



Universitatea
Transilvania
din Brașov

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Faculty of Physical Education and Mountain Sports

Ștefan TERIȘ

**Experimental study on the optimization of biomechanics in
the game of football by use of information technology**

SUMMARY

Scientific supervisor

Prof. Univ. Dr. Răzvan Sandu ENOIU

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FIRST PART

1. CONCEPTUAL AND METHODOLOGICAL THEORETICAL ASPECTS IN THE GAME OF FOOTBALL

Collective sports games have been the subject of many specialized studies (Delaunay (1976), Menaut (1982), Teodorescu (1984), Duricek (1985), Bayer (1986), Parlebas (1988), Hernandez Moreno (1994)), works that have tried to analyze their morphofunctional characteristics and create an extensive and rigorous ensemble of knowledge, in order to characterize and shape their nature and content.¹

Two of the most studied aspects were the causes or the motor mechanisms that made it possible to achieve movements, namely the different ways of performing a movement (Hernandez Moreno, 1994) and the structure of sport (Hernandez Moreno, 1994).²

1.1. General aspects of the evolution of the game of football

Football is considered the "king sport", managing to masterfully combine strength, intelligence, courage and elegance of movements. A team sport that is contested between two formations consisting of 11 players each, the playing surface being a rectangular one, with a gate at each end. The goal of the game is to insert the ball into the opposing gate, with any part of the body, except for the arms. The only player who can use the hands is the goalkeeper and only inside the penalty area.

Going closer to the current times, in 1904, on March 21, in Paris, the International Football Federation was founded, an association that is currently based in Zurich, Switzerland. It establishes the rules and competitions of the football game, the founding members being France, Germany, Belgium, Switzerland, the Netherlands, Denmark, Sweden and Spain.³

In Romania, football appears, without a trace of doubt, as a result of external trends. Sources say that the presence of football in our country has been felt since 1885, a great contribution being made by Romanian students who were studying abroad, but also foreigners from oil and textile companies, who practiced this sport in their free time.

1.2. Characteristics of the game of football at national and international levels

The game of football is truly a globally recognized phenomenon, being practiced in more than 130 countries and having over 25 million players licensed. With a modern history of over 100 years, in addition to attracting millions and billions of viewers, today's football trains and unfolds on the basis of well-defined ideas, specialized and professional attitudes and mentalities.

We note that the game was based mainly on static trends, which aimed at covering the playing surface in attack and defense, is no longer up to date. In the modern game, the trend is for them to be replaced by rules connected more to a dynamic aspect.

¹ Suarez, T.A., Sanjurjo C.A.C, (2018). Metodología de la enseñanza del fútbol, Editorial Paidotribo, Barcelona, Spania

² Hernández, J. (1994). Fundamentos del deporte. Análisis de las estructuras de los juegos deportivos. Barcelona: INDE, Spania;

³ https://ro.wikipedia.org/wiki/Federa%C8%9Bia_Interna%C8%9Bional%C4%83_de_Fotbal_Aso%C8%9Bie

Thereby, rules such as: "good use of players", or "coverage of the entire field" proved to be exceeded by the requirements of the current game. However, we find in the modern game some rules that are gaining more and more ground, rules that can be classified, as follows:

- The continuous movement of the players while the ball is in play;
- Maintaining a numerical balance in certain situations of the game.

Another factor of great interest in the game of football is the rapid transition from attack to defense and the interruption time required by the regulation. We note, therefore, that over the years, the time of passing the game from attack to defense has shrunk, the players having to adapt and possess the knowledge and tactical actions that are immediately required so that the constitution of the game does not suffer.

So, we can conclude that some of the specific features of the game of football are:

- Participation of all field players in both phases of the game (attack and defense);
- The tendency to cover the entire terrain and the frequent changes of places and tasks depending on the requirements of the phases;
- The total commitment and great mobility of the players make the space in the first third of the field in front of the gate more and more crowded.

