Monitoring and prevention of overtraining in athletes*

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ABSTRACT

Overtraining is characterized by the imbalance between stress and recovery. Besides that, stress factors can be found not only in situations of training and competition, but also in extra-training and extra-competition ones. The athletes, in the attempt of reaching high performance levels with training, can become excessively trained, showing signs and symptoms of overtraining. Overtraining can be identified through symptoms like underperformance, chronic fatigue, respiratory infections and mood swings. Although there is no indication that overtraining causes irreversible damage to the athlete, the risk of injury, diseases or drop-out of sport is increased, reducing athletes' life quality. Based on these considerations, parameters and instruments for monitoring and prevention in physiological and psychological fields are studied in this work. Therefore, the best strategy for monitoring is to associate psychological parameters with physiological evaluations. Concerning prevention and treatment of overtraining, the implantation of systematized program of prevention of harmful effects in the athlete's performance, in his health and consequently in his well-being is advisable.

Keywords: Excessive training. Stress. Recovery.

DEFINITIONS AND PRINCIPLES OF OVERTRAINING

According to Budgett[1] "the overtraining syndrome is a fatigue and low performance condition, frequently associated with infections and depression situations during intense training and competitions, where the symptoms do not cease in two weeks of rest, and do not present an identifiable clinic cause".

Several researchers call the phenomenon or the overtraining syndrome differently: chronic or persistent fatigue (*overfatigue*), physical fatigue (*staleness*), emotional exhaustion (*burnout*), excessive use (*overuse* – terminology also used for sports lesions with micro traumatic characteristic) and excessive work (*overwork*)[1-3]. For others, such lack of terminology standardization causes confusion and difficulty when diagnosis is needed[4-5]. Alves[4] considered all the presentation examples mentioned above as cause or symptom process, while the overtraining itself was considered as consequence, effect or process result.

According to Lehmann *et al.*[6], the overtraining occurs due to an imbalance between stress and recovery, that is, great stress factors combined with little recovery. However, the findings by Lehmann *et al.*[7], observed that the stress sources may be found not only in training and competition situations, but also in those derived from extra training and extra competition. Therefore, social, educational, occupational, economic and nutritional aspects, as well as trips not chosen by the athlete and monotony act in the risk increase of developing overtraining[7-8].

Kreider, Fry and O'Toole[9] differed short term (*overreaching*) and long term overtraining (*overtraining*), observing their distinctions in order to understand the relation between sports training and performance. Short term overtraining is described as being the decrease in the athletic performance in a short period of time, where the normal performance can return from a few days to two weeks of recovery. At this moment, a performance improvement is observed through the super compensation or ideal training[10-11]. Long term overtraining on the other hand, is characterized by a persistent decrease of the athletic performance, usually accompanied by biochemical, physiological and psychological changes, with time reversion of the situation occurring from some weeks to months of recovery[10].

The athletes, in the attempt to reach high performance levels with training may be led to or become excessively trained, and frequently exhibit overtraining signs and symptoms. Chronic fatigue, performance stagnation or decrease, respiratory infections and mood swings are among these signs[1,12-13]. Although there is no evidence that overtraining causes irreversible damage to the athlete, lesion, diseases or premature dropout risk is increased[14]. In order to control these factors, resting or reduced training within the training program during some weeks or months is necessary for the athlete's complete physical and mental recovery[15].

The identification of markers would allow coaches and athletes adjust their training loads in order to increase the training benefits as well as to avoid overtraining, and hence improving performance, health and the athlete's life quality. Considering these factors, this study aims to organize bibliography based on physiological and psychological studies and research conducted so far, providing the incidences and recommendations for the overtraining monitoring in athletes, besides highlighting the strategies designed to the prevention of this syndrome in athletes.

INCIDENCE OF OVERTRAINING IN ATHLETES

The relevance in the understanding of this situation was recently demonstrated by Gould *et al.* in the Atlanta Olympic Games in 1996. Investigation conducted with 296 athletes of 30 different sports, showed that 84 athletes (28%) were in overtraining and that evidence explained the decrease in their performance[16].

