

Motion analysis in sport training: the link between technology and pedagogy

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Abstract

Sport is an increasingly popular phenomenon among people probably due to the parallel evolution of the methods of development of physiological, technical and strategic capacities. People who play sports have learned to pay more and more attention to the loads they put on their bodies. This is because it is known that excessive loads during workouts can increase the risk of injuries. As the benefits of sport activity manifest themselves in many fields like in disability, in the presence of clinical pathologies, for recovery prison and especially in schools, it cannot be considered as simple gymnastics, since it involves physical, psychological, and cultural aspects and for these reasons we now increasingly speak of sport pedagogy. Many definitions have been proposed for the word training but all of them are almost always incomplete. This because training is to be understood as a complex pedagogical process in which various factors come into play such as, for example, motor, physical, technical, tactical but above all psychological, neurobiological and social factors. The aim of training is to describe, quantify and evaluate human movement. The analysis of human movement provides information about different aspects of a specific motor task (such as walking, jumping and running), through measuring instruments like cameras or sensors. These allow to obtain quantitative and qualitative descriptions of the observed sport gesture. The purpose of this review is to analyse how the motion analysis, through its different technologies, can help in the description and characterization of sport and training intended as pedagogical processes.

Keywords: Motion analysis, sport, training, technology, pedagogy

Introduction

More and more people nowadays practice sport activity, from school age to adulthood. The growth of the "sport" phenomenon has manifested itself with the parallel evolution of the methods of development of physiological, technical and strategic capacities. The competitive athlete, as well as the amateur sportsman, must pay attention to the loads to which his body is subjected, since errors in training programs can increase the risk of injuries.

The benefits due to sport activity are many, both in disability (Ascione et al., 2018a) and in the case of clinical pathologies (Belfiore et al., 2018; Di Palma et al., 2018a; Montesano & Mazzeo, 2018; Montesano, Tafuri & Mazzeo, 2013) but also in different contexts such as for recovery prison (Di Palma et al., 2019) and especially in schools (Di Palma and Agosti, 2020; Di Palma & Tafuri, 2016; Di Palma, Raiola & Tafuri, 2016; Raiola, Lipoma & Tafuri, 2015).

It is also to be considered that training, as defined by the Italian sprinter Carlo Vittori, is "*a complex pedagogical-educational process, which takes the form of the organization of physical exercise repeated in quantities and intensities such as to produce progressively increasing loads, that stimulate the physiological processes of supercompensation and improve the physical, psychic, technical and tactical abilities of the athlete in order to enhance and consolidate his performance in the race*".

Therefore it becomes important to be able to *quantify* the execution of the sporting gesture, and in this sense some technologies are useful because allow us to measure, with a more or less variable degree of accuracy, the characteristics of a movement. These measures provide an objective method (not based on subjective sensations) to describe, quantify and evaluate human movement.

Methods

In this section we will describe the search criteria and strategies of the topics that have been discussed in this review. The purpose of this work is to analyse how motion analysis is fundamental to characterize the execution of a sport gesture and to improve training practice. Specifically, the role that the measurement instruments used for motion analysis can provide necessary information was highlighted.

To this end, after an in-depth bibliographic research on the most important databases of scientific publications, some fundamental aspects have been analysed. Specifically, the sport pedagogy was analysed, intended as the science of the theory and practice of education in motor and sports activity that addresses the problems of motor

and sports activities using approaches and methodologies of the science of pedagogy. Subsequently, we tried to highlight the complexity of the pedagogical process of training. This is because there are several factors that come into play and that must be considered. Finally, after demonstrating the importance of motion analysis and the most suitable measurement tools, we discussed how these technologies are fundamental in the analysis of sports movements.

Results

Sport pedagogy

Sport, generally understood as motor activity, aimed at the wellness and health of the person, at healthy competitive play, can be intended a tool for promoting those values necessary for the person to live well with himself and with others.

Sport activity has always been a very educational discipline, since its origins. In fact, being a very widespread cultural phenomenon, it has educational and value implications that require the critical attention of pedagogy (Tinning, 2008).

Sport, in fact, is not only *gymnastics*, but it is also a set of emotional experiences that involve various aspects of the human being, from self-knowledge to motivation, from the ability to manage the stress of physical effort to self-esteem, to the willpower and to enter into relationship with one's own body and with one's own physicality. For these reasons it require the intervention of the Educational Sciences with relative methodologies and intervention strategies, to achieve certain objectives (Ascione et al., 2018b; D'Angelo & Rosa, 2020).