Considering the aforementioned aspects, it can be stated that for the game of football, all players are required both a good morphofunctional development and a good neuromuscular and neuropsychic balance.⁴

⁴ <http://www.marathon.ase.ro/pdf/vol3/2/Netolizchi.pdf>;

2.THE EFFORT IN THE GAME OF FOOTBALL - GENERAL CHARACTERISTICS

Unlike individual sports such as golf, swimming, cycling, athletics, etc., where the athlete imposes his own rhythm, football is a team sport. Such a sport consists of direct opponents, teammates, the ball and the regulation regarding fouls and sports conduct, applied over time and in accordance with offensive and defensive tactics.

Sports effort can have two connotations:

- The proper stimulus of the athlete's organism;
- Stress factor.

From the perspective of training, the effort is represented by stimuli that act on the body, but also on the level of difficulty, of an objective or subjective nature, which must be overcome within the organized training.

2.1.Addressing training factors according to the age of the players

For the age group 10-12 years, athletes have an average of 3 or 4 workouts per week, finding here an interdependence between technical training and physical training, in different percentages, the higher share being at the level of technical training, of about 50-60%, compared to the physical one, of about 30-40% of the time allocated to a training.

The value level is the one that establishes the content of the technical training during the training sessions including the degree of development of the physical training but also the level of acquiring the special skills that define the football player. This variable influences the time allocation for:

- Learning new technical procedures;
- Consolidation, through repetition of the previously learned technical procedures;
- Individual control (player-ball), characterized by fluency of movements and coordination;
- Work on specializations: defenders-strikers
- Basic situations with a small number of players (partners, opponents, spaces, etc.);
- Managing defensive and offensive situations.

Technical trainings are aimed at systematically treating their own content, in order to strengthen the qualities of the players during the gameplay activity. The sequence of technical characteristics can be continuous or can be correlated or alternated with other factors, both during a training and during a microcycle.⁵

At this age, the athlete begins to realize the advantage of teammates support, which he will take into account, defining the stage of formation of the collective spirit within the team. The training objectives can be found in:

- Coordination;
- Learning and perfecting the basic technique and tactics;
- Strengthening the actions of the individual and collective technique;

⁵ Enoiu R.S. (2015). *Introducere în Bazele Generale ale Antrenamentului Sportiv*, Editura Universităţii Transilvania din Braşov, Braşov, România;

- Execution of procedures related to the space-time-speed-adversary ratio.

2.2. The character of the effort in football, taking into account the age

Contemporary football tends to improve, depending on the development of the functions of the systems and apparatus engaged during the effort. Each of them leads to an increase in the volume and intensity of effort, which, in the end, have a role in increasing the player's performance regarding the game dynamics. In order to be able to see the whole picture of effort, in the game of football, a retrospective of the effort over time is necessary.

A diversified effort, which contributes to the development of complex tactical actions, determines the drawing of new tasks to replace or supplement with players, in order to achieve numerical superiority. Therefore, players get to travel distances in different ways, with changes in the amplitude and frequency of the pitch, throughout the game. A player travels a total distance of about 10 km, at a speed of 7.1 km/h, during a match, half the time being on active rest or walking. However, the distance travelled differs from the position on which a player operates. The greatest distances are covered by midfielders, compared to the other posts, about 11 km. Strikers travel, on average, about 9.5 km, with no significant differences between them and the midfielders or defenders. Defenders, however, travel a distance of about 8.5 km, on average, during a game.

Football is a predominantly aerobic sport, and in order to prevent fatigue, it is necessary to develop aerobic endurance. Its insufficient treatment leads to decrease of execution capacity at a certain intensity of effort, against the background of low concentration and tactical thinking, the lack of accuracy of execution of technical procedures, but also an increase in the risk of injuries. Strength is another basic factor in the game of football, being present in the execution of sprints, changes of direction and pace, jumping with or without conditions of adversity.

3. METHOD OF LEARNING THE TECHNIQUE

The stages of acquiring motor skills are stages of the didactic process but they should not be confused with the physiological phases. In the framework of the pedagogical process of training it is imperative to take into account both the physiological and psychological phases.

