training in each phase has a specific goal.

A consideration in prescribing training for rugby players is that the relationship between training load and performance varies at different stages of the season. This can be demonstrated by a study of Olympic swimmers which showed that the relationship between training load and performance varied according to the different phases of training <sup>(36)</sup>. Low-intensity training had a positive effect on performance in the long term, suggesting that this type of training is necessary to induce the adaptation of various physiological mechanisms necessary for the subsequent high-intensity training. This study also concluded that the swimmers' response to a given training volume may vary between seasons and even between training sessions. They found that, at the elite level, training variables only accounted for 30% of the variation in performance <sup>(36)</sup>. This supports the concept that training programmes need to be highly individualised for elite athletes <sup>(36)</sup>. In sports such as rugby, this can only be achieved if the players are monitored regularly, so that the various states of fitness of each player can be considered in the prescription of training.

### **THE PHYSIOLOGY OF OVERTRAINING**

Given that training adaptations arise from the balance between repetitive training stimuli and the recovery and regeneration after each stimulus, any imbalance (i.e. too much training and/or insufficient recovery) may cause a maladaptation or failure to adapt. This problem can be confounded by factors such as inadequate nutrition (energy or carbohydrate), illness (particularly upper respiratory tract infections), psychological stressors (associated with work, team, coach, family, financial matters) <sup>(58)</sup>.

A summary of the symptoms of underperformance as a result of overtraining are shown in table 1.

**Table 1: Symptoms associated with overtraining <sup>(43)</sup>**

- Poor performance
- Severe fatigue
- Muscle soreness
- Overuse injuries
- Reduced appetite
- Disturbed sleep patterns
- Mood disturbances
- Immune system deficits
- Concentration difficulties

Any diagnosis for underperformance needs to exclude factors such as endocrinological diseases (thyroid, adrenal gland or diabetes), anaemia arising from iron deficiency, and infectious diseases (myocarditis, hepatitis, glandular fever) <sup>(58)</sup>. In South Africa, with its high incidence of tuberculosis (TB), this disease also needs to be excluded before underperformance can be properly diagnosed. Indeed, a case of TB has already been documented in a professional player who presented with symptoms of chronic fatigue (Kohler, personal communication).

Physicians dealing with rugby players who present with symptoms of underperformance and fatigue need to take note of the study done in Australia which showed that 81% of elite athletes and 91% of coaches expected that the doctor would take a blood sample as part of the consultation <sup>(24)</sup>. These data are contrary to current knowledge about the diagnostic ability of a blood sample. Although blood samples may exclude various illnesses which can be measured in the blood, they do not have any diagnostic value for underperformance. A study has shown that while the various haematological parameters changed through a season (iron, transferrin, haemoglobin, haematocrit) in elite rugby players (Italian National rugby team) <sup>(3)</sup>, they were not associated with changes in performance or fatigue.

The ratio of the plasma testosterone/cortisol has been proposed as a marker of overtraining <sup>(4,88)</sup>. A study on rugby league players showed that the testosterone/cortisol ratio decreased following a period of training overload. However the authors were cautious in suggesting that the findings had any practical value <sup>(18)</sup>. Firstly, a regular blood sample from each player is impractical and, secondly, the predictive value of how changes in the testosterone/cortisol ratio can predict imminent fatigue are limited <sup>(38)</sup>. The testosterone/cortisol ratio can also be measured in saliva, and there are suggestions that changes in testosterone/cortisol track psychological changes <sup>(55)</sup>. However, it is premature to use this as a monitoring tool until further data are available on the validity of this measurement <sup>(25)</sup>.

In general, the practical value of measuring changes in hormones in the blood, with the purpose of making a diagnosis, is rather limited. This can best be summarised because of the inter-assay variability in measuring hormone concentration, the effect of food and prior exercise on hormone concentration, the pulsatility of some hormones, and the diurnal variation in circulating hormone concentrations <sup>(58)</sup>. For these reasons, it would be impractical to justify taking a blood sample to measure hormone concentrations as a way of detecting the onset of underperformance.

