



SYNCRETISM OF COACHING SCIENCE IN ANCIENT GREECE AND MODERN TIMES

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Abstract The aim of this theoretical scientific study was to investigate thoroughly into the phenomenon of sports training as comprehended both in ancient Greece and in modern times by establishing objective truth. Research into relevant information revealed levels of syncretism between how ancient Greeks understood the phenomenon of sport training and contemporary coaching theory/science. The science of sport training is included in the scientific system of sports, and, like other scientific disciplines, has its structural elements, i.e., its general information, function, basic concepts, methodology, and relationship with practice. There are several systems in sports: the system of preparing the athlete, the human-machine system, the training system, the system of performance in competition, etc. The application of coaching science/theory in practice is essential for the process of coach education.

Key words: *ancient Greece, modern times, coaching science/theory, scientific systems in sports, practice*

INTRODUCTION

Science is, in its widest sense, a synonym for knowledge. Although coaching science/theory has been widely discussed in literature by now, there is still a need to use the existing knowledge to add further perspective to its importance and application in the field of sports. Scientific consideration of sport training has met with tremendous success, so it has branched out into a significant number of particular sciences/disciplines. An insight into scientific knowledge from the past and present allows for anticipation of further tendencies in the development of coaching science/theory and its practical applications. This theoretical consideration built on the existing literature in order to analyze and explain prior theories and generate new ideas, viewpoints, theories, and the like. There should also be born in mind that the theory of cognition studies types, sources, structures, functions, developments, scopes, limitations and possibilities of cognition in its entirety, while a special part of cognition theory that has as its subject scientific cognition is called philosophy of science. Therefore, in its scope and content, **cognition theory** is wider than **scientific cognition theory** (i.e. philosophy of science) as an important segment of human knowledge and understanding [22].

PERCEPTION OF SPORT TRAINING IN ANCIENT GREECE

Each polis of ancient Greece wanted to hold its own competition as well as to be victorious in other poleis (similar to our days, this meant success in politics through sports). The emergence of popular sports games – competitions in Olympia, Nemea, Delphi, Isthmia, Athens and other poleis impacted on the development of a *system of physical exercise* that was called **gimnastiki** (γυμναστική) – which was a **training for sports competitions only** [8]. Training existed in ancient Greece. This meant that coaches had knowledge of basic training theory and of training systems. Thus a training session consisted of the following [15]:

- I part – preparations, warming up;
- II part – segments of training;
- III part – the principal part of training; and
- IV part – relaxation.

In order to create the training structure, ancient Greeks considered a number of factors such as the place, the venue (the stadium, the palestra), the time and the quality of training, measurements (the length of a shot or a jump, etc.), the athlete's physical and mental condition and so on [4]. The training differed depending on whether it was held indoors or outdoors, in hot or cold weather, on a wet or dry day [15]. However varied the approaches may have been, each maintained that the athlete should be psychologically stable so as to be able to endure the training with greater ease. They also held that after the training, when the athlete was tired, his rest should be comprised not only of a bath and a massage, but also of movements of arms and legs. Nowadays athletes use this in the form of relaxation exercises – limbering up and stretching their leg-, arm-, and trunk muscles.

Ancient Greeks used their theoretical and practical knowledge to set a series of **principles of sports training**, a great number of which are still in use. The famous physician Hippocrates [7] gave a stimulating piece of advice, which in time turned into a principle: "**Long-distance running should commence slowly** so as to make better use of the energy, since if the runner sets off abruptly, he will quickly be cut short." It was held that coaches should adhere to this principle in training.

Coaches employed the **principle of multifaceted preparations**. Philosophers and pedagogues held in high esteem and praised the exercises that had versatile effects on the body. They were called *general exercises* – *genikes askisis* (γενικές ασκήσεις), and belonged to so-called general physical preparations of the athletes.

Plato maintained that a well-kept body had greater abilities and that running and wrestling should apply the **principle of training the whole body for speed and strength** [18]. Modern sports training technology recognizes the fact that an athlete cannot accomplish significant results in competitions without completing thorough basic preparations [20].

Lucian [11] mentioned the **principle of training in exacerbated conditions**. His advice was that exercise should take place in the sun all year round, since the body should be beautiful and tanned, and free of excessive weight. Inside the gymnasium, one should not run or exercise on stone surface but on sand so as to add to the difficulty. One of the exercises involved a long jump where the athletes took off high in the air wearing suspenders with weights; another was yet more difficult – it included jumping over hurdles while holding small leaden weights in their hands.