In studies conducted in the Winter Olympics in Nagano, 1988, Gould *et al.*[17] observed that 8 of the 83 American Olympic athletes (almost 10%), of 13 different sports, reported that were in overtraining and that it led them to a low performance. The same athletes also considered other contributing factors to overtraining, such as excessive trips, decrease of resting periods, decrease of the necessary time for recovery and a 'not very healthy' lifestyle.

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According to other researchers, the incidence of signs and symptoms of overtraining may vary from 7 to 20%[18-19]. Years later, research involving *endurance* (predominantly aerobic sports) athletes, especially swimmers, observed similar results (7% to 21%), 10% presenting severe symptoms[20-22].

The incidence of overtraining in sports varies according to their kind. Sports that involve big training loads frequently demonstrate a greater amount of negative results, such as running styles[13]; swimming[18-19]; cycling[23] and rowing[24-25].

Although being more frequently found in elite athletes, overtraining is also a problem in other levels of participation. For instance, Raglin and Wilson[2] suggested that young athletes suffering from overtraining resulted from physical load, and with negative results in training, are particularly submitted to training load comparable to adult and elite athletes. An intercultural and well-controlled study[26], using physical and psychological tests and training load registry, showed that in 231 young swimmers, with age range of 14,8 years, 35% (81) presented physical fatigue (*staleness*), reaching the conclusion that the frequency of young athletes was similar to the ones found among the adult and endurance athletes.

These findings are examples of how the athletes are directly influenced by the excessive training practice and deficient recovery, demonstrating as well the importance of a better understanding of this phenomenon in order to improve their life quality.

OVERTRAINING MONITORING

Although there is a noticeable lack of well-controlled studies in which criteria for the diagnosis are reported, the decrease in the athletic performance, joined with the chronic fatigue, are evident indicators of the overtraining syndrome and have been used for the syndrome diagnosis[1,18]. However, little has been done in order to quantify such factors and there is little consensus on how much of the performance should be deteriorated before overtraining is diagnosed.

According to Hooper *et al.*[18], the performance decrease, specially those related to an unknown factor and that are clearly an overtraining result vary from 0.7 to 15% of the performance. Several investigators have suggested that the performance stagnation is sufficient to indicate overtraining when linked to other signs and symptoms[3,23]. Once the performance is deteriorated and the fatigue becomes chronically high, it is usually late to avoid the overtraining syndrome[3].

The isolated use of subjective signs and symptoms such as insufficient sleep and muscular pain make diagnosis difficult, since they are not demonstrated in all individuals, besides being able to occur as results of other diseases[27-28].

Physicians, psychologists, physical educators and physical therapists have been trying to reach diagnosis solutions related to overtraining[3-4,8,15,29-32]. Among the discussed criteria, we can highlight: (1) athlete's health history; (2) recognition of the markers and attention in order to identify them as soon as possible; (3) analysis of physiological variables and, (4) use of psychological measures in order to follow the perceptions and emotions of the athletes.

Based on this interdisciplinary context in the syndrome identification, a large number of signs and symptoms are associated to overtraining, and should be carefully followed and monitored by the group. Fry *et al.*[12] grouped this variety of symptoms in four categories:

(1) Physiological;
(2) Psychological;
(3) Neuro-endocrinal or biochemical; and
(4) Immunological.

However, based on the different combinations of manifestations in the athletes, other categories were associated: (5) Performance parameters and (6) Data processing (table 1)[12,33-35].

TABLE 1
Markers, signs and symptoms of overtraining[12,33-35]