The educational task of sport pedagogy is therefore to encourage the integral development of the individual's personality, helping the latter in problem-solving, in physical, social, psychic, educational, emotional, communicative and relational development. It was De Coubertin himself, the promoter of the modern Olympics, who recognized the fundamental value of sport in weaving interpersonal, international, interlinguistic, intercultural, interreligious relationships (Caillat and Brohm, 1984; de Coubertin, 1966).

Sport pedagogy therefore addresses the problems of motor and sport activities using approaches and methodologies of the science of pedagogy (Grupe and Krüger, 1997). Sport pedagogy is configured as a science of educational theory and practice in motor and sport activity; therefore as a critical-reflective science of such activity (Isidori and Fraile, 2008). Therefore, it has a fundamental role in educational and sport sciences; in fact, sport pedagogy has not only a role in ethics and in the respect for the rules but also in a communicative context (Habermas, 1997). These characteristics allows it to identify the values that underlie the relations of sports education with the society, the power, the economy, exposing their erroneous beliefs and ideologies.

Its task is therefore to promote motor and sports education by developing the educational values of sport and making it possible to adapt and integrate the new generations into complex social dynamics in continuous transformation and evolution (Di Palma et al., 2018b). Furthermore, the pedagogy of sport contextualises the meanings of motor and sport action in the cultural background in which they are generated (Grupe and Krüger, 1997).

The pedagogical process of training

Many definitions have been proposed for the word "training". In physiology, by training we mean the set of physical loads that cause a functional and morphological adaptation of the organism. More generally, training is understood today as any form of education organized in order to obtain a rapid elevation of an individual's physical, psychic, moral and technical-motor performance skills. In sport, it is intended as the preparation of athletes to achieve ever higher sporting performances (Harre, 1972). More generally, we can define sports training as a process of sports improvement oriented towards scientific and particularly pedagogical principles, which, with the methodical and systematic influence on the possibility and ability of performance, tends to lead the athlete towards high and maximum performance in a sport.

However, each of these definitions has limits; the first definition for example does not take into account the ethical aim of training. In the second definition, we speak of "rapid elevation of skills" which cannot be a good target for a child, given that he has not yet developed the physical requirements necessary to be able to talk about elevation of skills.

The difficulty in finding a definition resides in the fact that the training is something much more complex. It is in fact an educational pedagogical process that improve motor skills and techniques and consolidate them over time, by repeating in quantity and intensity of the execution of a gesture. In fact, each motor skill must be trained for adequate periods to avoid regression if the training is suspended. Which is not the same for technical skills.

In addition, when it comes to training, you have to consider that, because it is a pedagogical complex process, it is multi - faceted and includes various factors (Agosti and Sirico, 2020):

- **The physical qualities of the subject:** it includes the increase in the main conditional and coordinative skills of the performance
- **Motor skills:** the human being is not only a biomechanical, but also bio-energetic (which in his environment draws on energy reserves) and bio-information *machine*

- **Technical factors:** in order to perform specific gestures of the motor act
- **Tactical factors:** they aim to optimize the performance to run a proper conduct of the race
- **Psychological, neurobiological and social factors:** work on cognitive processes in order to develop a mental fitness in the athlete, with the aim of winning, ensuring that he is able appropriately to manage the various emotional states.

It should be kept in mind that training generates a relationship between two persons: the athlete and the coach. The athlete's ability to perform the technical gesture of his discipline is the determining factor for obtaining significant results. For the coach, on the other hand, it is necessary to know thoroughly not only the motor paradigm of the gesture but also possess the overview of its possible alterations in order to individually apply suitable corrective instruments. His activity will be productive only if it is based on a profound knowledge of the various types of physical load and consequently on the exercises to be proposed, on the reactions that these exercises cause in the systems of the human body (Agosti and Autuori, 2020). Furthermore, a coach for the achievement of goals in the athlete, in addition to the role of technician, must have many other roles. First of all, he should possess the important and delicate role of educator, because he teaches, corrects, helps the development of sensorimotor intelligence but also teaches respect for the opponent, he transmits the rules and values of sport and he educates to stay in a group. Furthermore, he should have a leading role, in the literal sense of the term, that is, he should lead the athlete to achieve the set goals. Some psychological and empathic aspects of the coach play a determining factor in this role. Finally, a coach should be an organizer, that is, he should be able to *make the team* to promote the sporting group being (Light and Harvey, 2017).

