Positive physiological adaptations to training result from correctly timed alterations between stress exposure and regeneration, which is termed periodization. Cycles of stimulation, maintenance, detraining and rest bring about improvements in performance capabilities. Negative adaptation occurs when a stimulus is too great and/or regeneration from stress is inadequate, which leads to exhaustion. The purpose of this second report is to outline the interrelationships between overtraining and adrenal function.

**Overtraining**

Most of the changes associated with adrenal fatigue mirror the signs and symptoms of overtraining (Table 1). Thus, an overtrained athlete may have increased risk for adrenal fatigue and the resultant negative stress adaptations caused by adrenal malfunction.

Overtraining is defined as a state in which the body has been repetitively stressed to the point that rest is no longer sufficient for recovery. Overtraining is preceded by a short-term overreaching period, or the point at which the body progresses from the resistance phase to the exhaustion phase of the general adaptation syndrome (GAS). Overreaching is characterized by a reduction in maximal performance capacity, symptoms closely associated with lowered adrenal function, and the initial inability to respond to stress.

With the onset of overtraining, the adrenal glands are unable to respond to the training stress, and symptoms are presented (Table 2).

**Types of Overtraining**

Overtraining has generally been viewed as a single phenomenon that affects all athletes in a similar manner. Recent studies suggest that overtraining elicits different autonomic nervous systems responses in aerobic athletes and anaerobic athletes, with signs and symptoms mediated by either the sympathetic or parasympathetic nervous system.

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**Table 1. Signs of Overtraining**

- Persistent muscle soreness
- Elevated resting heart rate
- Increased susceptibility to infections
- Increased incidence of injuries
- Irritability
- Depression
- Loss of motivation
- Insomnia
- Decreased appetite
- Weight loss

**Table 2. Symptoms of Overtraining**

- Impaired performance
- Decreased motor coordination
- Decreased force production
- Altered immune, hormonal, and autonomic activity
- Emotional, mood, and sleep disturbances
Sympathetic overtraining signs mimic those of a strong stress reaction and are normally associated with young athletes, power athletes, and sprinters. It could be considered synonymous to the classical overtraining model, which is associated with performance incompetence, hyper-excitability, restlessness, and increased sympathetic activity at rest. Parasympathetic over-training signs are often very mild and may be unnoticeable. This type of overtraining is characterized by decreased sympathetic activity, with parasympathetic activity dominating at rest and during exercise. It may cause a decrease in performance, fatigue, apathy, altered mood states, and altered immune and reproductive functions. Parasympathetic overtraining typically affects endurance athletes and those who have trained for many years. An athlete may present signs and symptoms associated both types of overtrained states.

Parasympathetic Overtraining

The high volume of training performed by endurance athletes may cause exhaustion of the autonomic nervous system. Sympathetic overtraining occurs when the body increases the sympathetic responses in reaction to the stress stimulus. When the exhaustion phase of the GAS Model is reached, sympathetic nervous system activity decreases and the parasympathetic system dominates. As a result, overtrained endurance athletes may present the following symptoms: decreased total testosterone level, decreased total testosterone/cortisol ratio, decreased free testosterone/cortisol ratio, decreased total testosterone/SHBG (sex-hormone binding globulin) ratio, altered cortisol level, decreased sympathetic tone, decreased nocturnal and resting catecholamines, increased sympathetic stress response, increased creatine kinase, and decreased exercise-induced lactate. Consistent with the depression of the sympathetic nervous system, endurance athletes may also experience a low resting heart rate, rapid post-exercise heart rate recovery, metabolic alterations (e.g., hypoglycemia and decreased maximal plasma lactate during exercise), and an increase in oxygen requirement as a result of excessive recruitment of motor units and incomplete recovery from increased nerve stimulation.

Sympathetic Overtraining

The neural demands of anaerobic training, and other factors like psycho-emotional stress, repetitive competitive events, and nutritional deficiencies, may contribute to sympathetic overtraining. Sympathetic overtraining elicits different hormonal effects on the body from those of parasympathetic overtraining. Parasympathetic overtraining is associated with increased cortisol concentration, which leads to a diminished stress response and reduction of growth hormone and reproductive axes secretion. Anaerobic exercise produces minimal disturbance in cortisol concentration and consistent acute elevation in testosterone concentration, along with elevated resting testosterone concentration after several months of training.

