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TRAINING LOAD MONITORING AND CONTROL SYSTEM

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Athlete preparation is a multifaceted process of rational use of factors (means and conditions), enabling a targeted influence on preparation progress and assuring specific work load for best perfrmance[1]. An athlete training management system involves participation of human and material resources. In order to achieve this goal, this system must be organized to ensure that desired quality is achieved. So relevant is the organization of this type of system that in Ancient Greece people were already concerned with this type of structure. At that time some of the questions related to preparation, involving competitions, the opinion of coaches, physicians, massage therapists, judges and organizers[2] had already been answered.

According to Verkhoshanski[3], training development is based on scientific principles, correcting past mistakes and theoretical speculations, basing itself on facts that impact athlete preparation organization and giving coaches new and increasingly complex tasks. These tasks encourage the search for new and often different ways of organizing training processes.

Athlete preparation systems are multidimensional. One of these dimensions is the **Trainning load monitoring and control system**. In reduced functionality models, training is processed in a closed loop system, where interfering during the process is not an option. Thus, whatever may have been planned will be carried out without any assurance that the object/effector/athlete is capable of withstanding imposed loads, and sought adaptations are actually taking place. These systems also fail to control other interferences that may occur during program implementation. (Figure 1).

By adding cybernetics and mechanics concepts, a load monitoring and control model was designed based on an open loop model. In order to create further possibilities of intervening in the training process, new components were added to the system, increasing system complexity, but providing further assurance that sought results will be achieved. (Figure 2).

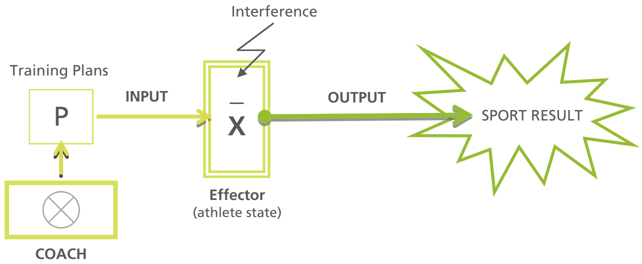

Figure 1 – Representation of a closed loop system most frequently found in sport training

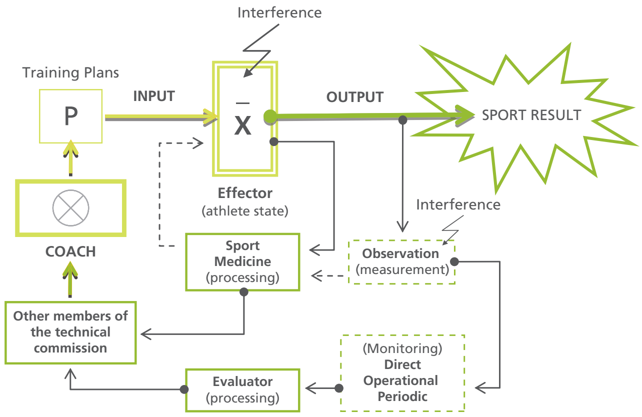

Figure 2 – Representation of an open loop system, found in more structured sport disciplines

Possibly, the leading determining factor of athletic potential results from athlete genetic component which, besides anthropometric and cardiovascular characteristics and fiber type rate, includes capacity to improve with training. Despite sport scientists not being able to do much to change inherited traits, sport scientists may suggest optimum training strategies to athletes, according to their genetic aptitudes.

> *Training loads account for a multidimensional stress, requiring athletes to produce force within certain space and time.*

In this new model, training programs are deemed to be system inputs and the results achieved by athletes its outputs. Programs and consequently program results are impacted by measurements, which, on their turn, enable evaluations and adjustments along the implementation of any given training program. Such adjustments are designed by a multidisciplinary technical commission (technical, statistics and medical departments, physician, coach, psychology counselor, nutritionist...).

There is no question about athletes being the most important of all of System components, with an effector function subject to constant adaptations in the direction of delivered load components. Training loads account for a multidimensional stress, requiring athletes to produce **force within certain space and time**. To respond to these loads that lead to body unbalance, athletes internal structure (energy, cardiovascular-respiratory, neuromuscular systems, etc.) must change to look for new homeostasis, which at times is not achieved. Thus, body response to loads can be measured and, therefore, controlled, using internal (physiological) or external (mechanical) variables[4,5].