Galen [6] spoke of **applying progressive modifications to intensity** ("Intensity should be gradually increased, peaking at the end. This should be of special concern in order to avoid injury to competitors.").

Music was used both in competition and in training. Ancient Greeks believed that training and music should coexist because they both pleased the man's spirit [18]. Flaceliere [5] wrote that each PALESTRA had at least one steady **aulos player**. "His duty was to improve not only the *exercise of limbering up*, as we today call 'Swedish gymnastics', but also throwing of discus and javelin, as well as other sports." One of the purposes of the aulos player was to produce rhythmical music that would help the young men master the exercises of the warm-up phase. These are in fact modern build-up and stretching exercises and other movements. Apparently, ancient Greeks knew how to use warm-up exercises to gradually introduce more strenuous work at the training. On the other hand, they took care of accurate performance of the exercises, with the aulos player having an auxiliary role and the coach being in the lead.

Hippocrates [7] said that "... those who walk after exercising will then have a stronger and more rested body." These words prove that Hippocrates, even without modern measuring apparatuses, knew that the **body recovers faster** if so-called *active recovery exercises* are applied, which also include walking, rather than with *passive recovery exercises*, which include e.g. standing, sitting or lying down. Aristotle [1] observed trainings and noticed that athletes when having a free day should not rest completely, but should instead do something of lower intensity. Nowadays active rest and other aforementioned principles of training are also used in practice. What does this mean? It means that age-long principles of sports training are still in practical use because they were well founded – upon knowledge and experience.

While studying classical literature, Muratidis [13] wrote: "Plato often mentioned coaches, called *gymnastis*, along with physicians, while Aristotle thought that they had special knowledge to prepare athletes.

Philostratos said that the **gymnastis had knowledge of both theory and practice** of training athletes, whereas the **paedotrib had knowledge of practice only.**" Muratidis [13] said of coaches: "The gymnastis were, as we would call them today, coaches to professional athletes or to those who attempted to win important sport competitions thus becoming popular in whole classical Greece."

From the IV century B.C. there were **specialist coaches** for particular sports, who had to be familiar with other sports as well. The training would begin with sketching (programming), where several factors had to be taken into account: the venue (indoor or outdoor), the place, weather conditions, the time of day, the quality of training, and the athlete's physical and mental condition. A new system of training emerged – **the tetras**, a 4-day cycle of varying training. In fact, this was the first appearance of a **microcycle** with the following structure:

- Day one – the day of *preparations* (toning, short duration, maximal intensity).
- Day two – the day of *intensity* (control of the extent to which the athlete can endure various exercises).
- Day three – the day of *resting* (active rest).
- Day four – the day of *medium intensity* (the athlete practised wrestling mainly, and paid special attention to tactics) [4].

Ancient Greeks held **competitions for three age groups** [16], which would correspond to modern categories of young juniors, juniors and seniors. Competitors underwent corresponding training procedures according to their age. Just as young athletes were selected for competitions, coaches were chosen for scouting and training young athletes to compete in a particular sport discipline. For example, the relay race with lit torches, which took place at night in the eve of the main Games, required from each **tribe to choose a coach** that would select the young athletes and take care of their diet and practice. The task of the coach (paedotrib) was to single out those who were best suited to such a race, since success depended on individual abilities regarding the techniques of relay and torch-bearing, as well as on the mental capacity to withstand great responsibility in the team [2].

The first fact that stands out from the aforementioned is that ancient Greeks recognized that those who were chosen had greater chances of success. Apparently, they knew of **selection of athletes**. Moreover, it was not at all easy to run at night, when the ground was hardly visible. Sole preparation, i.e. training, was complex, with special attention paid to this discipline (the precursor of modern relay racing). It required the following: the speed of running, the adroitness at torch relay, strength, and coordination related to balance (so as not to have the fire extinguished, and to run barefoot at night, when human sight cannot properly inform on various obstacles along the way, such as rocks, holes, rough terrain etc.). Presumably, the **paedotrib** had to **possess knowledge** on how to develop the speed of running and relaying the lit torch, on *ephebus'* mental characteristics and on other elements vital to the race. It should also be borne in mind that the helenodici conducted a selection of athletes that were able to participate in the Olympic Games. It is well-known that nowadays there are numerous selection systems, ranging from the selection at starting with a sports activity to pre-competition trials.

