Role of Sports Science in Fatigue Monitoritng and Recovery Management of Olympic Athletes

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Abstract: The importance of sport science in the physical preparation of Olympic athletes' is unquestionable; with sport science often highlighted as one of the most important factors in fatigue monitoring and recovery management. Coaches, athletes, sport scientists, and medical staff must center on the fundamental principle of the 'training response', of which, the stress/fatigue state is a key component. That is to say – the ability to monitor and manage the stress/fatigue state ultimately determines the athlete's training response. Therefore, if an athlete is not closely monitored imbalance in the stress/fatigue state will often lead to diminished performance. As such, development of an elite athletes' performance potential requires a systematic approach to training, with the use of sport science an integral component of the overall training plan. This paper shall describe practical sport science methods for fatigue monitoring and recovery management utilized at the 2016 Rio Olympic Games by the Indonesian National Badminton team.

1 INTRODUCTION

Development of an elite athletes' performance potential requires a systematic approach to training, and this includes addressing physical, psychological, technical, and tactical preparation (Bangsbo et al., 2006). Specifically, physical preparation strategies have centerd on the use of strength and conditioning methods to improve athletic performance (Newton et al., 2002, Bangsbo et al., 2006, Kraemer et al., 1998), and this is an integral component of the overall training plan (Kearney, 1996).

The importance of sport science in the physical preparation of Olympic athletes is best highlighted by Greenleaf, Gould and Dieffenbach (2001), who report several physical preparation factors that influence elite performance. Sport science was identified as a significant performance factor contributing to Olympic success due to its potential role in fatigue monitoring and recovery management. A former gold medallist said, *"the timing of my preparation [and of the races] was very poor and that contributed to overtraining and my performance was probably 80% at the Games due to fatigue and lack of recovery."*

Therefore, the monitoring and subsequent management of this should be crucial to any athlete program in preparation for the Olympics (Davison and Williams, 2009). As such, the purpose of this paper is to (1) overview current sport science concepts aimed at monitoring athletes training response and stress/fatigue state; and (2) describe the physical preparation strategies utilised by the Indonesian National Badminton team for the Games of the XXIX Olympiad, Beijing, China.

2 DEVELOPING AN ELITE SPORTS SYSTEM

An overview of elite sport systems presented by Green and Oakley (2001) outlines four key areas which are pertinent to the achievement of international sporting success, these include; (1) Sport organisation efficiency; (2) Identification of human resources; (3) Methods of coaching and training; and (4) Knowledge and application of sport science and sport medicine. The authors highlight that many nations have embraced elements of this systematic approach in the development of an elite sport system. Ultimately, international sporting

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success requires planned investment (Hogan and Norton, 2000).

The first priority is to gain a current perspective of the elite sport system structure employed by the key sport stakeholders, as previous work by the Australia-Indonesia Sport Program emphasised the importance of such an approach (Williams, 2002). For the 2016 Olympic Games campaign, Komite Olimpiade Indonesia (KOI) highlighted 12 primary focus sports for periodization and Olympic Qualification (January-June 2016). The 12 Sports included Badminton, Weight Lifting, Archery, Athletics, Swimming, Taekwondo, Judo, Cycling (BMX), Beach Volley, Rowing, Equestrian and Canoeing.

3 SPORT SCIENCE: 2016 RIO OLYMPIC GAMES

3.1 Athletic Performance Model

Due to the relative short preparation period (36 weeks), the preparation strategies employed focused on the *Athletic Performance Model* (Figure 1) present by Smith (2003). This model outlines several factors that influence peak athletic performance and provides a practical representation of five key components critical in optimizing athletic performance, these being; (1) physiology; (2) biomechanics; (3) psychology; (4) tactics; and (5) heath/lifestyle. Therefore, peak athletic performance can be defined as an integrated performance outcome, which requires a delicate balance between optional loading (training and non-training stress) and the recovery process.

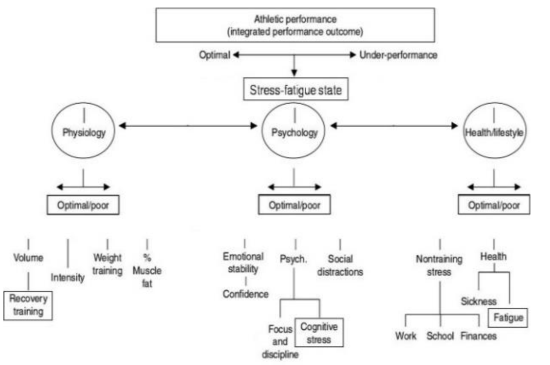

Figure 1: The Athletic Performance Model related to the stress/fatigue state. Three priority areas are circled, each with one targeted component (boxed) that was the focus of program design. Modified from Smith (2003).

