Training and overtraining: an introduction


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ABSTRACT

Training and overtraining: an introduction. Med. Sci. Sports Exerc., vol. 30, No. 7, pp. 1137-1139, 1998. Elite sport requires high training volumes. However, little is known about the relationship between training volume and performance development. This relationship appears to have an inverted U-shape. Short-term overtraining or overreaching is probably associated with insufficient metabolic recovery, resulting in a decline in ATP levels. Systemic overtraining or staleness is attributed to failure of the hypothalamus to cope with the total amount of stress. Clinically, a parasympathetic and sympathetic form has been distinguished. It is assumed that these two forms express different stages of staleness. No specific, simple, and reliable parameters are known to diagnose overreaching and overtraining in the earliest stage.

The primary goal of athletic training is to enhance performance and to peak at the right moment. To push the performance capacity to its upper limit, relatively high amounts of intensive exercise have to be done. Although little is known about the optimal amount of high-intensity training, athletes usually are generally inclined to do too much. It even appears that many athletes have to do high volumes of training to be able to sustain the amount of work they think they have to do. In effect, they train hard to adapt so that they can train even harder.

Training and Recovery

The generally used training model is based on the idea that physical exercise leads to a disturbance in cellular homeostasis (15,17). These exercise-induced changes are assumed to be the main stimulus for initiating physiological responses to restore homeostasis and to induce training adaptations. It is assumed that recovery processes do not stop when homeostasis is restored but continue until a small overcompensation is attained, which is referred to as supercompensation (17). The best moment for the next training is when the supercompensation is at its highest level. However, relatively little is known about the recovery rate and the adaptation processes. This is because simple
and easily obtainable measurements of training are not available to obtain 
insight into the different components of the recovery process. Consequently, it 
is not exactly known when recovery is complete and when the supercompensation 
is completed.

Although it is assumed that recovery is initiated by the disturbance in 
homeostasis, there is evidence that recovery processes are modulated by the 
endocrine environment (16,17). The endocrine system works in a concerted way, 
and the hormonal milieu can modify and amplify the recovery and adaptation 
process (17).

For a fine tuning of the endocrine system and the autonomic nervous system, a 
proper integration and control of these systems is necessary. To this end, the 
hypothalamus plays an important role. In the hypothalamus all kinds of external 
and internal stress are integrated and an adequate answer is prepared enabling 
the body to cope with each situation and threat to the integrity of the 
organism. The answer from the hypothalamus can be expressed via the endocrine 
system, the autonomic nervous system and behavior (1).

When exercise and the associated disturbance in homeostasis are not matched by 
adequate recovery an athlete is actually overdoing or overtraining, and may 
become overexerted or overtrained. To obtain optimal results in sports, it is 
important to maintain an optimal balance between training and recovery. The 
importance of optimal training is clearly illustrated by the small difference 
in performance between winners and losers. Snyder and Foster (14) studied 
speedskaters during the 1988 Olympic speed-skating event in Calgary and found 
that the difference in average velocity between all gold and silver medal 
performances was 0.3%, whereas the mean difference between all the gold 
medallists and all the fourth places was only 1.3%.

Unfortunately, few scientific data exist about the optimal training for peak 
performance. Costill and coworkers (3) studied the effect of increasing the 
training volume on performance capacity in swimmers. Doubling the training 
volume for 6 wk failed to induce a further increase in performance indices. 
Foster et al. (5) have demonstrated a curvilinear relationship between training 
load and cycling performance which displays saturation characteristics. Flynn 
et al. (4) investigated the relationship between training stress and hormonal 
and blood chemical markers for training stress. One of the findings of this 
study was that during the period of the highest training load, a 3-6% 
performance decrement was observed. Recalling the small differences in competitively 
meaningful performance, a 3-6% decrement may be equivalent to the difference 
between the winner and the very last places in an international event.

These studies indicate that there appears to be an optimal amount of training. 
Based on the relatively scarce data, there appears to be an inverted U-shaped 
relationship between training volume and increase in performance. However, the 
optimal zone is poorly defined, and passing the top of the curve may lead to 
overtraining.

Overreaching

An important component of early overtraining is insufficient recovery. As noted 
before, the first phase of overtraining or incomplete recovery is quickly 
reversible and usually referred to as "overreaching." Overreaching is usually 
encountered after some days of hard training. Sometimes overreaching is induced 
deliberately, in an attempt to obtain an increased supercompensation.

Overreaching is generally associated with muscle fatigue. It is hypothesized 
that this fatigue is caused by insufficient metabolic recovery and a decline in 
energy-rich phosphates. When high-intensity exercise is done in association 
with low glycogen levels, this may lead to an imbalance between ATP splitting 
and ATP generation. This in turn will lead to an accumulation of ADP. To 
restore the ADP/ATP ratio, 2 ADP yield 1 ATP and 1 AMP (13). The AMP is further 
broken down to IMP and eventually to uric acid. When no sufficient time for 
recovery is allowed, this may lead to a decline of the energy-rich phosphate 
pool and consequently to fatigue and decline in performance (2). Thus, 
overreaching is most probably related to insufficient metabolic recovery.
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Overtraining Syndrome or Staleness

There is a gradual transition from overreaching to overtraining syndrome or staleness. It is assumed that overtraining syndrome is induced when the hypothalamus cannot cope with the total amount of stress. This leads to a dysfunction of the neuroendocrine system (10), whereas changes in behavior may be encountered as well (1,6,9,11). This generalized form of overstress in athletes is generally referred to as overtraining syndrome or staleness. The overtraining syndrome is featured by premature fatigue, a decline in performance, mood changes, emotional instability, and decreased motivation.

For encountering an overtraining syndrome or staleness, training alone is seldomly the primary cause (6,9). It appears rather to be the total amount of stress exceeding the athletes capacity to cope.

In 1958 Israel (8) described two clinical forms of overtraining: the sympathetic form and the parasympathetic form. The sympathetic or Basedowian form is characterized by increased sympathetic tone in the resting state, whereas in the parasympathetic or Addisonoid form the parasympathetic tone dominates in the resting state as well as during exercise. The sympathetic form is most often observed in team sports and sprint events, whereas the parasympathetic form is preferentially observed in endurance athletes. The characteristics of the parasympathetic form of the overtraining syndrome suggest excellent health and may be misleading (8). Although the pathophysiological mechanism of both forms of overtraining are virtually unknown yet, it is hypothesized that both types reflect different stages of the overtraining syndrome. It is hypothesized that during the early stage of the overtraining syndrome, the sympathetic system is continuously alerted, whereas during advanced overtraining the activity of the sympathetic system is inhibited, resulting in a marked dominance of the parasympathetic system.

Diagnosis of Overtraining

Because the transition from adequate training to overtraining is a gradual one, it is rather difficult to diagnose an overtraining syndrome in its earliest stage. Several attempts have been made to detect overreaching and staleness in the earliest stage. However, all attempts to identify reliable, specific and sensitive parameters for overreaching and staleness have failed so far (2,7,12).

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Key Words OVERREACHING; OVERTRAINING SYNDROME; STALENESS

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