In his *Politics*, Aristotle [1] explained what constituted the system of raising and educating the youth in ancient Greece: "The customary branches of education are in number four; they are – reading and writing, **gymnastic exercises**, music, to which is sometimes added drawing. Of these, reading and writing and drawing are regarded as useful for the purposes of life in a variety of ways, and gymnastic exercises are thought to infuse courage... Music [is] nor again like gymnastic, which gives health and strength; for neither of these is to be gained from music." Not only does Aristotle explain why gymnastics is essential for youths, but he also illustrates this need through examples. Thus he says: "It is an admitted principle, that gymnastic exercises should be employed in education, and that for children they **should be of a lighter kind, avoiding severe diet or painful toil, lest the growth of the body be impaired**. The evil of excessive training in early years is strikingly proved by the example of the Olympic victors; for not more than two or three of them have gained a prize both as boys and as men; their early training and severe gymnastic exercises exhausted their constitutions. When boyhood is over, three years should be spent in other studies; the period of life which follows may then be devoted to hard exercise and strict diet. Men ought not to labor at the same time with their minds and with their bodies; for the two kinds of labor are opposed to one another; the labor of the body impedes the mind, and the labor of the mind the body."

Aristotle [1] was the first to say that **gymnastics** belonged to a particular **scientific field** and had a system of utilizing the exercises: "In all arts and sciences which embrace the whole of any subject,

and do not come into being in a fragmentary way, it is the province of a single art or science to consider all that appertains to a single subject. For example, the art of gymnastic considers not only *the suitability of different modes of training to different bodies*, but what sort is absolutely the best; (for the absolutely best must suit that which is by nature best and best furnished with the means of life), and also *what common form of training is adapted to the great majority of men*. And if a man does not desire the best habit of body, or the greatest skill in gymnastics, which might be attained by him, still the trainer or the teacher of gymnastic should be able to impart any lower degree of either. The same principle equally holds in medicine etc."

The preparations for competing at the Olympic games were first held in the city-states – **poleis**. Essentially, they trained warriors for combat in ancient Greek poleis and could be considered as basic preparations for subsequent brief competitions at the Olympic games. In accordance to this, ancient Greeks used to exercise the whole body in order to achieve a harmonious bodily morphology in the warrior/athlete.

As the use of arms was vital in running, throwing the javelin, swimming, martial arts and similar pursuits, ancient Greeks **exercised with suspenders** (1.5 kg weights held in hands). In his study, Muratidis [13] says: "One such exercise that constituted a part of daily exercise of the youths was known as **hironomin** (χέρη, *heri* arm, and νόμος *nomos* law; regularities in performing arm movements). This exercise was similar to a free movement of the arm, with an exquisite esthetics of movement, aimed at developing harmony and rhythm."

De Botton [3] had this to say on Socrates' method of logical thinking, which referred to knowledge: "To follow the Socratic example we should, when faced with criticism, behave like **athletes training for the Olympic games**. Information on sport was further supplied by *See Inside an Ancient Greek Town*. Imagine we're athletes. Our trainer has suggested an exercise to strengthen our calves for the javelin. It requires us to **stand on one leg and lift weights** (*author's comment*: modern trainers declare this exercise as "state-of-the-art", or "in", as very effective etc., forgetting they have discovered something that has already existed). It looks peculiar to outsiders, who mock and complain that we are throwing away our chances of success. In the baths, we overhear a man explain to another that we are *more interested in showing off a set of calf muscles than helping the city win the games*. Cruel, but no grounds for alarm if we listen to Socrates in conversation with his friend Crito:

SOCRATES: When a man is ... taking his training seriously, does he pay attention to all praise and criticism and opinion indiscriminately, or only when it comes from the one qualified person, the actual doctor or trainer?

CRITO: Only when it comes from the one qualified person.

SOCRATES: Then he should be afraid of the criticism and welcome the praise of the one qualified person, but not those of the general public.

CRITO: Obviously.

