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Evaluation of psychological measures for the assessment of recovery and stress during a shock-microcycle in strength and high-intensity interval training

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ABSTRACT

The aim of this paper was a) to analyse the intraindividual change and criterion sensitivity of the *Acute Recovery and Stress Scale* (ARSS) and its abridged version the *Short Recovery and Stress Scale* (SRSS) in response to a 6-day microcycle of intensified strength training (STM) and high-intensity interval training (HIIT) in comparison with the change in the criterion measures maximal dynamic strength (estimated 1 repetition maximum [$1RM_{est}$]; STM) or repeated sprint ability (RSA; HIIT), and b) to compare descriptively the results of the subjective measures with earlier reported physiological and performance markers of the same study. Participants were 23 (STM; 23.7 ± 2.0 years) and 22 (HIIT; 22.8 ± 2.6) well-trained athletes who completed 11 training sessions over 6 days to induce functional overload. The ARSS scales and the SRSS items were assessed every morning and the criterion measures 3 times (pre, $post_1$, $post_2$). Changes were analysed over the entire period and from pre- to post training as well as after 72-h of recovery. ARSS and SRSS ratings and the criterion measures presented deteriorations upon the intensive training as well as improvements following the recovery period. The overall and physical-related scales/items demonstrated large change effects in response to the physical stress stimulus in both training protocols (Cohen's *d* between |0.92| and |2.04|). The mental-related scales/items described moderate to large change effects ($d = |0.30|$ to $|0.73|$) and the emotional-related scales/items small to moderate change effects ($d = |0.07|$ to $|0.51|$). The sensitivity analyses revealed the highest diagnostic effectiveness also in the overall (45.50% to 73.90%) and physical-related (45.50% to 69.90%) scales/items, but they did not discriminate exactly athletes in fatigued or recovered state compared to the performance criterion measures. Correlation analyses also revealed no significant relationships between the changes in the scales/items and in the criterion measures. On a descriptive basis, comparisons with the change effect sizes and the sensitivity results of the performance and physiological markers underline the importance of psychological markers for the assessment of recovery and stress. Furthermore, the gained experiences in application and evaluation promote the practicability and economy of the questionnaires favouring the combination of subjective and objective markers for training monitoring in sports. The application and interpretation should mainly focus on the individual and longitudinal level.

1. Introduction

In recent years, there has been an increase of reports regarding an imbalance of stress and recovery leading to insufficient recovery and dysfunctional overreaching symptoms in several sports (Dupont et al., 2010; Ekstrand et al., 2004; Main & Landers, 2012; Schwellnus et al., 2016; Soligard et al., 2016). For example, Halson (2014) described that 15% of British elite athletes from different Olympic sports developed a state of overtraining over a 12-month training season. Excessive training as well as non-sport stressors might induce a shift of the athlete's physical and psychological well-being along a continuum progressing from acute fatigue to

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non-functional overreaching to severe illness, injuries or overtraining syndrome (Meeusen et al., 2013; Schwellnus et al., 2016; Soligard et al., 2016). It has been reported that progression towards overtraining syndrome is associated with poor performance, ongoing fatigue as well as psychological signs such as mood disturbances and symptoms similar to clinical depression (Armstrong, & Van Heest, 2002; Halson, 2014; Meeusen et al., 2013). Poor management of training load and recovery is considered as risk factor for injury and illness in elite athletes (Bourdon et al., 2017; Schwellnus et al., 2016; Soligard et al., 2016). Considering the intensity as well as the duration and the distribution of training sessions, the challenge is to define the exact point of effective training and the transition to dysfunctional overreaching (Koutedakis et al., 1999). Continous monitoring is, therefore, crucial for improving individual training prescriptions and to ensure competition readiness (Halson, 2014) as well as detecting maladaptation at an early stage to avoid unplanned performance decrements (Brink, Visscher, Coutts, & Lemmink, 2012; Saw, Main, & Gastin, 2015a).

Standardised diagnostic assessments can be used to identify signs of dysfunctional overreaching and to adapt the training plan individually (Meeusen et al., 2013). Hormonal, immune, inflammatory and haematological parameters as well as cardiovascular responses seem to be physiological markers of the mechanisms underlying the progression towards non-functional overreaching or overtraining syndrome (Saw, Main, & Gastin, 2016). Thus, the underlying mechanisms pertaining to the emergence of exercise-induced fatigue are very complex and driven by various central and peripheral regulatory pathways (Meeusen et al., 2013). A great number of diagnostic tools has been suggested as surrogate markers of fatigue and recovery including performance, cardiovascular, neuromuscular, physiological, and perceptual markers (Halson, 2014; Meeusen et al., 2013; Urhausen & Kindermann, 2002). The daily determination of a wide range of these markers as established in endurance sports (e.g., heart rate variability or several markers in the blood), however, seems to be inadequate and difficult to control in typical sport surroundings. Therefore, practical parameters that are determined at rest or during low metabolic and neuromuscular demands, without disturbing the training process, are preferred for the routine assessment of fatigue and recovery (Urhausen & Kindermann, 2002). While performance could be seen as the most direct indicator of the athlete's readiness to compete, its assessment is mostly physically demanding and induces additional fatigue; therefore, it does not seem useful for daily application (Currell & Jeukendrup, 2008).