However, in order to achieve a positive performance outcome one must consider the role of the stress-fatigue state to identify signs and symptoms of overtraining syndrome and under-performance (Budgett, 1998, Corcoran and Bird, 2012). Kentta and Hassmen (1998) describe the stress/fatigue state as a psychosociophysiological phenomenon (Figure 2), with psychological, social, and physiological factors recognized to have the greatest impact on this state. Collectively, when these factors are considered in relation to their potential effects on the stress/fatigue state and achievement of a positive performance outcome, the focus of physical preparation was selectively targeting three key components from the athletic performance model.

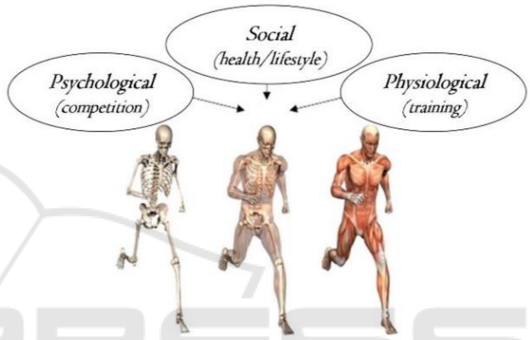

Figure 2: The stress/fatigue state as a psychosocio physiological phenomenon.

As previously reported (Bird, 2011) the training philosophy employed by the national coaches was that of high-volume, and this was consistent across the 12 sports preparing for Rio. This was further compounded by a lack of structured athlete monitoring and recovery practices which resulted in a significant number of athletes presenting with high stress-fatigue states (Bird, 2015). Therefore, a primary goal was to develop a central 'fatigue monitoring and recovery managing' theme which was addressed as one of five priority strength and conditioning areas and provided the theoretical basis for the physical preparation strategies employed.

3.2 Quantification of Training Load

The first step in the developing an athlete monitoring and recovery management approach is gaining an understanding of athlete training loads. Quantification of session/daily training load during and the potential implications on separating physiological and biomechanical load-adaptations (Vanrenterghem et al., 2017) may have specific relevance during athlete performance optimisation (Blanch and Gabbett, 2016). As such, the session-RPE (sRPE) method was employed, which has been widely used in training load quantification for various types of training across multiple sports, including tennis (Coutts et al., 2010), as determined by multiplying a sessional rating of perceived exertion (RPE: Category-ratio 10 [CR-10]) by the session duration (minutes) (Haddad et al., 2017). sRPE training load values were used to quantify changes in weekly workload, with a terminal change in weekly workload capped at no more than 10%. Importantly, when following this model in athletes undergoing rehabilitation (unpublished data) such loading did not elicit pain responses above 6 on self-reported pain (Numeric Rating Scale) (Bahreini et al., 2015), which was pre-determined as the upper limit for terminating the training session.

3.2.1 Training Load: Indonesian Olympic Badminton Team

Quantification of the training load (AU) was performed by the sRPE method for every training session/match during an intensified training camp (ITC) and the 2016 Rio Olympic Games (OGC) competition (Bird, 2016). Players were asked 30 min after each session/match to ensure that their RPE referred to the intensity of the whole activity rather than the most recent activity intensity. When examining training loads in 10 Olympic badminton players' (male: n=5 and female: n=5) competing in six events (Men's singles [MS]; Women's singles [WS]; Men's doubles [MD]; Women's doubles [WD]; Mixed doubles [XD1*Gold Medallists, and XD2]), as expected, training loads for both male and female players were was significantly higher during ITC than OGC (Figure 3, ITC: 999 ± 375 and 1004 ± 407 AU; and OGC: 723 ± 252 and 745 ± 245 AU).

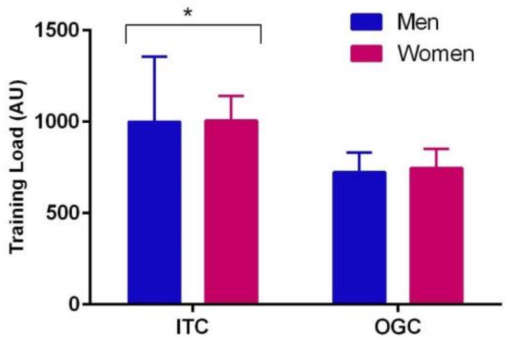

Figure 3: Daily training load (AU) of Olympic badminton players during an ICT and OGC.

However, individual players' training loads did not differentiate from each other. Differences in the six coaches' periodization strategy were evident during the OGC. Daily training load profiles for coaches of XD1* and XD2 employed a step-type reduction over 3-days, followed by an increased training dose on day 4. This profile was repeated twice over the remaining days of the OGC. In contrast, coaches of MS and WS players displayed an exponential reduction. Alternatively, coaches of MD and WD employed a combination of a step-type/exponential reduction (Figure 4).