Children's training has as main objective the discovery, selection and preparation of the future players of the senior teams with the help of a promotion strategy from one stage to the other, the performance objectives (victories, place in the ranking, winning tournaments) becoming secondary priorities. Training in the football game has a stadial character, its structure presenting instructive-educational objectives, content and methodology, in accordance with the age peculiarities, as well as with the optimal level of training necessary for real progress.⁶

The chronological age of children and juniors is not a fundamental trait in their training, the most important aspect, which is necessary to take into account, being the performance availability of the individual, the necessary training groups being organized by training levels: beginners and advanced. It is known that great performances in the game of football can only be achieved after an elaborate process of instructive-educational training, framed by the current trends and guidelines of research in this field. Given the increased interest in achieving superior results in adulthood, the training of children is perceived as an integrated factor into the structure of performance sports, having its own model of organization and training. The basis of future performances is directly connected with the formation of personality traits and natural development of children's motor skills, at the same time as the evolution, growth and maturation of body functions.

The notion of training consists of a multitude of forms and activities and is grouped into three main categories:

- Muscle training (contributes specially to improving the muscular system function);
- Organic training (influences the development of internal organs, but especially the circulatory and respiratory systems);
- Technical-tactical training (improves specific football skills and develops the tactical attributes of laying on the field, depending on the requirements of the game).

During a workout, the aspects listed above will never be found separately, as they integrate and influence each other each time, despite the fact that they have particular characteristics and manifestations.

⁶ Roman I. (2017). Studiul privind îmbunătățirea reacției motrice la jucătorii de fotbal 11 – 12 ani în urma folosirii problematizării, Universitatea Națională de Educație Fizică și Sport, București, România;

4. BIOMECHANICS OF MOVEMENTS SPECIFIC TO THE GAME OF FOOTBALL

Biomechanics refers to the movement of the body segments (actions), from the moment of starting the execution of a technical process until its completion, but also to the rules that must be observed in order to achieve an efficient execution.

The methodology of technical training follows the following aspects:

- Correct appropriation of the motor act that is learned;
- Execution of technical processes learned in the form of technical-tactical structures;
- Execution of technical processes in various complex situations;
- Improvement of procedures in conditions of adversity.

4.1. Generalities on the biomechanics of movements in the game of football

Biomechanics is the science that studies the mechanics of biological and cellular systems, tissues and the body. In the biomechanics of sport, we study the description of movement and the forces that produce movement, in order to improve physical performance while at the same time decreasing the risk of injury. A good understanding of the biomechanics of sport is very important in the game of football, because the laws of physics govern the abilities of the athlete to move quickly, to score or demarcate, to dribble, to jump, to apply force to kick the ball with maximum speed and accuracy. So, an understanding of biomechanical principles is necessary to increase performance, both in beginners and professionals.

Depending on the timing of the game and the shot that is required, for example, a penalty kick, or a shot on goal, we find two basic elements in hitting the ball. The first is the pendulum of the foot to the back, to impregnate the foot speed, and the second is the moment when the foot makes contact, effectively, with the ball. In general, the movement of the foot occurs in a tenth of a second, and contact with the ball lasts a hundredth of a second.

4. Analysis of the biomechanics of hitting the ball at the age of 10 to 12 years olds

We see the pendulum movement as a complex one that can be executed from various positions. Normally, it consists of two phases: one of preparation, in which the foot is taken to the rear, and the second, execution, in which the foot is energetically projected forward in order to hit the ball. Throughout these phases, the body rests on one leg, the trunk and upper limbs having the role of maintaining balance.

In the execution phase, the lower limb will execute a vigorous movement forward, which will lead to contact of the foot with the ball. Movement is composed of thigh flexion on the pelvis, knee extension and slight dorsal flexion in the ankle joint. If the ball is hit with the outer or inner part of the boot, slight pronation or supination movements of the foot will also be performed.

The supporting leg is generally slightly flexed in all joints, the position being ensured by the dynamic, failure contraction of the triple extension. Frequently, at the time of the shot, an extension occurs to the support leg, also provided by the chain of the triple extension, through the contraction of defeat.

4.3. Proprioception in the game of football

According to the online version of the Explanatory Dictionary of the Romanian Language, we can say that we mean by PROPRIOCÉPIE: s. f. 1. activity of proprioceptive sensitivity; its result. 2. Perception of oneself. (< fr. proprioception) .

