OVERTRAINING AND THE CENTRAL NERVOUS SYSTEM
The Missing Link?

Romain Meeusen
Vrije Universiteit Brussel
Faculty of Physical Education and Physiotherapy
Pleinlaan 2
B-1050 Brussels, Belgium

1. INTRODUCTION

From a physiological standpoint, exercise can impose a significant amount of stress on an organism. Muscular activity requires coordinated integration of many physiological and biochemical systems. Such integration is possible only if the body's various tissues and systems can communicate with each other. The nervous system is responsible for most of this communication through central command and peripheral adjustments. Regular exercise or training will result in better performance, however this 'challenge of homeostasis' can lead to an disturbed balance between training and recovery. This stress is counteracted by several adaptive and regulation mechanisms. The physiological responses to any disturbance of the body's equilibrium and its 'feed-forward' (60, 61) and 'feed-back' from and to the brain is primarily the responsibility of the endocrine system (59). The endocrine and nervous system work in concert to initiate and control movement and all physiological processes it involves. When all facets of the central nervous and neuroendocrine system are performing in harmony, the ability to coordinate and regulate key physiological and metabolic functions, under the perturbations imposed by physical exercise, is quite remarkable. To date, relatively little attention has been placed on the role of the central nervous system in overtraining and fatigue during exercise and training. This chapter will focus on the possible involvement of the central nervous system in the onset of fatigue during exercise and the role of neurotransmitters and neuromodulators in possible mechanisms that underlie overtraining.
2. STRESS, ...ABOUT ITS DEFINITION

For many years, the study of stress was generally synonymous with the study of Selye's model of stress. The essential element in Selye's definition of stress is that there is a non-specific effect of any demand upon the body. In the first paper on stress (a letter to *Nature* published on July 4th 1936) Selye defined a syndrome produced by 'diverse nocuous agents' (84). He described a non-specific response to non-specific agents as follows:

Experiments on rats show that if the organism is severely damaged by acute non specific nocuous agents such as exposure to cold, surgical injury, spinal shock, muscular exercise and intoxicants, a typical syndrome appears, the symptoms of which are independent of the nature of the damaging agent.

This 'general adaptation' syndrome develops in three stages: first there is a general 'alarm reaction', which is followed by a 'resistance phase' in which the 'organs' return to normal or in which they adapt. Finally, if the insult continues at the same high level, resistance is lost and the 'exhaustion phase' appears. More or less pronounced forms of these three-stage reaction represents the usual response of the organism to stimuli as cold, exercise, training and overtraining (Figure 1).

The first theories about stress were built around the concept that a 'disturbance of homeostasis' will cause a 'stress response'. When the body or organs are confronted with stimuli that disturb the 'intern equilibrium', they will start a 'counter reaction' to correct the disturbance and to reinstate the original homeostasis. This more medical or physiological concept was adapted over the years to a more general model of disturbance, including 'emotional' or 'mental stress'. Today, the most frequently reported stress stimuli in literature are so-called 'emotional loads'. These emotional loads are probably most commonly cited or used reasons for stress responses, although in exercise physiology, the stimulus

![Figure 1. The training–overtraining continuum. (I) Exercise can be considered as a stress stimulus that will create a 'general alarm reaction'. (II) When intensive training is continued or intensified, a resistance phase will appear with a possible positive adaptation (compensation–supercompensation). (III) Finally, maladaptation, with decreased performance are features of the 'exhaustion phase'.](image-url)