*SOCRATES: He ought to regulate his actions and exercises and eating and drinking by the judgement of his instructor, who has **expert knowledge**, not by the opinions of the rest of the public.*

The value of criticism will depend on the thought processes of critics, not on their number or rank. Don't you think it a good principle that one shouldn't respect all human opinions, but only some and not others... that one should respect the good ones, but not the bad ones? ... And good ones are those of people **with understanding**, whereas bad ones are those of people without it....So my good friend, we shouldn't care all that much about what the populace will say of us, but about what the expert on matters of justice and injustice will say."

The above quote leads us to believe that ancient Greece also knew of expert trainers, just as nowadays there are specialists in particular athletic disciplines. Socrates held the view that trainers were experts since they had "understanding". By this he most probably implied that they were good educators who possessed knowledge on how to conduct a training process.

SCIENCE OF SPORTS TRAINING HAS EVOLVED

When did science permeate training and began structuring theoretical approaches? Science of training sprung from ancient Greece, containing recommendations on how to create well-prepared warriors by the means of training healthily and getting ready for cult contests. Philostratos [4] says that it was **science of training** that designed and developed the program for competing at the Olympic games, simultaneously improving the methods and tools used in athletic training.

The theory that underpinned training practice existed as early as the V century B.C. Trainers knew of **basic theory of training**. The trainer and the athlete did not practise randomly but followed systems. It was not rare that trainers disagreed on the issues of principles, exercise etc. In his books on medicine Hippocrates [7], a physician, analyzed all existing physical exercises and concluded that athletic exercise imposed a certain stress on the body and the spirit (mental and physical load). Exercises imposing excessive load were forbidden since they negatively affected physical and spiritual development.

Philostratos [4] was the first to write a book entitled **On science of coaching** (*Gimnastikos*) in which he presented all available knowledge and experience of trainers from ancient Greece. It was athletics from the first half of the XX century that yielded concepts that impacted significantly on coaching science /according to [21]/: *General science on exercise* in the handbook *Athletics* (Krumel, 1930), *Knowledge on training* by Vaitzer (1937), *Primary Concepts and Methodology of Athletics* by Hoke-Schmith (1937), *Training athletes* by Ozolin (1952). However, other sports, such as swimming (Counsilman, 1980 etc.), also gave their contributions.

A general systematic approach to coaching science, structured on the foundations provided by experimenting both in theory and practice emerged in the 1950s in the then GDR, at the DHFK College for Trainers, and was strictly targeted at achieving results in sports. A new phase in the evolution of the science of training began in 1955-56, when educated graduate coaches started applying scientific methods in order to prepare athletes at all levels of sport performance (elite competitive sports, sports for the masses, school sports). It developed into an efficacious model of athletic advancement in all fields of sports.

A step towards structuring sport science, and therefore the science of training, was enabled by the inclusion of considerable experience gathered by accomplished coaches and athletes, as well as of knowledge from developmental theories with special contribution of biological sciences.

Fast progress in **Coaching Science** /Theory and methodology of coaching, cited from [21]/ became conspicuous after a number of expert publications appeared in several European countries between 1960 and 1980, such as: *Science of training* (Harre, 1957 and 1964) in the GDR; *Optimal training* (Weineck, 1980) in the Federal Republic of Germany; *Essentials of sport training* (Matveyev, 1977), *Modern sport training* (Platonov, 1980) in the USSR. The XXI century began with discoveries on sports training published in: *Supertraining* (Siff, 2000), *Essentials of Strength Training and Conditioning* (Baechle & Earle, 2000) in America, *Conditioning of elite athletes* (Željaskov, 2004), *Technology of sport training* (Stefanović & Jakovljević, 2004), *Theory and practice of sport training* (Stefanović, 2006) in Serbia etc.

The development of the science of sport training caused further comprehensive study into particular skills. Thus the American publisher Human Kinetics issued *Science and Practice in Strength Training* (Zaciorsky, 1995), *Science of flexibility* (Alter, 1996), etc. /according to [21]/. And what does contemporary science have to offer in the field of sport training? So far, most knowledge has come from books. However, the computer era provides significant advantages: abundance of information, expert debate forums, training software, and the like.

COACHING SCIENCE / THEORY OF TODAY

The ICSSPE (International Council of Sport Science and Physical Education) has systematized particular scientific areas whose principles in part intersect with sport. Thus they have become recognizable and important for the development of the scientific thought in sport, that is, sport itself. The ICSSPE has compiled a directory (Vade Mecum) of scientific disciplines that comprise the **scientific system of sport** [19].

