The adrenal glands assist the body's autonomic nervous system in coping with stress through production and secretion of hormones.\(^1\) When stress to the system is too great, however, adrenal hormone levels decline and adrenal fatigue syndrome may result.\(^2,3\) Adrenal fatigue syndrome is an under-recognized condition that may affect endurance athletes or athletes who over-train.\(^3,5\)

The body responds to the excessive stress with progressive physiologic changes that lead to hyperactivity of the sympathetic nervous system, which results in excessive secretion of adrenaline, noradrenaline, cortisol, and other stress-related hormones.\(^3,6\) These changes may result in decreased performance, increased injury risk, lack of motivation, delayed healing, and diminished overall health status.\(^6,8\)

The purpose of this two-part report is to alert athletic trainers and therapists to adrenal fatigue syndrome as a condition that may affect athletes. In part one, we present the pathophysiology of adrenal fatigue syndrome, as well as its recognition and strategies for management of the condition. Part two will focus on interrelationships between overtraining and adrenal function.

**Definition of Adrenal Fatigue Syndrome**

Adrenal fatigue was first described in medical texts as a clinical condition in the 1800s. It has a broad spectrum of nonspecific, yet often debilitating, symptoms that present a slow and often unnoticed onset (Table 1).\(^2,3\)

Although the symptoms are universally-recognized indications of low adrenal function, an adrenal-related diagnosis is rarely considered.\(^2,3\) As a consequence, a foundation for other related medical conditions is established (Table 2).\(^4,9\)

Despite the existence of effective diagnostic tools and treatment programs, conventional medical practitioners do not generally recognize adrenal fatigue as a threat to normal body function. The condition has seldom been diagnosed over the last fifty years, and it has been considered manageable though relaxation and stress control.\(^3\) Previously, laboratory tests could not detect abnormalities, but newer tests can accurately identify the existence of adrenal fatigue.\(^2,3\)

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**Table 1. Symptoms of Adrenal Fatigue**

<table>
<thead>
<tr>
<th>Symptom</th>
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<tbody>
<tr>
<td>Tiredness</td>
<td>Reduced memory</td>
</tr>
<tr>
<td>Fearfulness</td>
<td>Insomnia</td>
</tr>
<tr>
<td>Allergies</td>
<td>Low libido</td>
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<tr>
<td>Frequent influenza</td>
<td>Worn-out feeling</td>
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<tr>
<td>Arthritis</td>
<td>Inability to lose weight</td>
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<tr>
<td>Anxiety</td>
<td></td>
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<tr>
<td>Depression</td>
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</tbody>
</table>

**Table 2. Related Medical Conditions**

- Fibromyalgia
- Chronic fatigue syndrome
- Hypoglycemia
- Type 2 diabetes
- Auto immune disorders
- Increased occurrences of respiratory infections and allergies
Adrenal Function

The adrenal gland is divided into two parts: (a) the medulla and (b) the cortex. The adrenal medulla secretes the hormones adrenaline and noradrenalin, which act to dilate the bronchi, dilate blood vessels to the muscles, increase heart rate, increase strength of myocardial contraction, and in conjunction with cortisol, create the physiological changes associated with the fight-or-flight response. The adrenal cortex is divided into three zones: the zona glomerulosa, zona fasciculate, and zona reticularis. The zona glomerulosa is responsible for the secretion of aldosterone, which regulates sodium and potassium levels and fluid balance within the blood, cells, and interstitial fluids. It works in conjunction with other hormones to maintain the fluid balance and electrolyte concentration within the body. Adrenal fatigue causes circulating aldosterone levels to fall, which results in removal of sodium from the blood by the kidneys. This, in turn, results in a sodium deficiency and loss of body fluid volume. Low levels of sodium can cause confusion, drowsiness, muscle weakness, and seizures.

The zona fasciculata is responsible for the secretion of cortisol, which functions to maintain blood glucose, generate an anti-inflammatory response, and regulate the immune, cardiac, and central nervous systems. Adrenal fatigue is associated with an inability to secrete a sufficient amount of cortisol, which leads to hypoglycemia, an over-active immune system, increased smooth muscle contraction, and altered electrical activity of the neurons in the brain (manifested by altered behavior, mood, and excitability). The zona reticularis is responsible for the secretion of progesterone, dehydroepiandosternone (DHEA), and dehydroepiandosternone sulphate (DHEA-S).

Adrenal fatigue is associated with diminished responsiveness of the zona reticularis, which results in fatigue, bone loss, loss of muscle mass, depression, aching joints, decreased sex drive, and impaired immune function.

Causes of Adrenal Fatigue

Adrenal fatigue is related to stress stimuli. Stress can be classified as physical, emotional, psychological, environmental, or infectious, and a combination of stressors may be responsible for a physiologic response. The initial onset may be due to a single large stimulus, but smaller stresses that occur simultaneously can accumulate, become chronic, and result in the adrenal glands becoming incapable of maintaining a homeostatic state. When the recovery capacity of the adrenal glands is exceeded, adrenal fatigue occurs, and signs and symptoms become apparent.

The combined effect of individual stressors may not be obvious and may present different symptoms from those elicited by a single stressor that acts in isolation. A lack of awareness of the total stress load on the body and its cumulative effect on the adrenal glands may result.

Human Responses to Stress

The general adaptation syndrome (GAS) describes an animal’s generic response and adaptation to stress. The GAS has an alarm phase that is associated with a large rise in cortisol, which is followed by a low cortisol level. As the stress stimulus continues, the animal adapts, and cortisol secretion is increased during a resistance phase. If the stress continues, the adrenal glands eventually become exhausted. In the exhaustion phase, the animal is unable to respond to the stressor.

When the GAS model is applied to humans, variations occur in individual stress responses. Four patterns describe variations in complexity and timing of physiologic responses.

Pattern 1: Long Resistance Phase, Followed by Adrenal Fatigue

In this pattern, individuals are predominantly functioning in the resistance phase. A return to homeostasis occurs after a short period of duress. The pattern of stress alarm, resistance, and recovery continues until the aging process diminishes adrenal function. The occurrence of a major stressor may precipitate the first presentation of signs and symptoms. Patients exhibiting this pattern may be able to return to normal function but may be incapable of dealing with future stress.

Pattern 2: A Single Stressor, Followed by Adrenal Fatigue

This pattern may occur after exposure to a single initial stressor. It is similar to pattern 1, but it lacks the long resistance period. The body’s normal alarm response occurs, but recovery is only partial. Instead of progressing to the resistance phase response, the cortisol level remains below average but is sufficient to allow the individual to function at a suboptimal level. In this pattern, there is a decreased ability to return