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REVIEW

Monitoring strain and recovery in athletes. Application of a short inventory of perceptual well-being

EXERCISE IS MEDICINE

Horvath Stephan, Birrer Daniel
Elite Sport Department, Swiss Federal Institute of Sports Magglingen, Switzerland

Abstract

The right balance between stress and recovery is important to improve an athlete's performance (e.g., super compensation) and prevent overtraining and injuries. Although there are a number of objective (e.g., physiological or biochemical) indicators for the stress-recovery balance, they are outperformed by subjective indicators (i.e., self-reports on strain and recovery).

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In the present paper, a six-item inventory to monitor physical and mental strain and recovery in sports is presented. Based on empirical findings, and experiences from sport psychological practice in different sports, we discuss the pros and cons of self-report monitoring tools. On a more general level, we give advice on how and when to use such monitoring tools. In addition, we describe how different settings (e.g., monitoring during a whole season vs. monitoring before important competitions, like the Olympic Games) and samples (team vs. individual sports) might affect how such a monitoring tool is used and on what factors a successful application might depend. Finally, we offer guidelines on how to respond to unexpected monitoring results, ranging from clarifying discussions between athletes and (athletic) coaches to sport psychological consultations.

Zusammenfassung

Die richtige Balance zwischen Belastung und Erholung ist wichtig, um die Leistung eines Sportlers zu verbessern (zum Beispiel über eine Superkompensation) und Übertraining oder Verletzungen zu vermeiden. Obwohl es eine Reihe von objektiven (z.B. physiologischen oder biochemischen) Indikatoren zur Erfassung von Belastung und Erholung gibt, werden mehrheitlich subjektive Indikatoren (d.h. Selbstberichte zu Beanspruchung und Erholung) empfohlen.
Im vorliegenden Artikel wird ein Sechs-Item-Inventar zur Erfassung von physischer und psychischer Beanspruchung und Erholung im Sport vorgestellt. Basierend auf empirischen Befunden und Erfahrungen aus der sportpsychologischen Praxis in verschiedenen Sportarten werden die Vor- und Nachteile von solchen Instrumenten diskutiert. Auf einer allgemeineren Ebene geben wir Ratschläge, wie und wann solche Monitoring-Instrumente eingesetzt werden sollten. Darüber hinaus wird beschrieben, dass das Settings (z.B. Monitoring während einer ganzen Saison vs. Monitoring vor wichtigen Wettkämpfen, wie den Olympischen Spielen) und die Sportart (insbesondere Mannschafts- vs. Einzelsportarten) beim Einsatz eines solchen Monitoring-Instruments mitberücksichtigt werden sollte, um ein möglichst gutes Resultat zu erzielen. Abschliessend wird beschrieben, wie auf unerwartete Monitoring-Ergebnisse reagiert werden kann. Diese Reaktionen reichen von klärenden Gesprächen zwischen Athlet und Trainer bis hin zu einer sportpsychologischen Beratung.

Introduction

To be successful in elite sports, athletes are pushed to their limits, and sometimes—unfortunately—even over their limits. The possible negative consequences are, for example, injuries, non-functional overreaching, or even overtraining syndrome. Thus, when working with athletes, coaches often walk a fine line, and some of them have concerns about the right training load, specifically about if they should push for an increased training load or reduce the training load and focus on recovery. In other words, coaches ask themselves: “Is my athlete ready to train and perform in a way that does not risk his/her health and optimally develops his/her progress?” Therefore, it is not surprising that they are in search of good indicators to evaluate the current readiness of their athletes to train or compete. At first glance, there seem to be many potential indicators categorized as either objective or subjective/self-report measures. Objective measures cover all biological measures (e.g., heart rate, blood markers, oxygen consumption), and subjective measures are primarily self-reports on specific current sensations (e.g., fatigue, readiness to perform, global mood). Saw et al. [1] reviewed the literature and compared the two approaches. They

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concluded that practitioners' first choice should be subjective measures, and if possible, they should complement them with objective data.