A systematic approach for clinicians managing athletes has been proposed. The first steps are designed to exclude confounding factors which may cause symptoms of fatigue. As chronic fatigue can be the presenting symptom of many curable and harmful diseases, medical conditions which cause chronic fatigue have to be excluded. The clinician must then be able to differentiate between chronic fatigue

associated with training, chronic fatigue from other medical causes, and also between the chronic fatigue syndrome and the overtraining syndrome <sup>(21)</sup>.

Although various mechanisms explaining the overtraining syndrome have been proposed <sup>(1;6;35;43;51;59)</sup>, the most attractive theory links excessive training and competing to repetitive tissue trauma, of muscle, connective tissue and bony structures. This trauma results in chronic inflammation <sup>(81)</sup>. It is further proposed that traumatised tissue synthesises cytokines, a group of inflammatory molecules which coordinate recovery in the different systems of the body. The veracity of this theory however remains to be proved.

In summary, the symptoms of the overtraining syndrome arise from a failure to adapt as a result of an imbalance between stressors (training, nutrition, mental state) and recovery and regeneration. No single test has been identified which consistently predicts the imminent appearance of symptoms. Therefore it is logical to assume that if subtle symptoms of chronic fatigue can be monitored and detected before they manifest as serious and persistent symptoms of fatigue, the rugby player will have a better chance of sustaining a high volume of training, without developing full-blown symptoms. The next section will discuss practical ways of gathering information to monitor levels of fatigue in players. The ultimate goal is to use this information to adjust the prescription of training. The recommendations of the methods have been made, considering a few assumptions and requirements: (i) several players have to be monitored simultaneously, (ii) there is limited time each day for gathering information and this must not intrude on the coaches' time with the players, (iii) the tests cannot be aversive or exhausting, and (iv) the tests have to be sufficiently sensitive to detect early symptoms.

### **STRATEGIES FOR MONITORING PLAYERS**

The fitness trainer needs to be able to answer the following questions on a daily basis:

1. How hard did the player find the session?
2. How hard was the session?
3. How did the player recover from the session?
4. How is the player coping with the cumulative stress of training?

While some fitness trainers have intuition and experience, which allows them to subjectively answer these questions by observation and discussion with the players, a more objective approach of gathering information will provide more sustainable success, as training load can then be adjusted in accordance with how the player is feeling and adapting.



### ***How hard did the player find the session?***

#### Rating of Perceived Exertion (RPE)

A rating of perceived exertion (RPE) is based on the understanding that a player can inherently monitor the physiological stress their body is experiencing during exercise. A player's perception of effort is translated into a numerical score between 6 and 20 in the Borg 6-20 RPE Scale <sup>(9)</sup>, Table 2. This table has subsequently been adjusted to a 10-point scale <sup>(10)</sup> (Table 3).

This principle of monitoring physiological stress was demonstrated in a study by Robinson et al (1991), who found that during steady-state exercise the athletes' reported RPE correlated well to their average heart rate recorded during the training sessions. They concluded that it may be possible to adjust training intensity by using perceptions of effort <sup>(72)</sup>.

**Table 2: Borg 6-20 RPE Scale<sup>(9)</sup>**

6	
7	Very very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very very hard
20	

Ratings of perceived exertion have been proposed as possible detectors of impending overreaching, with RPE being found to increase during constant exercise load <sup>(90)</sup>.

### ***How hard was the session?***

#### Quantifying training using RPE

Several methods have been used to quantify exercise training intensity and have been reviewed by Williams and Eston (1989)<sup>(92)</sup> and Hopkins (1991)<sup>(39)</sup>. One such method quantifies a training session into a unit “dose” of physical effort. According to this method, a person’s heart rate response to exercise (an indicator of intensity), along with the exercise duration, collectively called a training impulse (“TRIMP”), may be a valid measure of physical effort<sup>(5;63)</sup>. However, the use of this method of quantification is limited by the necessity to use heart-rate monitors throughout training. The technique is also restricted to endurance types of exercise, which are characterised by steady-state workloads and therefore cannot be used with resistance training. Its use during intermittent high-intensity exercise is also questionable.