The first person to describe the movement's position as a "sense of locomotion" was Julius Caesar Scaliger in 1557. In 1826, a few centuries later, Charles Bell comes up with a hypothesis stating that information about the position of muscles is sent from the muscles to the brain, a theory that was at odds with the ideas of the time. In 1880, Henry Charlton Bastian renamed "the sense of muscles" with a new term, "kinesthesia", and emphasized that information comes not only from muscles, but also from joints, skin and tendons. Alfred Goldscheider, renowned German neurologist, classified kinesthesia, around 1889, as the sensitivity of muscles, tendons and joints.

Proprioception can also be defined as a specialized variation of the sensory way of touch, which includes the sensation of movement of the joint and the sense of its position. Proprioceptors include, in turn, receptors located in the joints and muscles, which help to adjust the articular angles.

It is the somatic and sensory functions that control the movement of different parts of the body, the collective functioning of these systems being essential for an effective proprioceptive sense. Sensory receptors, together with sensory neurons in peripheral structures and with the help of neurons in cortical structures, are those that make up the somatosensory system. Somatosensory receptors are classified into thermoreceptors, photoreceptors, mechanical receptors and chemoreceptors. They receive information from the peripheral somatic area such as tactile stimuli, proprioceptives, thermals and information coming from the skin and epithelium, skeletal muscles, bones, joints, internal organs and the cardiovascular system, and are then transmitted to the cortical structure. Pacinian corpuscles, Merkel's disc and Ruffini corpuscles, which incorporate mechanical receptors, are specialized in providing information to the central nervous system about touch, pressure, vibration and cutaneous tension.

Proprioceptivity can be considered more of a sense of movement, while proprioception is the awareness of the position of the joints, and kinesthesia describes the sensation of movement of the joints. The signals received from the mechanical and quantized receptors are important in the control of the movement of the joints (kinesthesia) and their position (sense of the position of the joints). With the help of proprioceptivity, the human body knows where and how to place the extremities and how to move them, with great accuracy, in different positions, such as: maintaining balance or turning with closed eyes. Following an injury or trauma, proprioceptors may be affected. Researchers are still debating the hypothesis that if an individual's proprioceptors have been affected, they are more vulnerable to injury or not.

4.4.1. Balance, as proprioceptive component

Balance is considered a very important aspect of the performance of all individuals, while they are engaged in a series of daily activities, and that is achieved through the harmonious functioning of the musculoskeletal and neurological systems.

The literature refers to two types of equilibrium, namely: static equilibrium and dynamic equilibrium. Of these, static equilibrium is the one that maintains our position at the time of stationary, while dynamic balance helps the body at the time of movement. We use our eyes, ears and sense of stability to maintain our balance.

The game of football requires a variety of motor qualities, including maintaining balance during running, flickering, hitting the ball, marking, dispossession and changes of direction. Balance, which, as presented above, represents the ability to maintain a stable position of the body on a support base, is an important component of human ability. Balance forms, the basis of motor qualities, from simple ones to complex ones. Balance in the game of football, dynamic by its nature, requires singular control of the joints in order to be able to perform tasks during the game and training, such as: hitting the ball, jumping, landings, dispossessions, runs, but also fents. Dynamic balance requires an ankle-knee proprioceptive combination and the stability of the center of gravity to be able to achieve a straight posture. The balance includes the visual, vestibular system, but also the afferent somato-sensory system and efferent to the different strategies used, using the other components of proprioception (coordination and skill).

4.4.2. Coordination, as proprioceptive component

Coordination is the ability to perform with fluidity, rhythm and precision the movements of different segments of the body, with the aim of carrying out a sports action, of great precision.

In his 1993 book *Taber's Cyclopedic Medical Dictionary*, Venes defines coordination as the work of a set of muscles in order to produce a certain movement. In the field of the science of drive systems, coordination is considered the ability of the body to organize two, or more segments, with the aim of achieving a certain motor goal.