Different attempts are made to find good objective indicators and thresholds suggesting when an athlete's training load capacity has been reached. Research focusing on training load has proposed threshold recommendations based on the acute-to-chronic workload ratio (ACWR), calculated by dividing the acute workload (present workload) by the chronic workload (habitual workload). However, these thresholds are often affected by other factors, such as age, training history, or current fitness level [2]. Gabbett [2] distinguishes three important metrics in this context: external workload, internal workload, and perceptual well-being. The external workload is defined as the objective load or how much an athlete has trained, e.g., a certain amount of distance swum with a certain amount of intensity ("How much did the athlete train?"). Usually, this is documented in the training plan and training diary of an athlete, but objective measures are possible too. In some sports, special power meters measure the exact power output in watts, for example in cycling or rowing. The internal workload indicates how the athlete reacts to the external workload ("How does the athlete respond to the training load?"). This is consistent with the psychological distinction between stress, as the objective load acting on a person, and strain, the person's subjective response to the load. Perceptual well-being indicates how an athlete copes with the external and internal training load ("Is the athlete coping with the load?"). How the athlete adapts to the training load is not just the subject of the training load itself but is also dependent on other factors, such as biomechanical factors, psycho-social stress, anxiety, academic stress, and sleep quality, among others. Based on the terminology of Saw et al. [1], the internal workload corresponds to the objective measures, and the perceptual well-being indicates the subjective measures. Importantly, Gabbett [2] proposed that the decision for whether an athlete is ready to train or compete should be based on perceptual well-being.

In contrast to objective measures, subjective measures (i.e., questionnaires or interviews) can cover different sources of stress and recovery, resulting in a global measure. Because of the general information inherent in subjective variables, they are suitable as an indicator of the load-bearing capacity of an athlete. Furthermore, subjective evaluations of general perceptual well-being also cover stress factors outside the sport setting that can have an impact on athletic resilience (e.g., stress stemming from schoolwork, family constraints, financial problems) [3].

The main challenges when it comes to injury and training overload prevention are the many factors that might influence the risk for injuries [2,4]. Although low chronic training load and rapid increases in workload are related to injury-risk [5] and not adaptive training processes, many moderators like age [6] or experience [7] affect these relationships. Thus, subjective measures (e.g., how well an athlete copes with the acute load) might be a good proxy for such moderating factors; thus, they are important variables to predict multifactorial events like injuries.

In contrast to injuries, which are caused by multiple factors (e.g., bad luck), non-functional overtraining (NFOR) and an overtraining syndrome (OTS) might be easier to prevent by monitoring training load and perceptual well-being. Functional overtraining (FOR), which is a desired outcome of a planned training process, comes with a temporary performance impairment. With appropriate rest and recovery (up to two weeks), performance can be improved (super compensation), a process referred to as tapering [8]. If athletes are diagnosed with NFOR and OTS, they typically do not recover within two weeks and exhibit an increase in mood disturbance [9-11]. Therefore, to calculate the risk for and prevent NFOR and OTS, mood should be monitored in addition to physical stress and recovery. Birrer et al. [12] showed that mood

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information, examined with a mood scale (Befindlichkeitsskalen; BFS) [13], had a 96.7% accurate assignment of 61 athletes to the categories overreaching, overtraining, and normal (no signs of training maladaptation) [12]. Having demonstrated the potential of subjective self-reports, covering physical and mental indicators of stress and recovery, we will now describe how such information can be captured and -monitored.

From state measures to monitoring tools

In an early stage of stress-recovery research, different questionnaires were developed and used to measure general perceptual well-being (indicated by physical sensations or mood) or stress-recovery balance [14,15], such as the profile of mood states (POMS) [16], BFS, [13], and recovery stress questionnaire for athletes (RESTQ-Sport) [17]. Birrer [15,18] summarized the pros and cons of these instruments and concluded that the ideal self-reporting instrument would meet the following criteria. Firstly, it should consider both physical (e.g., fatigue and positive activation/vigor) and psychological (e.g., positive and negative/depressed mood) components. Secondly, the instrument should cover positive as well as negative perceptions, for example, pleasant and unpleasant moods as both can be experienced in the same time frame (e.g., over the last two days) to various degrees. Thirdly, the instrument should have high comprehensibility, as it should also be applicable when working with young athletes. Finally, monitoring tools, in contrast to diagnostic tools, come with the additional requirement that the instrument should be as brief as possible to minimize the athletes' time expense [19]. One solution is shortening an existing questionnaire, as done, for example, by Hitzschke et al. [20]. They reduced their acute recovery-stress questionnaire from 32 to eight items to use it as a monitoring tool.

