DYNAMIC SYSTEMS THEORY AND SPORTS TRAINING

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ABSTRACT

Classical training theory is deeply influenced by a mechanical conception and a Cartesian view of athletes. Although the natural limitations of this classical approach are recognized, training methods are largely based on it. Nowadays, Dynamic Systems Theory is offering new tools to explain the behavior of the neuromuscular system and very useful principles to be applied to sports training (Kelso, 1999; Kurz, Stergiou, 2004). Instead of being thought of as machines, athletes are considered as complex dynamic systems, self-organized and constrained by morphological, physiological, psychological and biomechanical factors, the properties of the task and the environment. Due to this complexity, they are noticeably dependant on their initial condition and the distribution of attractors, showing fluctuations when passing from one attractor to another. The mechanism of adaptation to training, observed as a selforganization process, is transforming modern training stimuli and expected performance responses. Training loads should encourage the process of self organization in an integrated, overall way, changing the environment and the conditions to constrain the subject in the desired direction of the training process. The principle of individuality not only focuses on inputs but also on the outputs promoting the variability of the athlete's responses to each changing competition and training situation.

In conclusion, Dynamic Systems Theory is changing the view of mechanisms of adaptation to training and introducing important changes into performance targets and training methods, challenging scientists and modern coaches to find suitable solutions to optimize the training process.

Performance and training science has traditionally been deeply infl uenced by the mechanical conception of human beings. Although the need to integrate all aspects of training is constantly mentioned and more holistic proposals are sought, the dominant conceptual structure is still based on a Cartesian view. It conceives the organism as a machine divided into parts and performance as the sum of different qualities. Besides this, the computer metaphor is usedto explain the adaptation process and determine the most commonly applied training methods. Following classical training theory, it is expected that an input (the training stimulus) should produce, after the central

processing of the information, an output (the performance response).

This response has to be previously known by the subject and programmed by the coach (no correct response is expected otherwise). As there is generally just one possible correct response (the righttechnique, the right tactics ...) any deviation from this response will be considered as an error that will be corrected through repetition (necessary to achieve the automation of the correct response).
Sports technique is commonly trained by guiding athletes to copy and reproduce the correct model; conditional training is focused on supporting and enhancing this specifi ed technique, and tactical training is normally planned to produce previously determined strategies, which are expected to adapt to the opponent's weakest points, minimizing spontaneous decision-making by the team.....

improve this program, which defi nes previously specifi ed correct outputs? Inputs should be very analytical, as they must correct any small deviation, based on division into components and focused towards microscopic parameters in order to improve isolated functions. They should be very specifi c, as they have to inform the program about the structure of the motor action; big enough to produce a signifi cant change in response and correct possible errors, and they should increase progressively in order to achieve continuous performance development. The research available has empirically demonstrated these principles. In strength training, for instance, specifi city is often postulated, arguing for the importance of training in the specifi c angle of the sports movement (Weir et al., 1994), the correlation of the type of training with the type of gain in strength (Rutherford et al., 1986) or with specific speed (Ewing et al., 1990). However, the tests used to confirm these hypotheses are based on closed tasks and are consequently a long way from reflecting the constantly changing
reality of sports competition.....

The concept of the human beings as complex dynamic systems changes the mechanical view of athletes and the adaptation process based on the computer metaphor. This change in paradigm affects training proposals stemming from classical training theories and leads to a demand for its principles to be updated.....

The concept of the correct or right response has been fundamentally changed by the new paradigm. According to the research results obtained by applying DST to the study of human movement, the athlete does not need to know the solution of a new task beforehand. A complex interaction between the components participating in the motor

behavior, the task and the process of self-organization will produce the emergence of the right response. Practice or exposure to certain environmental conditions can guide, facilitate or alter the formation of differentiated movement patterns, depending on the initial conditions of the system. The presentation of the right model and the instructions intended to describe and guide it can even interfere negatively in the learning process (Hodges, Franks, 2002; Wulf, Prinz, 2001).
An ideal technique will exist for each situation and for each individual. For this reason, it will be necessary to train subjects to adapt to change instead of copying an external or foreign solution.....

In fact, variability is inherent within all biological systems, and it will not be possible to expect any identical responses (Bernstein, 1967) because of the non-linear interactions between the parts of...