Physiological	• Changes in the arterial pressure. Changes in the resting, during exercise and during recovery heart rate. Increased respiratory frequency. Increased oxygen consumption in submaximal exercise. Decreased fat mass. Increased lean mass. Anomaly in the T wave of the electrocardiogram (ECG). Increased respiratory frequency. Chronic fatigue. Increased basal metabolic index.
Psychological and Behavioral	• Constant mental fatigue. Reduced appetite. Sleep disturbances (hypo- or hyper-sonia). Depression. General apathy. Decreased self-steem. Emotional instability. Competition fear. Difficulty to concentrate on work and on training. Giving up when the goals are too intense.
Neuro endocrinal and biochemical indicators	• Rhabdomyolysis. Increased C-reactive Protein. Increased Creatine kinase. Negative nitrogen balance. Increased urea concentration. Increased uric acid production. Hypotalamic dysfunction. Deprived muscular glycogen indices. Minerals deficit (Zn, Co, Al, Mn, Se, Cu). Decreased hemoglobin. Decreased free testosterone. Increased serum cortisol. Decreased serum iron. Decreased plasmatic glutamin.
Immunological indicators	• Muscular and articulation pain complaints. Muscular sensibility. Increased susceptibility and severity to diseases, Colds and allergies. Recurrent infections by viral and bacterial herpes. Headache. Nausea. Gastrointestinal disturbances Increased amount of defense cells (lymphocytes, eosinophils, neutrophils, immunoglobulines-IgA). Lymphatic glands edema.
Performance indicators	• Decreased performance. Decreased maximal performance ability. Decreased load tolerance. Extended recovery need Decreased muscular strength. Inability to fulfill goals.
Data processing	• Coordination loss. Concentration difficulty. Reduced ability to deal with a great amount of information. Reduced ability to correct technical fails. Error repetition that was previously corrected.

Researchers have discussed the values of these initial symptoms or even confirmation symptoms in the sports practice[3,36]. Generally, these symptoms are milder in initial or temporary stages (short term overtraining), where the needs of recovery are smaller comparing to the more severe and extended stages[15].

While the decrease of the athletic performance is considered a reliable marker, no consensus was reached concerning the index and proportion of this decrease in performance in different moments of overtraining[3,37-38]. The decrease of the physiological markers such as the $\dot{V}O_{2max}$, blood lactate and heart rate, obviously explain and confirm a decreased athletic performance. However, athletes, coaches and scientists connected to sports are, for obvious reasons, more interested in an indicator that signals and prevents the undesirable effects of low performance [39]. Actually, some researchers have argued that the psychological tests are more efficient in the detection of the initial stages of overtraining[24,37,40-41].

O'Connor[24] pointed four advantages in the use of psychological markers in order to monitor the overtraining process.

(1) Psychological alterations are more reliable and the mood swings better follow the dose-response relation of the loads imposed to training;

(2) Some moods are more sensitive to the training load (for example, fatigue), while others are more sensitive to emotional exhaustion (for instance, depression);

(3) The variations in the humor measures are frequently correlated to the physiological markers and;

(4) The registry of the training load with the monitoring of the stress frequency and humor recovery and responses are potential in order to prevent overtraining.

Another relevant issue to be considered is about the individuality and differences among the athletes themselves. The physiological and psychological tests comparison may lead to doubtful results. Inter individual differences in the recovery potential, phys-

ical ability, stressors in non-training periods and tolerance to stress may explain different levels of susceptibility of athletes in similar situations[13]. According to Kellmann[15], a viable decision when considering the athletes individuality would be continuously and regularly monitor them, hence comparing the data longitudinally.

Thus, in order to optimize the diagnosis chances of the complex relation among all the systems and symptoms involved, an issue is clear in the literature: the inclusion of all the possible measures to the sports training process, such as psychometrical instruments, physiological and biochemical tests, besides an adequate training register[5,42].

PHYSIOLOGICAL PARAMETERS

Investigators have not been able to confirm overtraining physiological markers[3,33,36]. The parameters that have been studied include heart rate (HR) resting rate and after exercise rate, arterial pressure (AP), maximal oxygen consumption ($\dot{V}O_{2max}$) in resting and in exercise, blood leukocytes and hematocrits, hemoglobin, iron, glucose, urea and several other enzymes and hormones indices[10,43]. Changes in these parameters have been reported in some overtraining studies[10]., while some other researchers have found contradictory effects or that induce to criteria establishment difficulty. These findings also enable the division in two distinct kinds of overtraining: sympathic and para sympathic[15,44].

In the sympathic overtraining, a predominance of the sympathic activity is suggested, with HR and resting AP increased, decreased appetite, body mass loss, sleep disturb and irritability[15].