A 6-item inventory to monitor perceptual well-being

Based on these four criteria and our experiences with the POMS, BFS, and RESTQ-Sport scales, we selected six-items that examine strain and recovery on a very general level (see Table 1). The selection of the items was grounded on correlative comparisons of different marker items of the questionnaires of the three above mentioned questionnaires, based on extensive data material from different sports. The majority of athletes who completed these questionnaires preferred to answer in the RESTQ-Sport question format (i.e., frequencies of events). Thus, this format was favored over the format of POMS and BFS questionnaires with single adjective items (e.g., good humored, relaxed) and the instruction how much they felt them in the past three days and nights (from "not at all" to "extremely").

The statistical parameters (e.g., mean and standard deviation) of the items vary greatly. Whereas athletes often report that parts of their body are aching, they seem to be rarely in a bad mood. Generally speaking, the answers to items that describe more pleasant states are more or less normally distributed, while answers to items that describe more unpleasant states are left skewed. Thus, we suggest normalizing the row scores based on a representative sample in the first step. Afterwards, each of the six items is easier to interpret and to compare with other items. Therefore, the standardized values might now be used to calculate different scales (see Table 1). While the total balance score allows a quick estimation of an athlete's general workload readiness, the differentiation of physiological or psychological balance can help to interpret a negative total score and the risk of NFOR and OTS.

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Instruction: during the past (x) days and nights...		
Covering mental state (i.e. mood)		
Q1	I was in a bad mood.	
Q2	I was in a good mood.	
Covering physical state		
Q3	Parts of my body were aching.	
Q4	I did not get enough sleep.	
Q5	I recovered well physically.	
Q6	I felt physically relaxed.	
Response format: 7-point likert-scale from 0 = never to 6 = always		
Scales*:	total balance score	(Q1+Q3+Q4) – (Q2+Q5+Q6)
	physical balance score	(Q3+Q4) – (Q5+Q6)
	mental balance score	Q1 – Q2
Negative balance scores represent a dominance of strain over recovery.		

*All scale calculations should be based on normalized raw data (if possible, sport, gender, and performance-level specifics or even individualized data).

Table 1: Six items to monitor physical and mental strain and recovery (following Kellmann & Kallus, 2001), and how they can be combined to different scales.

Benefits and challenges of monitoring tools for estimating an athlete's readiness to perform

Based on our experiences and secondary analyses of monitoring data, we want to describe the benefits and challenges of using these six items or similar subjective monitoring instruments (i.e., questionnaires). To determine the validity of the items, a study with 55 young soccer players showed that the total balance score based on the six items was highly correlated with the total balance score of the RESTQ-Sport (r = 0.85) [21].

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Quality of the measure

The items are very clear and should be understood even by younger athletes. Furthermore, the items proved to be sensitive to changes in the acute training load. For example, the total balance score decreased after high-intensity training in a sample of 29 young cross-country skiers [22]. Social desirability can be a threat to the validity of these assessments. If athletes assume that their responses affect selection processes, they might manipulate their answers. Therefore, we highly recommend that athletes be well informed that the purpose of monitoring is to adapt the training load and recovery periods, thereby lowering the risk of non-functional overtraining and injuries.
If monitoring takes place over a longer period, motivation might become an issue. Therefore, it is important to respond to unexpected values and discuss the data with the athlete regularly even when the scores are unproblematic. Furthermore, the scores might be affected by an incorrect answer choice or strains stemming from other domains. Consequently, the results and following measures should always be cross-validated by a personal discussion with the athlete.

From a rule of thumb to individualistic norms

The first set of monitoring data from an athlete is difficult to interpret. Individual differences in response style can affect the baseline. In other words, not all athletes use the same threshold for negative mood or muscle pain. Nevertheless, general or sport-specific norms (using z-normalization) allow a very rough categorization (e.g., “rather low”, “medium”, “rather high”). Based on 15–20 data points covering high intensity trainings as well as recovery days, individualistic normalizations (z-transformations) can be run for more accurate individual interpretations of the scores.