As a result, training programs should consider each athlete's individual characteristics and the individual context the athlete interacts with. As has been mentioned, this individuality should also be present when proposing stimuli and when valuing the responses. This can be achieved by letting the athlete participate actively in the training process (Nitsch, Munzert, 2002). Instead of defi ning the right solutions, instructions should be addressed to external parameters related to the trajectory of the...

Movement or to the result of that movement on the environment (Mechsner, 2004; Wulf, Prinz, 2001), and should emphasize the self body awareness.
Related to this concept, the athlete's initial state should be considered. The process of learning or adapting to new movements or sports techniques will be constrained by the spontaneous movements that arise in each athlete (the distribution of the attractors). They will affect the progress and the stability of the adaptation process. By studying cyclical movements, the importance of destabilizing the existing attractors in order to learn new coordination patterns (Milliex et al.,2003) has been shown. This is observed also in sport when we want to modify certain aspects of a well-known technique. A coach's instructions about the athlete's "errors" will not be enough. Instead, other strategies must be sought so that the subject loses the "habit" he or she already has....

Classical training theory is mostly based on the design of the ideal task constraints. Training programs are usually based on division into components and on the improvement of the isolated functions and focused towards microscopic parameters.

The complexity of dynamic systems suggests that this should be incorporated into an overall view. Training methods can be more focused on a certain aspect, but always bearing in mind the infl uence of the whole organism.

Classical conditional training is clearly infl uenced by reductionism. In strength training, for instance, it is common to train each muscle independently.
Also, many athletes forget the stability muscles. Some machines are designed to isolate the work of specifi c muscles, even adding external supports to facilitate the adaptation of the areas of the body considered as weak. This type of protection
can be very benefi cial in avoiding injuries in beginners or for very specifi c objectives, but the exclusive use of this type of practice will lead to
an athlete lacking in important aspects. Stretching training is also often based on the division of muscular groups and on passive and static methods. However, the stretching of a muscle produces compensations in the rest of the muscular chain this muscle belongs to, and the exercise will not be fully effective if the whole chain is not stretched simultaneously (Souchard, 1996). Moreover, stretching could be combined
with strength training at the same time, in order to achieve a truly functional body. This combination can work by increasing the width of the movements or practicing active and dynamic stretching. In this case, technical training can also be added....

Training by breaking the serve down into parts leads to the exploration of the wrong region of the state space. In an analogous situation, training a team should always emphasize the overall responses of the system instead of developing isolated individual actions. At least, these individual actions should always be immersed in the overall system....

Another concept that should be adapted to the new view is the principle of variability of load. This considers changing different parameters related to the volume, intensity and type of contraction. However, the need to change the structure of the exercise or to train movements that do not correspond with what is considered to be the correct technique are not assumed. The consequences of DST application in training propose this kind of variation, which, surprisingly, is in agreement with classical training theory in some aspects. It is necessary to stimulate the subject to lose his or her "fi tness state" and receive a supercompensation. That is to say, it is necessary to destabilize the distribution of the attractors so that the subject can reorganize and

acquire a new state. The concept of supercompensation normally refers to conditional training, but this does not seem to keep in mind the need to adapt the technique to an infi nite number of situations and the athlete's need to be optimised by making his or her systems more adaptable and....

The proposal of varying stimuli for learning was already mentioned by N. A. Bernstein (1967). This author considered that an expert should control the task in all the possible situations. As conditions are never the same, practice should be
carried out not only to automate the task, but to develop fl exible strategies to adapt to environmental changes. For N. A. Bernstein, practice did not consist of repeating the possible solution, but of the process of solving the problems by means of techniques that were modifi ed in each "repetition". Practice will be a particular type of repetition without repetition....

Training should also not exclusively emphasize repetition but rather provide athletes with a wide spectrum of situations allowing them to generate changes in coordination,
to modify the intrinsic dynamics of the system and to provide them with a new group of experiences leading to the discovery of the fi nal answer.
However, this answer can never be fixed or static in an organism in constant change and evolution. If we consider that it is not possible to reproduce the initial conditions exactly, the repetition concept also loses its meaning flexible.

Dynamic Systems and Performance in Team Sports

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Dynamic Systems and Performance in Team Sports

1. Abstract

In order to create an appropriated training process for team sports, it is relevant to define a differential paradigm of sport performance. Traditionally, the sport training science has been developed through the study of the needs of several individual sports and, in contrast, its results are applied to team sports. We strongly believe that the analysis of the dynamic complex systems theories will provide us the best theoretical basis to construct a specific training science for team sports. Accordingly, it is necessary to modify the systematical Cartesian paradigm in such a way that can provide more adequate solutions to explain the complexity. Our proposal is to build channels of access between these theories and the different levels of the training process of team sports.