To improve coordination we find three main stages:

- General coordination: at this stage, the athlete tries to learn a new task, and the movements take place consciously. The athlete must pay attention to his own body in order to be able to complete the task. It depends, to a large extent, on the visual and auditory system, the rest of the senses not being prepared to provide high-precision information. This sensory hierarchy will be reversed as the learning process moves towards an evolution;
- Special coordination: at this stage, the athlete begins to internalize how information about movement will depend less on the visual and auditory systems, except for the information that comes from the coach and more from the proprioceptive and mechanical receptors (dynamic and static). The athlete uses feedback mechanisms that improve motor skills and, over time, inhibit unwanted actions, favoring the effective result of movement.
- Specific coordination: at this last stage of learning, motor programs run automatically, with fluidity, allowing the athlete to execute the movement effectively, in different directions.⁷

⁷ Irrgang JJ, Whitney SL, (1994) – Balance and proprioceptive training for rehabilitation of the lower extremity. J Sport Rehabil;

4.4.3. Skill, as proprioceptive component

Over time, skill has been defined as follows: "The ability to coordinate, either the movements of some segments of the body, or actions of movement, in which the entire locomotor system participates."

The skill, being a particularly complex quality, has several components, which we can organize as follows:

- Amplitude;
- Bilaterality;
- Ability to coordinate;
- Balance;
- Orientation in space and time;
- Accuracy.

The game of football cannot be practiced, at the level of performance, without mastering at a high level all the motor qualities, skill being the determining quality. A very good development of it gives the athlete a very good precision in the game, a superior orientation in the field, which is manifested by clairvoyance and a high development of the sense of rhythm and tempo.

5. SPECIFIC PARTICULARITIES OF THE AGE OF 10 TO 12 YEARS OLDS

5.1.Somatic peculiarities

The school activity also knows a series of changes, becoming relatively complicated by the complexity and demand it shows. The status of a small student is changed by engaging the puber in activities of a more responsible and competitive nature (thematic competitions, competitive games), which determine the puber to evaluate his own value and become aware of the skills and talents he possesses.

Differences in behavior occur between boys and girls, the latter developing faster from a biological point of view, being more stable, more diligent and more communicative. The behavior towards the parents also changes, the desire for independence makes its presence felt, the pubs wanting to spend as much time as possible with those of their age, which leads to conflicting relationships with the parents.

At this age, the muscle tone is lower, favoring the wider performance of movements in the joints, but at the same time it makes it difficult to perform fine, differentiated and precision movements.

5.2.Functional particularities

Even if at this age the child's brain has a weight approximately equal to that of an adult, it is not fully developed, from a functional point of view. In particular, sight and hearing will develop while the driving area is approaching maturity.

The development of strength is preceded by the gradual growth of the skeleton. This occurs due to the fact that the strength of the muscles depends on excitability and the ability to encompass, a maximum number of functional motor units, in addition to morphological development. This ability develops later, compared with morphological development, therefore the muscles of the young organism can not perform efforts of maximum strength. Fatigue quickly appears in long-term efforts, the muscles of children aged 11-12 years are long and thin, the increase in length of bones and elongation of muscles implying the avoidance of abuse of static efforts of force, since it negatively influences the growth process.⁸

5.4.Motor characteristics (in relation to the appropriation of the technique)

A. Demeter defines motor skills as "conditioned reflexes with a lower degree of stability, based on the repetition of interactions between kinesthetic, visual, auditory reactions etc., which simultaneously arrive at the level of the somatosensitive, auditory, visual cortical areas". This definition emphasizes the physiological substrate of movement skills.⁹

Motor peculiarities at the age of 10 to 12 years:

- Some of the motor skills are formed in the practice of life, others within the educational educational process; some motor skills, which have been misappropriated,

⁸ Ifrim M. (1986). Antropologie Motrică, Editura Științifică și Enciclopedică București, România;

⁹ Demeter A. (1982), The physiological and biochemical bases of the formation of motor skills, Sport-Turism Publishing House, Bucharest, Romania

can be corrected, in this process, and those appropriated correctly, can be strengthened;

