



TRAINING PROCESS CONTROL



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Physical exercise represents a significant challenge to homeostasis in the body, which to maintain its intrinsic stability precipitates prompt responses from the neuro-endocrine system and ensures necessary increases of cardiac output, arterial pressure and glucose and free fatty acid production, besides shifting blood from organs to skeletal and cardiac muscles and increasing reabsorption of fluids in kidney tubules. This brief description of a complex set of “fight or flight” responses expresses the activation of nervous system autonomic sympathetic division to prepare the body to move as necessary to fight for survival¹.

The autonomous nervous system, which also includes a parasympathetic division, is part of an integrated system that constantly receives information from both the internal and external environments and producing fine organ adjustments for subject preservation through mobilization of neurological resources². Neurons located in the rachidian bulb regulate the level of activity of sympathetic and parasympathetic neural centers in the spinal cord, which, on its turn, issues neuronal projections capable of innervating organs like the heart, liver, kidneys and the supra-renal gland¹.

Oversimplifying the process we could say that while sympathetic division prepares the body for significant physical exertion and parasympathetic division is associated to the required post-exertion processes of energy conservation and cell restoration. A single training session increases sympathetic activity proportionally to its intensity, an effect which is mostly associated to central release of the vasopressin neuropeptide³. On its turn, chronic repetition of several training sessions promotes adaptations, implying predominance

at rest of parasympathetic activity and, therefore, of the above-mentioned processes of energy conservation. This last effect leads to slower heart rate at rest (sinus bradycardia), a response indirectly associated to increase in rachidian bulb of the number of receptors and central release of oxytocin, a neuropeptide involved in parasympathetic division activation⁴. Thus, physical exercise is capable of acute and chronic influence on rachidian bulb, drastically changing its autonomic function.

In order to bring forth maximum expression of human potential, the load of daily stimuli should be coupled to adequate rest and nutrition in order to enable specific biological adaptations to happen⁵. Thus, each training session should necessarily have a specific physiological objective to be achieved and if successively applied with regular intervals of rest, such training sessions may ensure not just recovery to previously existing levels, but also the overcompensation that reflects the morphological and functional changes associated to training phases⁶.

Bringing together the ideas about internal environment equilibrium initially proposed by Claude Bernard⁷ and subsequently developed by Walter Cannon⁸, in 1956 endocrinologist Hans Selye⁹ laid out the concept of a physiology of stress by demonstrating the existence of biological limits to the assimilation of homeostasis disturbing stimuli.

In this context, pinpointing the exact moment when new training load must be applied represents one of the most difficult tasks coaches must face, once the new stimulus must be applied before the effect of the previous one is completely lost, but, without interfering with the natural processes of body recovery and adaptation. An early application of training load prevents compensation (recovery) and overcompensation (adaptation) of athlete's body, pushing it to a physiopathological overtraining condition, perfectly reflecting the failure of the adaptive mechanisms and, which, according to Selye, could be associated to disease^{5,10}.

The “overtraining” condition happens when training load exceeds one's body capacity to recover and overtraining may have a sympathetic (excitatory) or

parasympathetic (inhibitory) nature¹⁰. Excitatory overtraining is associated to the high frequency of high intensity stimuli typically seen in power and speed sports, and produces symptoms like sleep problems, weight loss, mood changes with increased irritability, temperature, blood and heart rate (HR) increases at rest and delayed post-exercise HR recovery¹⁰.

Athletes must engage in high training loads, since there are adequate conditions available to allow recovering between sessions. Each energetic system must be strained with challenging loads and provide enough rest and recovery in a way that the created stress don't become intolerable.

On its turn, inhibitory overtraining, constantly seen in long distance race athletes withstanding high volumes of training, in general goes unnoticed to coach's eye once symptoms are confused with adaptive success of training, inducing fast post-exercise HR recovery, increased bradycardia at rest and also prolonged sub-maximum effort associated to the long series of daily training¹⁰. However, the associated parasympathetic hyperactivation prevents maximum effort from happening (limits maximum HR range) and, besides compromising maximum performance expression, it may be associated to an apathetic behavior and episodes of postural hypotension seen in some of these athletes^{11,12}.

Daily application of excessive training loads impacts the autonomous nervous system, changing respective function at rest. Frequent exposure to high intensity challenges promotes chronic sympathetic activation, significantly increasing the levels of circulating catecholamines which, instead of going promptly back to pre-exercise values after the training session, could stay high for several days.

On the other hand, a high volume of stimuli leads to increased parasympathetic tonus at rest, imposing body shift to energy conservation and preventing maximum effort directly associated to high performance^{5,6,10,12}. Thus, recovery parameters must be constantly checked, enabling an assessment of athlete general conditions and the residual effects of prior training sessions.

In order to increase the level of control over the effects of a training load and, indirectly, over participation of the autonomous nervous system, in 1982 Dziasko et al.¹¹, proposed calculation of the recovery efficiency index (REI). REI enables observation of reserve HR recovery percentage used in each training session and, when compared to HR at rest, measured immediately after subject wakes up in the morning, may assist in correcting training volume and intensity (table 1).

The complexity of the physiological effects elicited by sport training requires daily control of athlete's life routine to ensure accelerated recovery and adaptation. It also requires a careful observation of symptoms revealing the assimilation stage achieved, taking into account the existence of other stress factors that could exist in the lives of these athletes. Besides controlling autonomous nervous system activity, which, as already mentioned, directly affects HR, specific tests must be used enabling to enable pinpointing mistakes in prescribed load and adjusting it to the adaptive possibilities of each athlete.

Recovery Efficiency Index (REI) enables observation of reserve HR recovery percentage used in each training session and, when compared to HR at rest, measured after subject wakes up in the morning, may assist in correcting training volume and intensity.

TABLE 1

	ADEQUATE LOAD	VERY LITTLE LOAD	EXCESSIVE LOAD
BASAL/IER	50%-60%	> 60%	< 50%
No change or small changes	From 5-7bpm are said to be tolerable and associated to adequate load	Unchanged FC, means that load (volume & intensity) are too small	Unchanged FC, means that load (volume & intensity) exceeds body capacity to compensate
Downward trend	Reduction of 3-5bpm means adequate workload, but with incorrect proportion between volume and intensity (high volume)	Downward trend means that workload may be increased with increments predominantly to training intensity	Downward trend represents excessive load with excess volume training sessions
Upward trend	From 10-15bpm increments mean adequate load but with improper volume/intensity ratio (high intensity)	From 5-10bpm increments mean workload can be increased with increments predominantly to training volume	Upward trend means excessive load with excess intense training sessions

REI- Recovery Efficiency Index; HR – Heart Rate; bpm – beats per minutes
REI valid only for activities where cardiovascular system response is proportional to effort

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