Preventing injuries

It is difficult to estimate the effect of perceptual well-being monitoring tools on the prevention of injuries (i.e., frequency and severity). The intention behind the use of monitoring tools is to intervene as soon as an increase in the injury risk is likely. For a sample of 35 ice-hockey players, we ran a secondary analysis of recovery-strain monitoring data that were not used for training adaptations. The results showed that neither total nor physical or psychological balance scores were systematically lower before injuries than during injury-free periods [23]; maybe other factors (i.e. external forces involved in a body check) caused this null result. We suggest complementing subjective strain and recovery monitoring with other indicators. Furthermore, we presume that utilizing a subjective strain-recovery tool will increase an athlete’s and coach’s sensitivity to strain and (under)recovery, thereby decreasing injuries.

Preventing overtraining

The possibility of generating separate scores for physical and mental balance allows grading of the risk for NFOR. Remember that based on Meeusen et al. [11], NFOR is characterized by (a) a period of more than 14 days of reduced training without successfully regaining the old performance level and (b) sleep issues, motivation issues, eating problems, or mood disturbances. As mood seems to be the most relevant

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indicator for NFOR [12,15,18], a negative psychological balance score in combination with a long period of negative physiological balance scores may indicate the risk for NFOR.

Practical Implications

When to use monitoring tools to measure perceptual well-being

Strain-recovery monitoring can fulfill different functions. Primarily, it should help adapt individual training loads. Based on our experiences in different sports (e.g., gymnastics, alpine skiing, cross country skiing, ice hockey) and different performance levels (from junior to elite teams), we want to give some practical advice.
In the first stage of a strain-recovery monitoring, it is crucial that many data points covering different strain and recovery situations are gathered. Once an athlete's individual strain-recovery ranges (i.e., the highest and lowest scores he or she reports) are known, they can be used as a solid baseline, and the monitoring frequency can be reduced. With the help of this baseline data, the application of perceptual well-being monitoring can be adapted to the specific situation and requirements of training and competition planning. For example, at specific points of a hard training period, changes in subjective strain-recovery information might help to fine-tune the training load, as well as the recovery measures. As the measure covers more than sport-specific strain and recovery, it can also be very useful in other situations. For example, it could be used before major sport events, when travelling over several time zones (i.e., jetlag), and when private changes have occurred (e.g., new partner, job), which can cause an imbalance that demands more recovery than before.

Basic application guidelines and the role of sport psychologists

Most coaches understand the importance of perceptual well-being in the training process. Therefore, they are very interested in simple monitoring tools and are willing to use such tools. However, they are often unsure of how to respond to negative balance-scores (i.e., strain > recovery) and developments. Their reaction is often time-delayed, guided by the anxiety of training too little or not hard enough; therefore, the response often comes too late.
Negative scores are not always alarming, e.g. after high training loads, one expects that athletes will show fatigue and incomplete recovery. However, if the last training had recovery purposes, and the scores were still negative, the recovery or low load phase should be extended. If after a week of reduced training, the athlete still shows no recovery and the athlete shows signs of permanent fatigue and depressed mood, we recommend, after discussing this state with the athlete, contacting a sport psychologist or other specialists with adequate knowledge regarding strain-recovery issues. Conversely, if the negative scores are mainly based on physical parameters, it might be sufficient to have a discussion between the coach and athlete about adequate training load and recovery strategies.

Increasing recovery or decreasing stress

The standard response to strain-recovery imbalance is a reduction of load, i.e., less hard training sessions or the omission of a session. However, focusing directly on recovery might be more effective. Sleep

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(quantity and quality) [24,25]and nutrition are the main sources of recovery [26]. The effectiveness of other methods (e.g., cool water immersion, sauna, or massage) also depends on the right timing [27-29]and the individual preferences of the athletes. The same method can work very well for one athlete but not for another. Thus, athletes should be encouraged to try different strategies and then evaluate them critically.

Future directions: Physiological vs. psychological load

In the past, research has focused on physiological stress and recovery. Recently, mental stress or fatigue and mental recovery [30], which also includes self-control issues, have gained more attention. Future research might examine factors that deplete self-control resources in the sport setting, and how to recharge the mental battery effectively.

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Corresponding author

Stephan Horvath
Swiss Federal Institute of Sport
Magglingen, 2532 Magglingen, Switzerland
Tel: +41 58 467 63 30
Email: stephan.horvath@baspo.admin.ch

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