Saw et al. (2016) pointed out inconsistent results of physiological measures which are explained by intra-individual and inter-individual variability, the influence of circadian and pulsatile rhythms, nutrition and hydration status, climate, psychosocial factors and exercise characteristics. Moreover, several authors highlighted the economic, effective and practical advantages of self-report measures compared to traditional physiological and performance measures (e.g., Coutts, Wallace, & Slattery, 2007; Kellmann, 2010; Meeusen et al., 2013; Raglin & Wilson, 2000; Saw et al., 2016; Saw, Main, & Gastin, 2015b).

In their systematic review, Saw et al. (2016) highlighted that subjective measures, particularly measures of mood disturbance as well as perceived stress and recovery, reflect acute and chronic training loads with superior sensitivity and consistency compared to objective measures. They reported that 85% of the reviewed studies favoured subjective measures. An explanation for the effectiveness of psychological measures could be seen in their global approach to assess multidimensional aspects of recovery and stress, as athletes process physiological, mental and emotional inputs in the central nervous system which mediate the actual 'overall' perception of their psychophysiological state. As the response to certain training programs as well as adaptation and regeneration processes are highly individual, the subjective perspective allows for an effective monitoring, especially in larger training groups or teams (Saw et al., 2015b). Self-report measures may be characterised by 1) whether or not they are specifically developed for athletes, 2) if they include single or multiple constructs, 3) whether the constructs are based on stressors or resulting symptoms, and 4) whether the measures have a practical short form to implement easily in the training course (Saw et al., 2016). It has been suggested that athlete-specific measures, evaluating multiple constructs, should be preferred for monitoring procedures as they may better reflect performance capacities compared with one-dimensional constructs (Grove et al., 2014).

The following subjective measurements are currently used in sports science research and practice: Borg's Rating of Perceived Exhaustion (RPE; Borg, 1998), Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1992), Recovery-Stress Questionnaire for Athletes (RESTQ-Sport; Kellmann & Kallus, 2001, 2016), and Delayed-Onset Muscle Soreness (DOMS; Ohnhaus & Adler, 1975). Kellmann, Kölling, and Hitzschke (2016) concluded that none of these measures sufficiently meets the requirements of applied settings, in terms of being specifically developed for athletes and at the same time achieving the balancing act between the fulfilment of psychometric requirements while granting a high economy and practicability for time-saving application in sport practice. Indeed, there are already economic measures such as the RPE and DOMS, as well as multidimensional methods such as the RESTQ-Sport and the POMS. However, a method that combines multidimensionality, sports specificity and economic application was lacking for the sport practice.

Therefore, Kellmann et al. (2016) developed two promising tools to assess and monitor the actual multidimensional recovery and stress state. The *Acute Recovery and Stress Scale* (ARSS) and its abridged version, the *Short Recovery and Stress Scale* (SRSS), can be applied on a daily (and even more frequent) basis for training monitoring in elite sports. Both instruments aim at the assessment of emotional, physiological, mental and overall aspects of recovery and stress. In a four-stage process, the ARSS was developed via an expert survey and initial factor analysis, until the final model with 32 items (summarised by eight scales) was verified and validated via confirmatory factor analysis among elite athletes ($N = 574$). Afterwards, the SRSS was derived by selecting the eight scales as items for direct rating (Kellmann et al., 2016).

Their applicability and change sensitivity to training stimuli have been shown in several laboratory and field studies (Collette, 2016; Hammes et al., 2016; Kölling, Steinacker et al., 2016; Kölling et al., 2015; Pelka et al., 2017; Wiewelhove et al., 2016). However, generalisability is limited, as participants were either female hockey players (Kölling et al., 2015), swimmers (Collette, 2016), male cyclists (Hammes et al., 2016), junior athletes in rowing (Kölling, Steinacker et al., 2016) and tennis (Wiewelhove et al., 2016), or physical education students (Pelka et al., 2017). Thus, the sensitivity and internal validity of the questionnaires need to be investigated among more representative training protocols in a controlled laboratory setting in order to attribute variability to the training stimuli and to demonstrate questionnaires' universally valid application. Furthermore, a controlled setting is more suitable for the valid calculation of the criterion validity and the accuracy of the subjective markers in relation to the criterion measure, respectively.

Recently, two studies with a uniform study design of a six-day microcycle of intensified strength training (STM; Raeder et al., 2016) as well as high-intensity interval training (HIIT; Wiewelhove et al., 2015) were carried out to evaluate physiological, psychological and performance markers of recovery and fatigue in relation to criterion measures. The publications of Raeder et al. (2016) and Wiewelhove et al. (2015) focused on the evaluation of the physi-

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