Concerning the para sympathic overtraining, a predominance of the para sympathic activity is suggested, characterized by the decrease of the HR and resting AP and long periods of sleep and depression. Both kinds present deterioration in the performance and persistent fatigue. It is possible that the overtraining responses follow a progression, reflected by a predominance of the sympathic followed by the para sympathic stimulation[45].

Alternatively, differences in the kind of stress imposed in different sports, such as endurance sports versus short term and high power, with the intense training may result in different psycho physiological profiles. The sympathic overtraining has been especially pointed in athletes who use high power and velocity, which is the case of jumpers, runners and swimmers who are in short distance competitions. The para sympathic overtraining on the other hand, preferably reaches endurance athletes, such as runners, cyclists and long distance swimmers. In more severe and extensive cases, the sympathic kind, characterized as exciting, is rarely found or perceived[13]. The overtraining symptoms reported in the literature in endurance athletes, tend to reflect besides para sympathic characteristics, sympathic ones as well. Even though, little evidence supports the overtraining syndrome classification in these two presentations[6].

HR and recovery HR after submaximal exercise measures are a viable daily and training load monitoring instrument. Increased morning HR above 10 bpm reflect an initial stage of fatigue and overtraining. However, before short term overtraining other signs as infections, emotional imbalance, compromised sleep quality, inadequate carbohydrates intake and dehydration may be observed and investigated[3,43].

Certainly, monitoring blood parameters have been shown in order to indicate an effective coming overtraining. For instance, decreased blood lactate index after a maximal exercise is related to overtraining due to the reduction of the muscular glycogen storage after extenuated physical activity, decreased sympathic activity, reduced sensibility and plasmatic indices of catecholamines or a combination of factors. Overtraining has been shown as a modifier of the neuro endocrine control due to its ability to alter hormones blood indices and neurotransmitters such as glutamine, dopamine, catecholamines and serotonin. The procedures and costs of these monitoring measures in a long term do not make them completely satisfactory, of easy application, fast and financially reasonable[46].

PSYCHOLOGICAL PARAMETERS

Psychometrical questionnaires have been used and improved in the latest years for the sports context[8,30,47]. In the research involving overtraining monitoring and prevention, several instruments are used, namely, the Profile of Mood Swings – POMS[48] and the Questionnaire of Stress and Recovery for the Athlete – QER-D[4,25].

The research on Sports Psychology has been dealing with the relationship between overtraining and the emotional situations. The mood swings the way they are measured by the POMS successfully identify athletes with stress signs due to intense training of high volume, providing measurements of the mood disturbs in six mood levels (tension, depression, anger, fatigue, vigor and confusion)[19]. However, it is not clear yet whether it will determine the overtraining in all athletes and whether it will be able to be efficiently used during the competitions season. Moreover, significant disturbs in the mood have been observed in athletes after intensive training in which the overtraining syndrome is not found. Therefore, further research is necessary in order to establish under which circumstances the mood may be totally reliable to monitoring[15].

More recently, the questionnaire has been more widely used, especially by the American, German and Brazilian Olympic Committees, besides the monitoring of Brazilian Para Olympic athletes, the QER-D (RESTQ-Sport, in English), with the purpose to monitor the extension of the mental and physical stressors (*stress*) and the abilities or not of recovery (*recovery*) in the last 3 days and nights. The QER-D consists of 19 multidimensional scales, 12 general scales and 7 sports-specific scales, in order to acquire from the athletes information about their training emotional routines and their lives outside the training and competition environment[47,49]. The QER-D is validated in Brazil through reliability tests and test-retest conducted by Costa (2003) and Alves (2005).