Foster et al (1996)<sup>(27)</sup> subsequently introduced a Session RPE score to measure training load instead of using heart-rate data, in an attempt to simplify the quantification of training load. The Session RPE scale is a rating of the overall difficulty of the exercise bout, obtained 30 minutes after the completion of the exercise<sup>(27)</sup>. It is based on the Borg Category Ratio (CR-10) RPE Scale, which translates the athlete’s perception of effort into a numerical score between 0 and 10. This test is designed to encourage the athlete to respond to a simple question “How was your workout?” with the goal of getting an uncomplicated response that reflects the athlete’s global impression of the workout. The Borg scale and the Session RPE adjustments are shown in Table 3.

**Table 3: Borg category ratio scale <sup>(10)</sup> and Session RPE Scale <sup>(27)</sup>**

Category ratio scale		Session RPE
0	Nothing at all	Rest
1	Very weak	Really easy
2	Weak	Easy
3	Moderate	Moderate
4	Somewhat strong	Sort of hard
5	Strong	Hard
6		
7	Very strong	Really hard
8		
9		Really, really hard
10	Very very strong	Just like my hardest race

According to Foster, a daily session load (training impulse) can be calculated by multiplying Session RPE (Borg Category Ratio (CR-10) RPE Scale) by the duration of aerobic exercise in minutes, or the number of repetitions performed in resistance exercise(26;28) (Equation 1)

$$\text{Session load} = \text{Duration (or number of repetitions)} \times \text{Session RPE} \quad (\text{Equation 1})$$

This method has been shown to be a valid and reliable measure of exercise intensity in aerobic exercise when compared to heart-rate-based methods <sup>(28)</sup>. Session RPE has also been used to measure exercise intensity in resistance training <sup>(20;56)</sup>. In these studies RPE was influenced more by resistance load than by volume, so that performing more repetitions with a lighter load was perceived as being easier than performing fewer repetitions against a heavier load<sup>(20;56;86)</sup>. The session RPE method provides reasonably accurate assessments of training load compared with the TRIMP method ( $r = 0.73$ ), but the method deviates in accuracy when proportionally more time is spent training at low or high intensity <sup>(12)</sup>.

The use of Session RPE to quantify training load has potential in being a mode- and intensity-independent method that can be used for multiple types of exercise, such as high-intensity, or non-steady state exercise like resistance training, high-intensity interval training or plyometric training <sup>(28)</sup>. However, there are questions about the accuracy of its use in both aerobic and resistance training. Impellizzeri et al (2004) found only moderate correlations ( $r = 0.50-0.85$ ) between training loads calculated using Session RPE and a heart rate based method for members of a soccer team <sup>(40)</sup>. They

suggest that the RPE based score cannot yet replace the heart rate based methods as a valid measure of exercise intensity as only 50% of the variation they measured in heart rate could be explained by the session RPE<sup>(40)</sup>. Sweet et al (2004)<sup>(86)</sup> and McGuigan et al (2004)<sup>(56)</sup> found that the RPE varied significantly among different muscle groups used during resistance exercise performed at the same percent of 1-repetition maximum. They explained this phenomenon by proposing that perceived exertion increases as muscle mass (and hence metabolic demand), range of motion and the number of joints involved in a movement increase. They further suggested that the order in which the exercises are performed, the fibre type of the muscle used, the mode of exercise for which the athlete is trained (i.e. the level of experience the athlete has in resistance training), as well as the time at which RPE is reported, may also affect RPE<sup>(86)</sup>. For example, a study by Day et al (2004) found no difference between session RPE and mean RPE recorded after 1 set of resistance exercise<sup>(20)</sup> at equivalent exercise intensities, whereas Sweet et al (2004), who recorded mean RPE after 2 sets, did report differences. It was subsequently found that RPE increased significantly between the first and second sets of resistance exercise<sup>(86)</sup>.