- Adapted Physical Activity
- Biomechanics
- **Coaching Science**
- Comparative Physical Education and Sport
- Kinanthropometry
- Neuromotor Psychology, Motor Learning and Control
- Philosophy of Sport
- Political Science of Sport
- Sport and Exercise Physiology
- Sport and Exercise Psychology
- Sport History
- Sport Information
- Sport Facilities
- Sport Law
- Sport Management
- Sports Medicine
- Sport Pedagogy
- Sports Vision

The International Council of Sport Science and Physical Education (ICSSPE) has three fundamental objectives:

1. To encourage international co-operation in the field of sport science;
2. To facilitate differentiation in sport science whilst promoting the integration of the various branches; and
3. To make scientific knowledge of sport and practical experiences available.

Although a great number of authors are active in the ICSSPE, its Vade Mecum is not intended to be a "Who's Who" in sport science, but rather "What's What". In order to make the directory easy to use, the authors sorted out the information according to the following:

- Section one: *General Information* – includes functions, fundamentals of learning, methodology and the relationship with practice.
- Section two: *Information resources* – includes relevant journals, books of references, encyclopedias and cycles of books of proceedings from conferences and workshops. The earliest publications contain legal considerations, while data series and internet sources were added later.
- Section three: *Organizational network* – describes organizational activities in each field of sport science on the international, regional, and national level. Finally, with an increasing number of opportunities for pursuing an international academic career, additions of international study programs have been made to the edition.
- Section four: *Additional resources* – include terminology and views and opinions.
- Section five: *References* – these are included in particular sections when authors make references to otherwise unlisted publications.

Which key factors determine coaching science? It is clear that coaching science represents a part of the scientific system of sport and, like other scientific disciplines, has its structural elements:

General information. General coaching science/theory considers what is common to training in every sport, while specific coaching science/theory deals with training in each particular sport. This paper is dedicated to general considerations of coaching.

Function. Sport coaching is an activity aimed at guiding and directing the athlete or the team so that they should maximize their performance in the given sport, especially at high-ranking competitions. Coaching science sets the guidelines which enable the efficient accomplishment of this task. Numerous aspects of coaching include instructions on the techniques in the given sport, boosting fitness, managing diet, tactical developments and efficient execution of the techniques, mental preparedness of the athlete or the team, measuring the intensity of training, providing tactical, technical and mental support during competitions, as well as analyzing previous competitions and drawing appropriate conclusions. In case of competitions held abroad, the coach should also consider the acclimatization process. Besides, coaches attempt to identify prospective athletes among the youth and to be assured about their sporting abilities. In order to work rationally and efficaciously, there is the supporting knowledge supplied by coaching science/theory.

Fundamentals of learning. Coaching science/theory unifies data gained from physiology of physical activity, biomechanics, psychology, sport medicine, sport sociology, kinanthropometry, motor learning, pedagogy, etc., and empirical data collected by coaches from every sport; seen from the coaching perspective, such data can be joined into a multidisciplinary, practice-oriented discipline. The list of resources is not final; new developments in various fields can open fresh insights to coaches.

Methodology. The data "imported" from a wide range of aforementioned disciplines are gained through methodologies of their relevant sciences. They must be checked empirically and logically so as to become relevant to the coaching process as well. A common mistake is made when data obtained from a general population sample are used in training elite athletes, whose physical characteristics and mental status are completely different. The data used in coaching practice largely depend on antecedent information from the very same practice. However, most data will not satisfy the usual criteria that apply to scientific requirements: the population is too small for statistical significance, or there may be no control groups, so that double-blind studies cannot be sustained. These are the reasons why some experts prefer the term "coaching theory" to "coaching science". Future solutions to problems in sport lie in interdisciplinary studies. Researches will take into consideration the interactions between mechanical and physiological systems, cognition and emotion, social grouping,

political and economic factors. These fields of studies will have direct influence and practical consequences in identifying talents, adherence to training, and developments in programs for prevention and treatment of sport injuries. The scientific character of coaching theory will become more prominent; measuring the level of the athlete's response to training will become more accurate and reliable. Consequently, coaches and scientists will grow more precise in understanding the amount of intensity to be applied and thus acquire a clearer view of the relationship between causes and effects in training. Massive involvement of electronic media in almost every sport – from amateur, through competitive, to elite levels – will probably require information from specialists belonging to a team including the athlete, the coach, the sport scientist and specialists in sport medicine.