- The formation of motor skills is long-lasting, through systematic and continuous repetition;
- They are concrete forms of motor activity and are based on dynamic stereotypes, achieved through temporal connections, in the cerebral motor crust. These ties are all the more secure, the more they are repeated, and the younger the age of the subjects;
- The main arousal that contributes to the formation of temporal connections, but also of conditional reflexes, is the repeated physical exercise systematically and continuously. This excitation must transmit to the cerebral crust the information in the same order and with the same intensity with which it was received, in order to form motor skills;
- Through practice, one can reach the automation phase, a phase in which the control of the cerebral crust over the performance of motor skills is preserved, but the attention is focused on the changes occurred in the ambient context and on the creative resolution of the motor tasks, and not on the sequence of the chain of movements specific to the respective skill;
- At the moment of mastering motor skills, based on the interaction of the analyzers with the thinking, it will lead to the formation of complex sensations, specific to sports branches, such as: "the sense of the ball", the "sense of the gate" etc.;
- Progress will be less and less noticeable, the more advanced we are; in other words, it is gradually and unevenly improved;
- Movements chain in one direction, and they are irreversible and unique at the same time. The reversal of some elements, if possible, leads to the elaboration of a new motor skills;
- Gradually, the motor skills are lost if they are not fixed by multiple repetitions.

6. THE EVOLUTION OF THE FOOTBALL GAME AND THE RESEARCH ON THE DIRECTION OF THE THEME

6.1. The evolution of the football game

The evolution of football has known over the years essential qualitative improvements both in terms of competitions, but especially in the preparation process. The adaptation of great teams to the multitude of game variants that exist today has diminished the rigid separation that existed between defenders and strikers. This way, they express themselves better and adapt more easily to the current requirements of the game and can more easily comply with the tasks they have during the game depending on the position they are evolving on.

In the framework of the training, the current ones includes some features that we list below as follows:

- The training factors must be approached simultaneously during the training sessions, which is why complex methods and means must be selected to force the player to highlight his creative thinking;
- Knowledge of players with the help of tests and observation method, in order to discover new methods of training, means and methodical procedures to which they respond favorably;
- The use of information technologies during the training sessions, the purpose being to improve the training process from the level of children and juniors; Error! Bookmark not defined.

6.2. The dynamics of research in the game of football

In the game of football, research can procure precious data of a biological, technical - tactical, psychological and socio-pedagogical nature that help to understand the functions that the human body performs under certain conditions and moments during the game.

In general, scientific research in the field of sport is making progress in relation to the specific needs felt by different branches of sport. However, in order to be able to make the most efficient use of the research results, technicians need to know the basic principles of scientific disciplines, in order to design training models adapted to the specifics of the branch.

The results of scientific research can ensure the improvement of the model of organizing the game of football both from the perspective of the team and from the perspective of improving the individual capabilities of those who practice the game of football. ⁶

6.3. Theoretical conclusions

From the analysis of the specialized literature, we summarized the important ideas, which we ordered and present as follows:

- a) As a result of going through the specialized literature we find that one of the important problems of the game of football is the improvement of the players' technique, which becomes a permanent requirement in the modern sports game. Referring to the young ages, when the appropriation of technique is essential, we find that a reference point is the biomechanics of the game of football. Studying the specialized literature, for the age between 10–12 years, we



identify a series of bibliographic references that concern this aspect, but which are limiting in terms of the use of specialized equipment, on this subject.

- b) From the literature studied we have found that it is not so vast in terms of treating the biomechanics of the game of football in general, but especially at the age of children 10–12 years. This is one more reason why we study the aspects of the development of biomechanics at this age, through computer technology.
- c) The research thesis wants, through the scientific approach carried out, to prove the fact that the optimization of biomechanics, in the game of football at the age of 10–12 years, can be achieved by using information technology, adapted to the main technical procedures specific to the age.
- d) We consider that the use of information technology in optimizing biomechanics at the age of 10–12 years represents a factor of optimization of the training process, contributing to the improvement of the technical training of footballers of this age.
- e) The means of training proposed and used at this age must be in agreement with the principles of sports training and its methodological requirements, proving their effectiveness in this direction.
- f) The opinions of the specialists regarding the optimization of biomechanics in the game of football at the age of 10–12, represent a starting point in the realization of our future research.
- g) The game of football is a specific means of sports activities, and its organized practice produces biological, mental and personality developments, at the level of children aged between 10 and 12 years.
- h) Optimizing the biomechanics of kicking the ball in the game of football cannot be treated without addressing the notions of balance, skill and coordination specific to proprioception.