The complex interaction of many factors that contribute to the personal perception of physical effort, including hormone concentrations (e.g. catecholamines), substrate concentrations (e.g. glucose, glycogen, lactate), personality traits, ventilation rate, neurotransmitter levels, environmental conditions or psychological states may limit the use of RPE in accurately quantifying or prescribing exercise intensity<sup>(92)</sup>. However, although using objective physiological measurements such as heart rate may be a more accurate way of calculating training load (for steady state endurance training), the subjective measure of RPE remains useful for a various types of exercise. Thus if heart rate monitors are not available, or an easier, more practical means of reporting and calculating training load is required, the RPE method measures the “hardness of the training session” with sufficient accuracy. The research on the RPE method and resistance training shows that the timing of the measurement is important and should be kept constant.

The fitness trainer should also rate the “hardness of the training session” according to the same scale. The way the scores (players vs. trainers) track one another can be informative.

### ***How did the athlete recover from the session?***

The basic principle of training is that breakdown (training) is followed by recovery (rest), which results in an “overshoot” in performance and adaptation<sup>(43)</sup>. It follows that the greater the training load, the more recovery is needed. A sequence of these training load/recovery units stimulates adaptations which are associated with physical performance. Imbalances (too much training/insufficient recovery) over time will result in symptoms of chronic fatigue.

A scale for monitoring recovery, analogous to the Borg 6-20 point scale<sup>(9)</sup> has been proposed <sup>(43)</sup>. This is shown in Table 4.

**Table 4: The recovery scale <sup>(43)</sup>**

6	
7	Very, very poor recovery
8	
9	Very poor recovery
10	
11	Poor recovery
12	
13	Reasonable recovery
14	
15	Good recovery
16	
17	Very good recovery
18	
19	Very, very good recovery
20	

According to Kenttä and Hassmén (1998) there are two versions of this test: (i) perceived recovery, (ii) action recovery. For the perceived recovery the athlete is asked before bedtime to rate his/her recovery for the previous 24 hours, including the previous night's sleep, using the scale described in Table 4. There is only one study which has reported using the received recovery scale <sup>(65)</sup>. In this study an elite Japanese sprinter was studied for 1 year during which time his session RPE and recovery scores <sup>(43)</sup>, amongst other variables, were monitored on a daily basis. The authors developed a mathematical model, which enabled them to predict performance with a high degree of accuracy. Although there are not much published research data on this technique, the method is based on sound principles, has excellent practical value as it is easy to administer, can be done on a daily basis, and educates the athletes about the nuances of recovery.

For the action recovery the athletes score themselves for each of the four main categories: (i) nutrition and hydration, (ii) sleep and rest, (iii) relaxation and emotional support, and (iv) stretching and active rest

shown in more detail in Table 5 <sup>(43)</sup>. These four categories summarise factors that can affect recovery and need to be considered when information is gathered about recovery status <sup>(43)</sup>.

There are no published data using the action recovery method although there is a practical description on the test described on a website <sup>(54)</sup>. As with the perceived recovery test, the action recovery is measured over the previous 24 hours. The score is measured for each of the four categories. A total of 20 points are available for this test and a score of less than 13 points indicates that recovery from training is incomplete <sup>(43)</sup>. An example of the scoring is shown in Table 5 <sup>(54)</sup>.

**Table 5: An example of the scoring for action recovery <sup>(43;54)</sup>**

<b>Nutrition</b>	<b>Points</b>
• Breakfast	1
• Lunch	2
• Supper	2
• Snacks between meals	1
• Carbohydrate reloading after practice (assuming healthy, quality balanced meals)	2
• Adequate hydration through the day	1
• Adequate hydration during/after training	1
<i>Maximal subtotal</i>	10
 <b>Sleep and rest</b>	
• Good night of quality* sleep	3
• Daily nap (20-60min)	1
<i>Maximal subtotal</i>	4
 <b>Relaxation and Emotional Support</b>	
• Full mental and muscular relaxation after training	2
• Maintaining a relaxed state throughout the day**	1
<i>Maximal subtotal</i>	3
 <b>Stretching and active rest</b>	

• Proper cool down after each training period	2
• Stretching all the exercised muscle groups	1
<i>Maximal subtotal</i>	3
<b>TOTAL</b>	20

\* individual perception

\*\* the goal is to use a variety of relaxation techniques (breathing, massage, etc.)