The relationship with practice. Coaching science is the key issue in the process of coach education. In the past, coaches were inadequately educated and they based their coaching on the mechanisms of intuition. Nowadays, such an approach has become insufficient. Both the annual syllabus and its appendices must be based on coaching theory. Elite athletes in leading countries are supported by the state and/or sponsors and they train in almost ideal conditions. The requirements for ever higher results lead to innovations in the process of training, deeper understanding of coaching and further developments in coaching science/theory. Such innovations are:

- Altitude training;
- ECG and sport fitness monitoring;
- Biofeedback in mental training;
- Metabolic assays (e.g. measuring lactate concentrations to determine the optimal speed in running/swimming in training and competition, etc.);
- Simulation camps as part of preparations for major competitions;
- Use of computer technology and video equipment for the analysis of training and competition performance;
- Understanding and application of post-training recovery process.

SCIENTIFIC SYSTEM IN SPORT PRACTICE

Without practice, scientific systems cannot exist in sport. Thus, there are several systems within sport: the system of preparing the athlete, the human-machine system, the training system, the system of competition performance etc. How particular systems are manifested in sport practice will be seen through their basic characteristics [21].

THE SYSTEM OF PREPARATIONS

Athletes feel an urge to compete; this should be understood as a desire to improve their result potential. In order to get to the core of the phenomena of competing, sport training and recovery, it is necessary first to explain the position they hold in sports.

Is sport not an organized activity with its own system of competition, training and recovery? If the answer is affirmative, it is not difficult to explain that the system of preparations is a specific process in which athletes prepare for the realization of their maximal abilities while competing with other athletes; these preparations are carefully planned and form a harmonious bio-psycho-social whole. In wider context, the **system of athletic preparations** integrates three areas – *competition*, *training* and *recovery* – fundamental for achieving results/success. Thus each single competition, sport training and recovery represents a significant subsystem within athletic preparations.

Planning and programming a sport training is a specific integral part of **managing the preparation system**. For this system to function, it must be manageable, i.e. managed by another system [9, 10, 12, 21]. The coach has the role of the managing system. A cybernetic model is used in order to describe the relationship between the athlete and the coach, that is, between the systems of managing and of being managed.

Among other tasks, the coach should decide upon the model to represent the aim of management (cybernetic model). This mainly includes certain internal and external factors that affect the success at competitions. The coach must first become aware of the final aim and then how to achieve it. In order to succeed, the coach must check the *output* of the management system and compare it with the desired outcome (*feedback*), and use the data to make managerial decisions. In the process, the coach must pay attention to the environment disturbances and try to minimize them by affecting the preparation system while influencing the environment of the system.

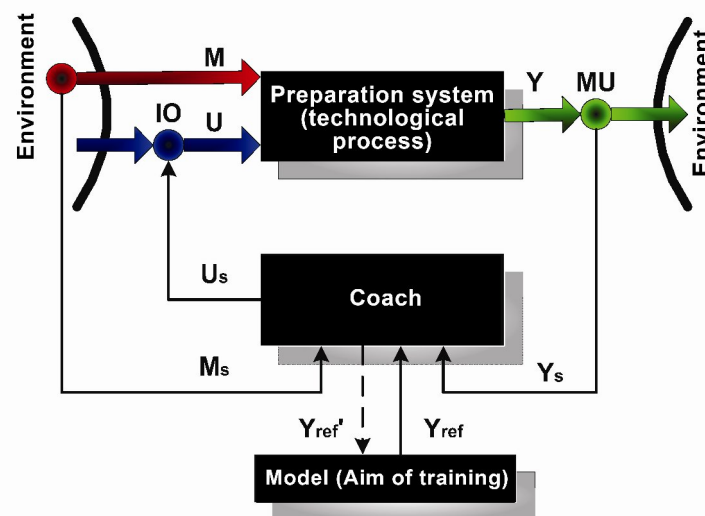


Figure 1. The cybernetic model of managing the system of preparing athletes. M – Disturbance effects; U – Management effects; IO – Executive medium (the method, the tool, the load); Y – System output (performance); MU – Measuring device (competition, tests, monitoring); Y_s – Performance information signal, i.e. system output; Y_{ref} – Desired performance of the system and its stipulating factors; Y_{ref'} – Model information; M_s – Environment disturbance signal; U_s – Management signals.