Several studies have verified that the training may be effectively monitored through the QER-D and the POMS[4,19,24]. Similarities are found concerning the dose-response relationship (training volume/stress situations and recovery, humor) and the inter-relation between these scales. Kellmann *et al.*[50], using the QER-D before a competition while following 21 American female swimmers, observed significant improvement after a 4 day-holiday which preceded the competition, characterizing thus, the training and recovery effect efficiency in the athletes (super compensation). The scale indices pointing to stress decreased concomitantly to the increase in the recovery scales prior to the competition. In another study, Kellmann and Günther[24] examined the relationship between stress and recovery in 11 rowers, 6 females and 5 males, from the German Olympic team in Atlanta, using the QER-D, in four occasions until the Olympic Games, when 8 team rowers filled in a fifth occasion, two days prior to the competitions. The results showed significant components of the stress somatic scales, such as energy loss, somatic complaints, lesions and recovery scales, as well as being in shape, paralleling to the related scores with the training volume and intensity. Kellmann *et al.*[51] applied the QER-D in 54 rowers, 30 males and 24 females, during the opening competition and the 6 weeks prior to the Junior German Championship in the sport, demonstrating that the higher the training demands/loads to the athletes, the higher were the values of the stress scales and the lower were the recovery ones.

Contrary to the POMS, the QER-D improvement is due to its multi dimension feature, presenting a distinct and systematic view of the athlete's life, even when the competition is near[4,8,25]. Such nature helps the user (the coach, for instance) subjectively evaluate the current stress and recovery situations, while the "*iceberg profile*" of the POMS mainly incorporates the negative humor

states, and only deals with one positive state (vigor) of the humor aspect. The immediate extraction of the QER-D results analyses the profile of the stress-recovery state, as well as concrete solutions to current problem, reflecting in the interruption of the causal factors[25].

OVERTRAINING PREVENTION RECOMMENDATIONS

Concerning the alterations related to overtraining, it is not wrong to question the means that would identify such phenomenon. However, one situation seems clear – its prevention will hardly occur applying the concepts of only one science or marker, especially due to the fact that metabolic and organic alterations are associated with several body systems.

The risk of extended performance decrease, lesion, disease, early dropout and compromising of the athlete's life quality are probable harmful effects in overtraining, and hence, prevention becomes the ultimate aim. Recommendations with the aim to prevent overtraining in athletes are presented below:

- Consider that the athletes have different levels of ability and tolerance to the training load[3];
- Monitor the performance through the registry of trainings and competitions. Athletes and coaches should register training frequency, duration and intensity joined with periods of resting between the sessions[52];
- Progressively increase the training load through the periodization in the exercises establishment. Do not increase the weekly training load in more than 10%[53];
- Provide training load modifications, with volume reductions, intensity alterations, avoiding monotony in the training as well, giving priority to recovery periods[54];
- Integrate mental and relaxing sessions in the daily training with the purpose to recover energy and reinforce concentration in the training routine[55];
- Establish realistic and attractive goals to the training and competitions, encouraging the fulfillment of these goals and creating a retro-eating process in order to increase motivation[31];
- Avoid excessive competitions through an annual adequate planning[56];
- Encourage the development of psychological, physiological and social abilities, through the maintenance of good health and physical conditioning, with control of the stress factors, diet and balanced training[54];
- Keep a balanced diet, with large variety of nutrients which mainly contains carbohydrates, proteins and electrolytes. The use of vitamins and electrolytes may be necessary in case the diet is deficient[10,32];
- Control the psychological stressors external to the physical training, such as family and professional pressure, excessive or very long trips, sponsor's and the club's pressure as well as any other routine events. In case the external personal stressors become high or if their control is deficient, a reduction of the training load is recommended[15,53];
- Use the active and passive recovery processes, associating periods of absolute resting with the use of small games, pleasing trips as well as some other examples of leisure activities (swimmers could play soccer, for instance) and regenerating runs[54].

CONCLUSION

A monitoring program on the overtraining may be considered part of the management of the athletes' life quality and maintenance of their professional status during their careers. However, the most appropriate methods for such program are still being discussed. Comprehensive physiological tests have not been more efficient than psychological tests. Moreover, they have shown easier procedures with lower costs. The POMS, QER-D and register of daily training loads are some examples. On the other hand, physiological mechanisms may dedicate psychological responses in overtraining, suggesting the association of psychological parameters for the monitoring joined with physiological, biochemical and/or immunological evaluations. Thus, based on the overtraining complexity and difficulty of detection in sports, one may reach the conclusion that the best action from the coaches and professionals related to sports, such as physicians, nutritionists, physical therapists and psychologists, is the implementation of a systemized prevention program to the harmful effects on performance, health and consequently in the athlete's well being.

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