This test draws attention to the psychosocial cues which are associated with poor recovery. The application of this method allows the coach to monitor recovery and match this to the training load. While more research is needed to determine how to interpret the scoring system, the concept of monitoring recovery using this test system is practical, easy to use and should be of practical benefit.

### ***Muscle pain***

It is inevitable that after a hard training session the muscles will be stiff and painful<sup>(17)</sup>. The pain is usually delayed and peaks 24 to 48 hours after the activity which causes the pain. The aetiology of this pain has been well studied and seems to have its origins in inflammation<sup>(70;80)</sup>. The pain can range from a mild stiffness to a more serious pain, which affects muscle function<sup>(16)</sup>. It has been shown that when exercising with stiff muscles there is a higher exercise stress during submaximal exercise<sup>(31)</sup>. Trying to sustain a high training load with sore muscles will lead to symptoms of overreaching<sup>(58)</sup>. As rugby is a contact sport during which players incur muscle damage<sup>(87)</sup>, it is important to monitor any symptoms of muscle pain which may result from training and competition. Training load can then be adjusted in accordance with the symptoms of pain. There are no clear guidelines about what level of muscle pain should be reached before training load is reduced. Decisions about muscle pain and training should be made based on the player's position and the phase of the season.

This pain can be measured objectively with a specially designed pressure probe. However, we have found that a subjective pain assessment is just as accurate and as quick and easy to administer as the objective assessment<sup>(47;77)</sup>. For this assessment the subjective scale ranges from 0 to 10, where 0 represents "no pain", and 10 represents "maximal, unbearable pain". Specific muscles should be identified for this assessment, based on the type of training and the player's position. This assessment should be done at the same time of day, every day and following a standardised movement (e.g. knee bend). If the fitness trainer is organised he can gather this information in minutes from the whole team.

### ***How is the player coping with the cumulative stress of training?***

#### *Profile of Mood States*

The Profile of Mood States (POMS) questionnaire was published in 1971 as a self-report test designed to measure the psychology of mood state, mood changes and emotion <sup>(57)</sup>. The POMS test has 65 items that measures six identifiable moods or feelings: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment. The respondents answer according to a scale (0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, 4 = extremely). The test was initially designed for patients undergoing counselling or therapy but has evolved to be used in sport.

Studies on swimmers showed that mood state disturbances, measured with the POMS, increased in a dose-response manner as the training stimulus increased, and that these mood disturbances fell to baseline levels with a reduction of the training load <sup>(62)</sup>. Filaire et al (2001) found that the moods of soccer players improved with an increase in winning performances despite an increase in the intensity of training <sup>(25)</sup>. They also observed an increase in depression and tension during a period of poor performances, where relationships between players and coach, financial and family problems, and levels of fatigue appeared to be unchanged. Reitjens et al (2005) studied various physiological, biochemical and psychological markers (using the shortened POMS score) in an attempt to determine whether overreaching could be diagnosed early <sup>(71)</sup>. Subjects underwent cycling training where the training load was increased by 100% and maintained for 2 weeks in an attempt to induce overreaching. Cycling performance was not impaired but cognitive speed tests worsened, indicating the development of central fatigue. There was a trend towards a decline in mood on the POMS questionnaire. They concluded that changes in central fatigue may be the first and most sensitive parameter with which to detect overreaching, with changes in mood being secondary markers of this state <sup>(71)</sup>. This conclusion however needs to be supported by further experimentation in studies where symptoms of overreaching are induced. Collectively these studies show that the POMS test can be informative, providing other information about the athlete is collected simultaneously.