Key Words

STRUCTURAL TRAINING, TEAM SPORTS, DYNAMIC COMPLEX SYSTEMS.

2. Sport in the 20th Century

Sport in the 20th century is developed by means of its teaching and its training. The teaching-learning processes are based on behaviorists theories ("what is observable") such as psychology, pedagogy, didactics and methodology. The training-performance processes are based on mechanistic theories ("what is measurable") such as physiology, physics, medicine and biomechanics. These sciences –through its contributions- have been useful to construct an atomist and multidisciplinary sport model; in other words, a model based on the dualism "mind-body" that has been an ongoing debate since the beginning of the human knowledge.

Classical Paradigm

In the classical paradigm there exists a reproduction of models by ... "contrasted evolution". The model is reproduced depending on:

-The evolution of the rules.

-The evolution of the competition demands.

-The evolution of the knowledge of the coach.

-The evolution of the social and economical valuation of sport.

-The evolution of technology and research applied to sport.

All of them are external, alien to the athlete. The model is made up from the sport and from society.

Fundamentals to Practice

Behaviorist and mechanistic theories have developed certain practices to achieve these models.

-Practices of global tendency (during the first stages of sport learning): global training and small games.

-Practices of analytical tendency (during stages of sport performance): technique, tactic and physical

conditioning.

Both of them, are developed by quantitative practices of lineal and progressive sequences of analytical exercises.

The player is built in order to fulfill the demands of a certain model that at this moment “dominates” a concrete sport.

This paradigm, now in recession, has dominated our culture for several hundreds of years, during which it has been constituted our occidental society and considerably influenced the rest of the world.

Such paradigm consist of an entrenched set of ideas and values among which we can mention the following: the vision of the universe as a mechanical system that is compound of pieces, the vision of the human body as a machine, the vision of living in a society as a competitive struggle for survival, the belief in the unlimited material progress by the economical and technological growth, ...(Capra, 1998).

3. Sport in the 21st Century

Sport in the 21st century is developed by means of an integral development of the athlete (“mind-body” as a whole). Its teaching and training are an unique optimization process of the athlete. Cognitivism and structuralism _supported by organizational biology, neural-sciences, theory of the systems, theory of the information and ecological theories_ achieve the auto-modeling or auto-structuring of the athlete.

Consequences: New Paradigm

The aim is to achieve the auto-structuring by “differential optimization” and this is obtained by means of:

-The establishment of technical-tactical skills in which the player shows a certain competence.

-The observation of the impact that competition causes to the player.

-The constant acquisition of new knowledge of the player about the game, training and himself.

-The formation of the own social image.

-The achievement of the knowledge of the player during practice by means of technology and adequate research tools.

All of them are related to the athlete. The proposals are taken from the athlete.

If proposals are taken from the athlete, it is necessary to modify our thought, ideas and values about the sport-person as a living being that seeks the constant dynamic interaction between what is rational, analytical, reductionist, lineal, competitive, quantitative (for individual sports) and what is intuitive, synthetic, holistic, non-lineal, cooperative, qualitative (for team sports).

The Athlete According to These Theories

Based on the new paradigm, we are nowadays able to interpret the sport-person as a hyper-complex structure that is made up by interactions and retroactive actions between the following structures:

-Conditioning structure.

-Coordination structure.

-Social-Affective structure.

-Emotional-Volitive structure.

-Creative-Expressive structure.

-Mental structure ... ?

Each structure must be considered as the expression of underlying processes.

This means that the processes _a complete net of dynamic connections among systems_ become apparent through what we call structures.

Also, what we traditionally call capacities are just forms of sectorial evaluation of part of the

processes that occur in some systems which makes up a determined structure.

1st Contribution of the Systems Theory to the Development of Training

This systematic and holistic conception of the player will provide clues about the conditions under which the athlete must develop his training activity in order to obtain his differential auto-structuring. As a result, the own contents of the structural training appear; understanding that despite it can also provides new elements to “individual” sports, it is much more adequate for “team” sports in which the continue interaction among objects-partners-opponents requires high levels of auto-structuring of all their components.

Therefore, high variation contents and high variability practices are relevant.