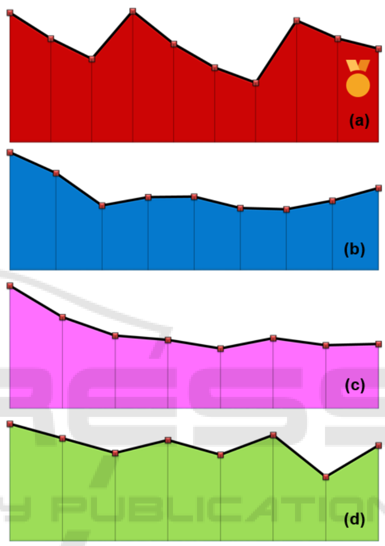

Figure 4: Periodization strategy of daily training load dose employed by coaches during OGC. a) Mixed doubles, Gold medallists; b) Men's and c) Women's singles; d) Women's doubles.

3.2.2 Fatigue Monitoring

Self-report subjective well-being measures: The second step in the developing a fatigue monitoring and recovery management focus is gaining athlete wellness and recovery data. In high performance sport environments, self-report questionnaires identifying perceived changes in muscle soreness, feelings of fatigue and wellness, sleep quality and quantity and a variety of other psychosocial factors are relied upon for *'flagging'* athletes in a state of fatigue (Taylor et al., 2012, Corcoran and Bird, 2012).

This is further supported by the recent works of Shaw (2015a, 2015b), highlighting the importance of subjective well-being measures for athlete monitoring. Given that subjective measures reflect changes in athlete well-being and provide a practical method for athlete monitoring, coaches can employ self-report measures with confidence (Saw et al., 2015a). As such, an online wellness and recovery program consisting of daily questionnaires was employed (AccelerWare, Sports Performance, Systems Brisbane, Australia). Wellness and recovery questions examined fatigue, sleep, soreness, stress, recovery, sickness and injury status, along with training load quantification via session RPE method (Foster, 1998). Results of the data are compiled with daily reports sent to the head coach when an athlete is flagged ‘at risk’. Figure 5 presents wellness profile data as a percentage with the threshold set at 65% for the men’s national team. If an athlete falls below the threshold they are flagged for medical review. This data is included in the *‘Athlete Wellness Profile’* which presents an overview of the current health and wellness status each athlete, providing daily recommendations for the athlete and coach

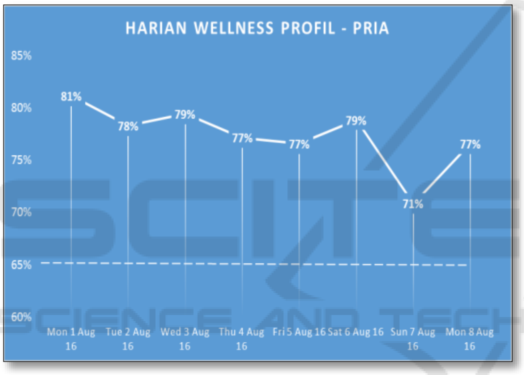

Figure 5: Wellness profile scores as a percentage. The threshold value is set at 65%.

Neuromuscular Profiling: Jump Assessments: An additional tool to quantify an athletes ‘readiness to train’, which refers to the ability of an athlete to generate sport-specific power output in a training session with an absence of accumulated fatigue, is that of jump assessments. Taylor et al. (2012) reported that one of the most commonly employed tests of functional performance was that of vertical jump assessments, which is suggested as a convenient model to examine neuromuscular function with studies investigating the time course of recovery from fatiguing training or competition (Cormack et al., 2013, Cormack et al., 2008).

The practicality of vertical jumps as measure of neuromuscular fatigue is reflected by the adoption of such testing procedures in the high performance sporting environment (Markwick et al., 2015). However, several protocols and equipment are available, with little consensus to date as to the optimal methods or variables of interest for accurately measuring the state an athletes fatigue and/or recovery. One of the most popular tools is that of linear position transducers (Cronin et al., 2004, Harris et al., 2010), with the use of individual standard deviation values (±1 SD) to identify changes outside of normal intra-individual trends often employed as the threshold (Figure 6).