#### ***Daily Analysis of Life Demands for Athletes***

The Daily Analysis of Life Demands for Athletes (DALDA) was developed as a sport-specific test to monitor an athlete's specific stress of training <sup>(73)</sup>. This test monitors the physiological stress of training in addition to the stresses that may exist outside the training environment, and which may contribute significantly to the total stress exposure. The content of the DALDA has been validated, the readability checked and the reliability established <sup>(73)</sup>. The DALDA can be administered in a few minutes throughout a training season. It is designed so that it can easily be incorporated into a training logbook with the scoring being done by the player or coach.



The first part of the test (Part A) involves the general sources of stress that occur in daily living (Table 6). The second part of the test (Part B) involves symptoms of stress (Table 7). The definition for each question occurs adjacent to each variable.

**Table 6: Sources of life stress for the DALDA including their definitions<sup>(73)</sup>**

<b>Variable</b>	<b>Definition</b>
Diet	Consider whether you are eating regularly and in adequate amounts. Are you missing meals? Do you like your meals?
Home life	Have you had any arguments with your parents, brothers or sisters? Are you being asked to do too much around the house? How is your relationship with your wife/husband? Have there been any unusual happenings at home concerning your family? How are you getting on with your roommates?
School/College/Work	Consider the amount of work that you are doing there. Are you required to do more or less at home or in your own time? How are your grades or evaluations? Think of how you are interacting with administrators, teachers or bosses.
Friends	Have you lost or gained any friends? Have there been any arguments or problems with your friends? Are they complimenting you more or less? Do you spend more or less time with them?
Training and exercise	How much and how often are you training? Are the levels of effort that are required easy or hard? Are you able to recover adequately between efforts? Are you enjoying your sport?
Climate	Is it too hot, cold, wet or dry?
Sleep	Are you getting enough sleep? Are you getting too much? Can you sleep when you want to?
Recreation	Consider the activities that you do outside of your sport for enjoyable relaxation. Are they taking too much time? Do they compete with your application to you sport?
Health	Do you have any infections, a cold, or other temporary health problems?

**Table 7: Symptoms of stress for the DALDA including the definitions of the test <sup>(73)</sup>**

<b>Variable</b>	<b>Definition</b>
Muscle pains	Do you have any sore joints and/or pains in your muscles?
Techniques	How do your techniques seem/feel to you? Have your technical skills changed?
Tiredness	Your general state of tiredness is:
Need for rest	Do you feel that you need a rest between training sessions?
Supplementary work	How strong do you feel when you do supplementary training (e.g. weights, resistance work, stretching?)
Boredom	How boring is your training?
Recovery time	Do the recovery times between each training effort need to be longer?
Irritability	Are you irritable? Do things get on your nerves?
Weight	How is your weight?
Throat	Have you noticed your throat being sore or irritated?
Internal	How do you feel internally? Have you had constipation, upset stomach, etc.?
Unexplained aches	Do you have any unexplained aches or pain?
Technique power	How do you rate the level of power you develop in your techniques?
Enough sleep	Are you getting enough sleep?
Between sessions recovery	Are you tired before you start your second training session of the day?
General weakness	Do you feel weak all over?
Interest	Do you feel that you are maintaining your interest in your sport?
Arguments	Are you having squabbles and arguments with people?
Skin rashes	Do you have any unexplained skin rashes or irritations?
Congestion	Are you experiencing congestion in the nose and/or sinuses?
Training effort	Do you feel that you can give your best effort at training?
Temper	Do you lose your temper?
Swellings	Do you have any lymph gland swellings under your arms, below your ears, in your groin, etc?
Likeability	Do people seem to like you?
Running nose	Do you have a running nose?

Each question is scored with either a “worse than normal”, “normal”, or “better than normal” response. This test is not designed for comparisons between players, but rather for comparisons or changes within a player over a season. Therefore a profile has to be established for each player and the changes or

trends in the scores provide information about the exposure to stress of the athlete. The test is widely used by coaches in different sports and is also sufficiently robust to be used in research <sup>(34)</sup>.