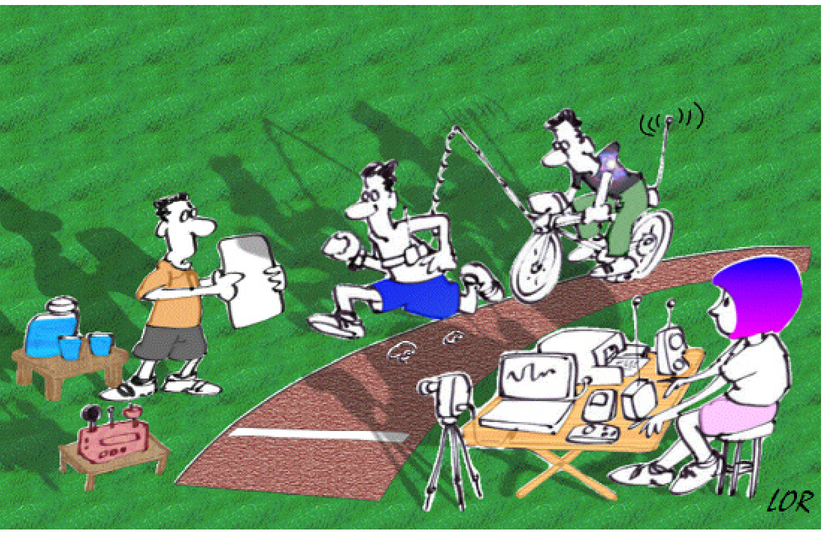

Figure 3 – An example of a setup for sport training monitoring, using internal (physiological) or external (mechanical) variables

An example of an internal – physiological – variable, is heart rate, which despite existing limitations, is deemed to be one of the most practicable and most frequently used variables for sport training. Others like lactate, ammonium, internal temperature and hormonal secretion are more expensive, invasive and, therefore, could hinder training process. These variables are important once they provide information about subject internal condition, but they may also be impacted by external factors and are not practical for field work. On their turn, the mechanical variables answer for the quality of executed load. **Space, force and time** are the basic variables that lead to several others, such as speed, acceleration, power and work. There is a wide range of control instruments used to measure mechanical variables, going from simple stop watches and tapelines, to automated systems provided with photoelectric sensors, dynamometers, recording and GPS (*Global Positioning Systems*).

Both types of variables must be used for training load control and monitoring. This process should take place at three different levels, each one aimed at the identification of different responses, namely:

1. **Direct Control (monitoring)** enables following and actual recording of loads to which an athlete is subject. This type of control is responsible for controlling the load imposed by exercise stress. With direct control, training can be kept as previously planned in the program. An example is speed (km/h) taken as a mechanical variable during a race, and heart rate (bpm) as a physiological variable, being simultaneously recorded by a micro-computer carried by the athlete. Direct control applies just to the training unit level (during training).
2. **Operational Control** this is the most important process for monitoring the acute adaptations related to the state of **fatigue-recovery**, mostly during the period that precedes competitions. It happens inside the training unit and in microcycles, representing one of the most important factors capable of detecting that the program needs to be changed. It can also be applied using a mechanical variable, such as performance during a vertical vault (cm), or a physiological variable, such as heart rate variation (Standard deviation).
3. **Periodical Control** enables checking the chronic effects of training, that is, the status of permanent adaptations. It is applied at the meso and microcycle levels. This type of control may also be used for athlete selection.

Applicable tests may be the same tests used for operational control, supported by classical laboratory testing, such as maximum oxygen consumption tests, anaerobic threshold (bpm, km/h, mmol/l), 1RM (kg), isometric force (N), speed test(m/s), Wingate (W, J, percentage power drop) test, etc.

In order to achieve a smooth system operation, because of their complexity, monitoring and control must be conducted and interpreted by a specialist-assessor, who hands out results to the other system members: coach, physician or nutritionist, depending on the type of result obtained. After evaluating the results submitted by the expert, these other members must make operational decisions about introducing changes to planned program or keeping it unchanged.

The knowledge about the states of **fatigue–recovery–adaptation**, allowed by this system, results in further knowledge about the athlete and the training process itself. It can minimize program manipulation errors, avoiding, for example, injuries because of excess load, and maximize athlete performance, taking it to his/maximum performance, once his/her response to physical load is well known and controlled by system components.

Just as every other system, this one is also subject to noise, interferences causing problems in obtaining, interpreting or conveying information. To minimize such noises it is important to be strict about the quality of equipment to be used and professionals that form the system. If a prior knowledge of system operation is added to all this, the training load monitoring system may yield excellent results to the Brazilian sport education and training system.

This proposal represents and advancement relatively to the models used in the past, when the adopted systems were characterized by a closed structure. Simply, designed programs were not subject to any adjustment of training loads and failed to detect changes caused by noise, with results achieved in competitions directly related to the initially proposed program added to noise. With this new proposal, control, applied since the training unit, enables larger and improved adjustments to proposed program and provides assurance to technical personnel about athlete results and his/her physical health.

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