As pointed out in the new paradigm, teaching and training are a single fact of optimization of processes which will become apparent as properties of each aforementioned structure, because these properties can only be considered from two standpoints:

-The dynamic inter-activity of all the systems.

-The global consistency of their interactions ...

We must construct specific exercises of structural training that provide such dynamic inter-activity and consistency; in contrast to the repetitive and analytical training exercises typically used by individual sports and based on other theories.

Practical Conditions

These practice requirements are offered by Preferential Simulation Situations. It must be defined such determined conditions of work that fix a “preferential” performance on some of the functional systems of the athlete. Thus, we will make up the building of the conditioning substratum of the training system. It is applied by certain movement forms that the athlete performs during his practice. These movement forms must include basic coordination elements that support the sport technique _execution of coordinate simulation_. (Stable levels that assure the consistency of the interactions). They are practiced under concrete situations which contain relevant information that must be processed so as to perform consequently. The cognitive structure must be involved. Connections with the partners-opponents-object must be established to feed the social-affective structure. Episodes of specific personal challenge must be experienced so as to commit the emotional-volitive

structure. (Levels for the variability that provides dynamic inter-activity).

2nd Contribution of the Systems Theory to the Development of Training

One of the essential properties of any life manifestation is the irreducible tendency to construct multi-level structures of systems inside of systems. These structures are consequence of varied inter-active processes among systems of differential complexity that take shape as a net in which nothing is the most important.

This triggers the need to modify the laws of the traditional training, inasmuch as synergy relations are more used than progressive training loads and sequential planning is substituted by differential priority. Many other principles based on the hierarchical and lineal conception must be substituted by inter-connected multi-level guidelines.

Practical Consequences

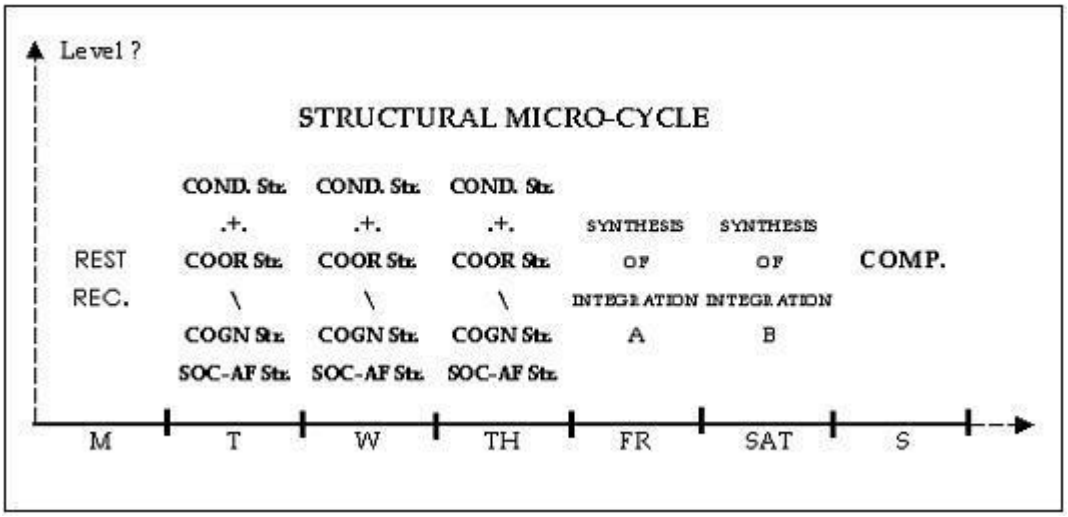

Figure 1. Model of a Structural Micro-cycle.

Every training day, there exists a differential priority adjusted to the needs of the athlete. All priorities are integrated in the synthesis pre-competition.

The total of contents of each micro-cycle are related with the consecutive and next micro-cycles. This is based on different inter-connection guidelines so as to obtain a high level of structural optimization.

3rd Contribution of the Systems Theory to the Development of Training

We know that the function of the components of such nets is to participate in the production or transformation of other components of the net. Consequently, all the net is built by itself. This provokes that the product of processes is the own organization, the differential auto-organization based on processes of qualitative production which bring about each unique human being.

On the whole, the called improvement of performance can not be evaluated by quantitative criteria that are alien to the person; on the contrary, they should be evaluated by qualitative proposals which are based on the interpretation that the own athlete is able to complete at any episode and from any perspective of the practice that performs.

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