According to Malacko [12], the primary task of sport training is to lead the athlete from the **initial state** (Si) to a newly formed **final state** (Sf), i.e. Si → Sf. Such a transition, however, cannot happen instantaneously but rather through a series of successive transformations in definite time intervals. Therefore, sport training is formally defined as the **operator** (a series of actions) by which the athlete (or the team) is transformed from an initial state (Si) into a newly formed state (Sf); that is, the athlete or the team has the same definition but different **parameter values** (more, better). Consequently, there must be **found** such operators (training content) of the transformation that will reach the final state at the greatest approximation possible, i.e., with best results at the least expenditure of time and energy. Thus it is necessary to define the final state first, since **only when the final outcome is known can the transformation process be defined**.

THE HUMAN – MACHINE SYSTEM

Recent time has witnessed a growing use of computerized systems in training. There is the question whether the computer (an expert system) can replace the coach in managing the system of athletic preparation.

In some fitness clubs, the member simply enters the desired outcome into the computer, which then designs an appropriate program of training. As the member passes through different exercise machines (stops), the computer follows his or her reactions and corrects the program accordingly. What if one day information technology is able to create an expert system that will be homomorphous, analogous, even isomorphous to the coach? Will it be better at guiding the athlete toward the final success, i.e. competitive results? In order for such an expert system to develop, there should be devised an algorithm that would emulate the way in which the coach manages the system of preparations. Here the program of training and its subsequent corrections are the results of such an algorithm, with an aim to reach the condition desired by the model. Above all, this issue concerns a deterministic approach, which can be applied not only to training but also to entire life. Is human conscience just a complex algorithm?

Some authors [17, 21] firmly maintain that it is not, since it would deny the existence of free will. This issue has direct implications for the human vs. machine problem in training management. How can a machine be creative, or have an inventive spirit? A machine can learn and adapt, but it can never be a creative inventor, nor have free will like a human coach. It should be borne in mind that in its great part managing the system of athletic preparation is art just as it is science. And a machine can never be an artist.

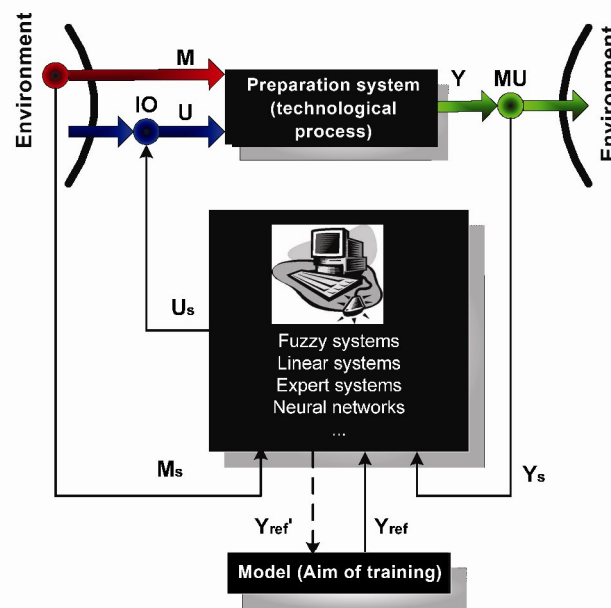


Figure 2. A cybernetic model of managing preparation of the athlete without the coach

TRAINING SYSTEM AND RELATIONSHIP ANALYSIS

Modern tendencies in sport can be observed also through the analysis of the training process, i.e. training system. The relationship analysis is concerned with similarities and differences in the training process, comparing new unknown items with known **training systems**. The relationships are determined upon the (non-)existence of such relationships. For instance, a causal analysis can establish the relations between training processes through:

- Overlap between two training methods-processes: if there is an overlapping factor between the subject of the analysis-training model;
- Difference between two training methods-processes: if there is a differing factor between the subject of the analysis-training model;
- Variants of training methods-processes: if changes to one of the factors of training results in overall change in the effects of training. Variants in training can be positive or negative, linear or non-linear, direct or inverse, large or small, or pattern-, situation- or individual-dependent.
- Unexplained variant of training methods-processes: if all known training effects are eliminated, the differences that still appear result from residual factors.