### **Resting heart rate**

Resting heart rate has been a popular marker of training status for many years. Resting heart rate decreases slightly after endurance training <sup>(8;53;69;89;93;94)</sup>. However, other researchers have found no significant difference in resting heart rate in trained individuals <sup>(60;66)</sup>. Many studies reporting a difference in resting heart rates between trained and untrained individuals are cross-sectional in nature, thus limiting the ability to determine whether the difference is due to training or due to inherent variation between the two populations <sup>(82;93)</sup>. The longitudinal studies have also produced varying results. For example, longitudinal studies have found heart rate during sleep to be reduced<sup>(74)</sup> or unchanged<sup>(76)</sup> after several weeks of exercise training. Resting heart rate of highly trained athletes who reduce their training load during a taper as they prepare for a peak athletic event does not change <sup>(64)</sup>.

The changes in resting heart rate after exposure to periods of high volume training/competition are also varied. Morning heart rate of runners decreased in the first week of a 20-day race and then increased by about 10 beats.min<sup>-1</sup> towards the end of the race <sup>(23)</sup>. Another study of swimmers (n = 12) who increased their training from 4266 ± 264 m.day<sup>-1</sup> to 8970 ± 161 m.day<sup>-1</sup> for 10 days showed that the swimmers also developed signs of overreaching without any change in resting heart rate <sup>(44)</sup>. However, in a study of competitive cyclists (n = 7) who increased their training load for 2 weeks with the intention of inducing symptoms of fatigue, the heart rate measured during sleep increased from an average of 50 to 54 beats.min<sup>-1</sup> <sup>(41)</sup>. This study suggested that measuring heart rate during sleep, rather than resting heart rate upon waking, may be a marker for training status and monitoring cumulative fatigue <sup>(41)</sup>. One of the reasons for the varied data may be that resting heart rate may be influenced by many environmental factors <sup>(48)</sup> and if these are not controlled properly the heart rate data will be influenced. With this as background, and based on the assumption that during sleep these factors will have less of an effect on heart rate, a study was designed to determine the precision of measuring heart rate during sleep in a group of subjects who maintained a constant level of training. Ten females who maintained a constant training load over 3 weeks were studied <sup>(91)</sup>. Although the average heart rate was similar over the 3 weeks (65 ± 9; 63 ± 6 and 67 ± 7 beats.min<sup>-1</sup>), on an individual basis the minimum heart rate during sleep varied by up to 8 beats.min<sup>-1</sup> during the study. With this amount of variation, it is unlikely that changes in heart rate measured during sleep will have any practical prognostic value in identifying fatigue in rugby players. This conclusion was supported by a recently published meta-analysis on resting heart rate and training <sup>(13)</sup>.

### ***Heart rate variability***

The development of heart rate monitors <sup>(50)</sup> has allowed further research into the mechanisms behind heart rate responses during exercise and adaptations to training. Particular attention has been focused on heart rate variability, largely as a means with which to evaluate cardiac autonomic control. While there are potentially aspects of heart rate variability which will have practical use for monitoring autonomic control in rugby players undergoing training, it is premature at this stage to use it in a diagnostic way <sup>(2)</sup>. A review of the literature revealed that prospective, randomised, controlled, long-term studies using validated measurements are needed before heart rate variability can be used with confidence in monitoring training status <sup>(2)</sup>.

### ***Heart rate recovery***

Heart rate recovery may be defined as the rate at which heart rate decreases, usually in the first minute or two, after moderate to heavy exercise. The heart rate response to the cessation of exercise is governed by the autonomic nervous system, specifically parasympathetic re-activation and sympathetic withdrawal <sup>(42;68;75;78)</sup>. The parasympathetic system dominates during rest and the sympathetic system dominates more as the exercise intensity increases. When exercise stops there is increased parasympathetic activity and reduced sympathetic activity. A well regulated autonomic nervous system can cause the heart rate to decrease by up to 60 beats in the first minute after exercise. Changes in autonomic nervous system activity during recovery after exercise is affected by exercise training <sup>(53)</sup> and overtraining <sup>(45;52)</sup>. A recent study showed that the recovery heart rate worsened in a group of athletes exposed to sudden increase in training load (55%), supporting this theory <sup>(11)</sup>. Therefore it may also be a practical and reliable marker of chronic fatigue and provide information about how the athlete is coping with the cumulative stress of training.