Management of Overtraining

Adrenal fatigue is best managed through prevention of overtraining. Athletic trainers and therapists (ATs) should monitor fatigue, watch for indications of slow recovery from exercise, and respond to the earliest symptoms that are presented. Fatigue may be manifested by an athlete's reduced willingness to train and an increased level of muscle soreness. Both of these factors are indicators of altered hormone levels and nervous system recovery.

Alterations in sleep patterns, body weight fluctuation, altered heart rate upon rising, and diminished appetite can indicate the onset of overtraining (Table 3). Such occurrences should be recorded in a daily training log, which may reveal an altered recovery response and failure to return to homeostasis after training. Preventive actions may arrest the progression of overtraining.

Overtraining and Adrenal Recovery

Complete recovery of adrenal function after overtraining is possible through a reduction of the stress placed on the body and an increase in the time allowed for recovery and return to homeostasis. Lifestyle and

**Table 3. Observations Indicating Onset of Overtraining**

- Sleep patterns: sudden decreasing in the amount and quality of sleep
- Body weight fluctuations: a sudden drop in weight of 2 pounds or more
- Rising heart rate: a heart rate on rising of 3 beats or more above normal
- Appetite: a diminished appetite
exercise modifications are the most important factors in aiding recovery. Lifestyle modification includes learning to de-stress and cope with stressful situations, adopting proper nutrition, and implementing correct sleep and recovery patterns. Changes in the volume, frequency, duration, and intensity of training, administration of contrast baths and massage, and implementation of a scheduled rest period will be needed before the athlete is allowed to resume full training. Dietary supplements, adrenal cell extracts, and hormone replacement may accelerate recovery.

Dietary Supplements

The Food and Drug Administration (FDA) only requires general information to be displayed on the labels of dietary supplement containers. The purity and content dietary supplements are not regulated and do not require FDA approval to be sold.

- Vitamin C can be considered the most important dietary supplement for adrenal recovery. It is essential for synthesis of adrenal steroid hormones and the adrenal cascade. Increased secretion of cortisol by the adrenal glands in response to stress increases the need for vitamin C.

- Vitamin E eliminates free radicals produced by the process of synthesizing adrenal hormones. Uncontrolled levels of free radicals can cause damage within cells, slow down enzymatic reactions, and eventually cause physical damage to the adrenal cell structure.

- Vitamin B6 is a co-factor in several of the enzymatic reactions of the adrenal cascade.

- Calcium has an effect that calms the nervous system, which benefits adrenal recovery.

- Magnesium is essential for the production of enzymes that play a role in the adrenal cascade.

- Ashwaganda is considered an adaptogenic substance that may help to normalize cortisol level.

- Ginger root is also believed to be an adaptogenic substance that modulates cortisol level. It also functions to normalize blood pressure and heart rate, helps lower cholesterol, increases metabolic function, and stimulates enzyme secretions for digestion of proteins and fatty acids.

- Ginkgo leaf is a powerful antioxidant that promotes the removal of free radicals that are produced by the stress response, thereby protecting tissues from damage.

Adrenal Cell Extracts

Adrenal cell extracts, which are available in the form of liquid or powdered bovine adrenals, have been successfully used for treatment of low adrenal function. They are believed to enhance adrenal activity and accelerate recovery from adrenal fatigue. Adrenal extracts are not replacement hormones, but rather provide necessary components for adrenal repair. They include all the adrenal cell contents (e.g., DNA, RNA, and nutrients) required by the adrenals to correctly function and repair themselves.

Hormone Replacement

Hormone replacement therapy involves the administration of either natural or synthetic hormones. Although symptom resolution may be dramatic, this intervention has potential drawbacks. A negative feedback loop may be elicited by the introduction of a substance that was not produced within the body. In addition, many hormones are considered performance enhancing substances that are banned by various organizations. The most commonly used hormone replacements for treatment of adrenal fatigue are cortisol, DHEA, progesterone, and pregnenolone.

Conclusion

Adrenal fatigue results from a complex interaction of stressors that the body is unable to effectively manage. Improper periodization of training can eventually lead to overtraining, which may elicit signs and symptoms that mirror those associated with adrenal fatigue. ATs should be aware that diminished adrenal function can adversely affect recovery from intense training.

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