THE SYSTEM OF ANALYSING COMPETITION PERFORMANCE

There is a system of analysing performance at competitions for each sport/discipline. What does it look like in volleyball? Data Volley 2 is unique data scouting software for volleyball, used by the best teams in the Italian League, as well as by the best national teams in the world. This statistical tool enables the coach to immediately apply extremely reliable, easy-to-read data and make quick decisions during the match. The analytical phase includes recording performance of one or more players in great detail with multiple options to analyse skills, teams, players, rotations, sets, etc. so as to enable instant identification of the segments on the court where the best or worst moves are made. The software also shows the direction of the serve and attack, using multiple colors to highlight the best and the worst moves, as well as those in between.

OMEGAWAVE SPORT TECHNOLOGY SYSTEM (OW)

Software for supercompensation training [14] diagnoses the impact of physical and psychological loads on the athlete/team with an aim to optimize the training process. OW analyzes the electric activity in

the heart and slow brain waves so as to make an "insider insight" into the athlete's body functions. Besides, OW does it fast, non-invasively and stress-free. For the first time ever athletes, coaches, physiologists and sport scientists can monitor the cycles of stress and recovery in their athletes on daily basis. With the OW system it is possible to follow each athlete's adaptation to the requirements of training, competition, travelling and other causes of stress. Through adequate management of the stress and recovery cycles, it is possible to train the adaptive response of the athlete and consequently improve it.

What does it do? OW is an assessment device which provides a comprehensive and exhaustive "insider insight" into the functioning of various body systems: cardiovascular, ergometabolic, central nervous, humoral, cardiopulmonary, detoxifying, and hormonal. These physiological systems determine the athletes' power, strength, and stamina, their reactions, and, last but not least, their success. Quick regular tests enable the coach, the physiologist or the sport scientist to gather a dynamic picture of each individual athlete's adaptation to the training regimen. The coach is informed on what and how hard to "push", when to let the athlete rest, and how to adjust the training so as to achieve top results. Since OW shows the effects of stress regardless of its cause, it can also be used to assess the impact of travelling, changing altitude, hydration or lifestyle. OW is equally efficient at fast explosive or endurance sports, individual or team sports. This state-of-the-art technology is presently used by world record holders, top-ranking professional athletes, and also by athletes who wish to boost their careers and enhance their performance to the top level. The OW system has been obtained by Olympic committees, national teams, professional teams/clubs, prominent universities, elite training centers, fitness clubs, sport nutrition companies, personal trainers, and individual athletes.

How does it differ (What are its advantages)? OW has been specially designed for frequent use. A concise comparison of OmegaWave system with alternative testing methods is given below:

- Clinical environment/Easy portability
- Long-lasting processes/Quick
- Exertion until failure/Non-exertive
- Blood/tissue samples/Non-invasive
- Individual tests/Exhaustive, comprehensive
- Waiting for results for days or weeks/Immediate results
- Requires professional diagnosis/Gives readily applicable results

CONCLUSIONS

Just as in modern times, sport training in ancient Greece included specialist coaches, experts from sport medicine, scientists and others. In ancient times there were collective preparations for the Olympic games, and nowadays there are simulation camps that are included in the preparations for major competitions. It was in ancient Greece that there appeared the first training aimed exclusively at sport competitions. Ever since the classical times, the structure of training has remained practically the same. Ancient Greeks knew of the basic principles of training. There used to be sketches of the training where now computer technology and video equipment are used for analysis of training and competition. Music has been used in training and competing as a stimulus for achieving success/good results in the chosen sport activity. Both periods have paid great attention to the area of recovery. Considerations of coaching science have always corresponded to the existing technology and the levels of knowledge. Using terminology, selecting athletes, categorizing competitors, preparing comprehensively, using optimal load in training, being aware of periodization (microcycles), diet and other considerations form a strong link between knowledge on sport training from the two sport cultures of different eras.

PRACTICAL APPLICATION

The practical aspect of this theoretical research lies in systematizing and broadening the insight into science/theory of sport training, which is fundamental for transfer of knowledge into practice. Such stimulation of creative thinking is vital for the development of scientific thought in the area of training and coaching.

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