Movement analysis

The analysis of human movement aims at the observation of a specific motor task (for example, walking, jumping, running) by means of certain supports and/or measuring instruments (photographs, videos, sensors) in order to collect qualitative and/or quantitative information able to describe and characterize the motor gesture for diagnostic and improvement purposes (Cappozzo et al., 2005).

It allows the measurement and description of different aspects of a motor activity and it aimed to improve the motor performance, to deep physiological knowledge, and to evaluate the post-injury. The study of human movement aims to collect information concerning both the kinematics and the dynamics of the motor gesture. In particular it describe the absolute movement of the body's centre of mass, the absolute movement of bone or body segments, the articular kinematics (i.e. the relative movement between adjacent bones or body segments), the forces and moments exchanged with the environment, the energy variations of body segments, muscle work and power. Not only that, it also analyses some characteristics of the movement such as the constancy or variability of a motor gesture, its precision and its fluidity.

For the analysis of many sports, studies can be conducted in a laboratory by simulating the situation on the field. For other sports, however, it is necessary to study the athlete's performance directly on the field. Different measurement techniques are used, many of which are low cost, easy to use and easily accessible by all; others have a high cost, are more complex and take a long time to apply. The latter are generally used only in the laboratory.

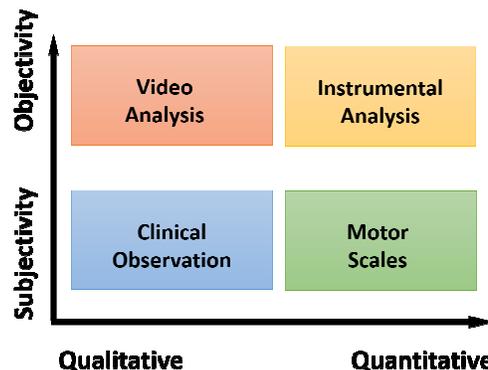


Figure 1: The characteristics, in terms of subjectivity/objectivity and in terms of qualitative/quantitative measures, of different kind of motion analysis systems.

As shown in figure 1, each motion analysis system has different characteristics, with different degrees of objectivity of the observation: operator-dependent (subjective) measures or objective measures. Furthermore, movement analysis systems involves two types of measures: qualitative (visual analysis and videotaped analysis) and quantitative (instrumental analysis).

The choice of which motion analysis system to use depends on several factors:

- Nature and complexity of the motion to be analysed;
- Environment and conditions in which the motion takes place;
- Economic and human resources available;
- Skills of the observer;
- Characteristics of the measuring instrument.

Analysis of sports movements

In order to make sporting activity a real pedagogical activity, it becomes therefore essential to be able to describe in the most suitable way what a coach observes in the athlete and what he wants to teach him. For these reasons, applying the various technologies for the motion analysis to sports gestures becomes fundamental in daily training practice.

By measuring a sports performance, the coach will in fact be able to identify, explain and correct errors in the execution of a gesture, customize a technique by improving motor control and making more effective both training processes and motivational support. He will be able to build educational progressions that can personalize the achievement of the athlete's goal, defining and modifying theoretical models useful for the study of sports techniques.

Discussion and conclusions

Studying a sporting gesture in order to improve the pedagogical process of training can be useful for many reasons. If you want to improve a performance, it becomes essential to identify the optimal posture for the athlete, studying for example the joint excursions, space-time parameters. Not only that, it is also useful in the prevention and evaluation of injuries to identify behaviours that can compromise a posture and generate injuries. Finally, it allows you to evaluate more precisely the recovery from an injury.

In summary, the analysis of movement in the sports field is a useful tool for injury prevention, functional recovery, monitoring of the evolution of the subject and optimization of training. It is very important also for clinical (Liparoti et al., 2019; Sorrentino et al., 2016) and ambient assisted living applications (Rucco et al., 2018).

However, there are also some problems related to the application of these techniques in the sports field, such as the heterogeneity of the sporting gesture, the use of specific tools and the difficulty of recruiting athletes. It is therefore necessary to know how to choose the most suitable tool for individual contexts, trying to find the best possible balance between the difficulties of the analysis and the results to be obtained.

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