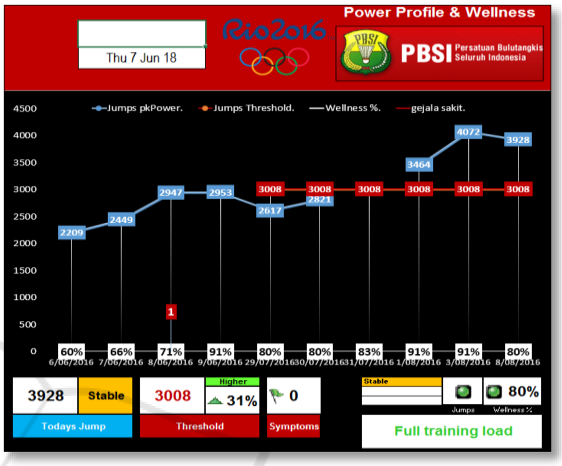

Figure 6: Athlete power profile report provides an overview of jump assessment neuromuscular profiling variables (peak power *blue*; jumps threshold *red*) along with other variables including sickness symptoms and wellness percentage score.

3.2.3 Recovery Management

It has long been recognized that without adequate recovery an athlete will not achieve their full performance potential (Kentta and Hassmen, 1998) due to the accumulation of progressive fatigue, often termed ‘overtraining syndrome’(Budgett, 1998). Therefore, optimizing recovery is an essential component of the overall training plan. The 100 point weekly recovery checklist provides a useful tool for athletes to implement self-initiated, proactive recovery strategies thereby educating athletes on the importance of post-training and post-competition recovery (Bird, 2011). Recovery strategies such as compression therapy, nutrition and hydration, hydrotherapy and water immersion, massage and myofascial release, athlete self-monitoring, and lifestyle factors such as sleep and reducing stress have been recommended to target four key recovery focus areas (Table 1).

Table 1: Proactive Recovery Focus Areas.

Neural	Massage; compression therapy
Muscular	Hydrotherapy; contrast water
Substrate	Nutrition; hydration
Psychological	Sleep; lifestyle quality

The numerical value of each recovery strategy has been determined by the evidence-based effectiveness of the strategy and the level of athlete proactive engagement required, see Bird (2011) for complete description. Two primary considerations were (1) the effectiveness of the recovery modality (research evidence supporting use of the modality); and (2) the level of athlete engagement (self-initiated, proactive recovery). Therefore, the numerical recovery point value was to represent a combination of effectiveness and engagement. Unpublished data suggests that athletes who score less than 65 weekly recovery points are *'at risk'*, and this may present a significant impact to both training and performance.

In preparation for the 2016 Rio Olympic Games, a modified 24 hour recovery checklist was used to engage players in daily self-initiated, proactive recovery. Throughout a 9-day intensified training camp (Sau Paulo, Brazil) a daily numerical target was set at 20 recovery points. This was immediately followed by Olympic Games competition (Rio de Janeiro, Brazil) over 6–9 days, where the daily numerical target of 15 recovery points was employed. Higher numerical points were allocated to recovery strategies

4 CONCLUSIONS

Fatigue is often experienced by Olympic athletes and this is a necessary component to stimulate appropriate responses to training demands (i.e., adaptation), however achieving such an optimal condition may leave athletes 'fragile' and susceptible to illness or over-training. Furthermore, due to the pressure to perform at Olympic Games there is a tendency for athletes to prepare 'too much' in an effort to get that competitive the 'edge' and in doing so athletes may not devote appropriate time to mental and physical recovery (Davidson and Williams, 2009)

The application of sport science in the fatigue monitoring and recovery management is to gather athlete wellness data and provide feedback with a primary goal of encouraging pro-active athlete engagement in the recovery management of their stress/fatigue state (McFarland and Bird, 2014). Components of the systematic process outlined above employs commonly used measures delivered in a format considered to be easily presented to the athlete and coach.

The combination of subjective self-reported measures, suggested to trump commonly used objective measures (Saw et al., 2015a), and objective measures, allows a complete picture of the current status of the athlete. Coach and athlete feedback to should be rapid (within 1 hour of completion), occurring well before the planned training session. This is a key feature of the fatigue monitoring and recovery management process to achieve *'buy in'* from all involved in the training process (coaches, athletes, sport scientists, medical staff) and allow appropriate time for discussion and resource allocation in the event that an athlete is *'flagged'*.

Feedback can be written or verbal or, most often, a combination of the two so that a dialogue can occur about the recorded data. Importantly, the information must be end-user-friendly (i.e. jargon-free), visually appealing, and performance focused (Davison et al., 2009). Finally, it is important that all data is analyzed with appropriate statistical methods in order to identify potential problems, providing confidence in the process being undertaken.

The recovery checklist provides a useful tool to educate Olympic athletes about the importance of post-training and post-competition recovery, and to promote self-initiated, proactive recovery strategies for maximum performance. In agreement with Robson-Ansley and colleagues (2009), it is concluded that well-accepted recovery methods such as nutrition, hydration, and sleep (Bird, 2013, Halson, 2008) appear to be the most effective strategies for optimizing recovery in Olympic athletes during competition.

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