Some cross-sectional studies have shown that there may be potential in the use of heart rate recovery to distinguish trained from untrained individuals. A study by Bunc et al (1988) showed that trained athletes reached steady state sooner and had a faster recovery than untrained subjects, for the same absolute intensity of exercise <sup>(15)</sup>. They concluded that endurance-trained athletes have faster heart rate responses at the start and cessation of exercise and therefore suggest that an athlete's state of training can be established by assessing the changes in heart rate after exercise <sup>(15)</sup>.

A longitudinal study by Sugawara et al (2001) showed that post-exercise heart rate decreased significantly faster after only 4 weeks of an 8-week moderate intensity training period and returned to baseline levels after 4 weeks of subsequent detraining. They suggest that exercise training may enhance post-exercise vagal re-activation, but that a relatively short period of detraining may reverse this effect <sup>(64)</sup>. The effects of 5 months of detraining were studied by Michael et al (1972) in 10 female middle-distance

or sprint runners that had been participating in a 3.5 month interval training programme. They found that heart rate recovery after a standardised step-test and treadmill run became slower as detraining time increased <sup>(61)</sup>.

In accordance with the potential of recovery heart rate to be a valid measure of autonomic function, we have designed a submaximal shuttle test comprising 4 stages of increasing intensity interspersed with recovery periods <sup>(49)</sup>. In this test the players are asked to run between two lines, drawn 20 metres apart on a rubberised indoor floor. The pace of running within each of the four stages (8.4 km·h<sup>-1</sup>, 9.6 km·h<sup>-1</sup>, 10.8 km·h<sup>-1</sup> and 12.0 km·h<sup>-1</sup>, respectively) is set by a pre-recorded auditory signal recorded onto a CD. Each stage lasts two minutes followed by one minute of rest. Therefore, the total duration of the test is 13 minutes. The heart rate recovery is measured during one minute after the end of the test while the player stands still. This test was designed to be submaximal and non-aversive for the players so that it can be administered frequently during different phases of training. Furthermore, the test is easy to administer and about 20 players can do the test simultaneously. The test has a high reliability and low standard error of measurement (1.1%) <sup>(49)</sup>. For the information to be useful, the test needs to be done on a weekly basis, so that a profile for each player can be established. While the heart rate recovery test on its own may not be diagnostic, if the data are interpreted in context with other data gathered it will provide useful information about how each player is coping with the psychological and physiological stress as the season progresses.

### **Summary**

It may be concluded that the outcome of training (i.e. predictable performance) is dependent on a balance between the training load and recovery. Although a fitness trainer may have a broad plan of training for the players within the team, it is important to make minor adjustments to the training load, based on how the player is responding and adapting. Coaches need to carefully prescribe the training load against the symptoms which manifest in response to the training. The chances of the players adapting and reaching a competitive peak in a predictable way will be increased if the fitness trainer adopts a systematic approach by gathering information after each training session. As there is limited time to gather information at each training session it is important that tests are used which provide the most accurate information with the least amount of time and effort. Until further information is available, it is recommended that the questions that need to be answered, and the tests which can be used to provide information, are:

***How hard did the player find the session?***

Solution

- RPE (every session)

***How hard was the session?***

Solution

- Player Session RPE (every session)
- Trainer Session RPE (every session)

***How did the player recover from the session?***

Solution

- perceived and action recovery (daily basis)
- muscle soreness (daily basis)

***How is the player coping with the cumulative stress of training?***

Solution

- POMS (every week)
- Recovery heart rate test (every week)
- DALDA (daily basis)

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