SECOND PART

7. PRELIMINARY RESEARCH ON THE ANALYSIS OF THE BIOMECHANICS OF THE FOOTBALL GAME AT THE AGE OF 10 TO 12 YEARS OLDS

7.1. Prerequisites for preliminary research

The premises of the preliminary research consist in the correct learning and in the correction of the biomechanics of kicking the ball in the basic procedures at the age of 10–12 years. In this regard, the training of the players must be aimed at appropriating as high a degree of technicality as possible. Kicking the ball, in its basic procedures, is a priority factor in the technical training of the players.

At the age of 10–12 years, the biggest problems concern the technical aspects, more precisely the deficient appropriation of the technical processes. They attract shortcomings in the correctness of the execution from the biomechanical point of view of kicking the ball. The qualitative leap is conferred by the acquisition of a correct technique, which is based on proprioception, its components (coordination, balance, skill) requiring special attention in the sports training process.

7.2. Objectives of the preliminary research

The preliminary research aims, as concrete objectives, three important directions, specific to the training of children at the age of 10–12 years, materialized in:

1. The use, in the training of children aged 10–12 years, of a system of means specific to the football game, carefully selected, through which it is aimed at optimizing the biomechanics of kicking the ball at this age.
2. Knowing the opinion of specialists / coaches on the importance of technical training, on optimizing biomechanics and on the need to use computer technology in the training of children aged between 10 and 12 years, in the game of football.
3. The preliminary research shall also aim at validating the tools selected and used in the research (experimental questionnaire and mesocycle developed and used to achieve the proposed assumptions).

7.3. Purpose of preliminary research

The purpose of the preliminary research is, on one hand, to highlight the opinion of the coaches, regarding the importance of optimizing the biomechanics of kicking the ball, and on the other hand, the importance of using computer technology in correcting biomechanics in the game of football, at the age of 10–12 years.

Another purpose of the preliminary research is to highlight the increase in the technical level of children age 10–12 years, through the correct learning and by correcting the biomechanics of kicking the ball, within the preparation process.

7.4. Preliminary research tasks

The tasks proposed in the preliminary research result from the establishment of the theme and from the necessity of the theoretical-methodical argumentation of our research. These are:

- Identification of groups of children who will be subjected to testing;

- Organizing the necessary framework for the tests;
- Selection of tests and control samples proposed in the preliminary investigation;
- Application of tests selected under standard conditions;
- Conducting a questionnaire on testing the opinions of coaches working with children aged 10–12 years;
- Applying the questionnaire and interpreting the answers obtained;
- Validation of the questionnaire applied, by calculating the Alpha Cronbach coefficient, on the sample of 100 coaches;
- Identification of specific parameters necessary for the analysis and interpretation of the results;
- Establish the preliminary conclusions and the proposals to be made following the preliminary testing.

7.5.Hypothesis of the preliminary research

Assumption 1. We assume that the testing of coordinative capacity (balance, skill, coordination) can provide information on the indices that intervene in the biomechanics of kicking the ball at the age of 10–12 years (backward pendulum, forward pendulum, mobility at the level of the coxo-femoral joint, angular values in the lower limb joint).

Assumption 2. We assume that the use, in the preparation process, of the means intended to improve the balance, skill and coordination will lead to the optimization of the biomechanics of hitting the ball in the game of football, in juniors aged between 10 and 12 years.

7.7.Period, place and subjects of the preliminary research

The preliminary research consisted in testing the two groups of subjects legitimized at the two clubs that activate in the Junior D championship, aged between 10 and 12 years.

As part of this preliminary investigation, the two batches of subjects were subjected to two tests. The initial testing was carried out at the beginning of the preliminary research period and had the role of observing the initial level of the two groups of subjects at the beginning of the pedagogical experiment. The second test, the final test, was applied at the end of the preliminary research period, with the aim of highlighting the differences recorded between the two experimental groups. Between these two tests, we applied, in the process of preparing the experimental group, the specific means identified and selected, with the help of which we made the four training microcycles used in the research.

The two groups involved in the research were:

- The experimental group, CS Coltea 1920 Brasov, consisting of 20 subjects.
- The control group, SR Steagu Rosu Brasov, consisting of 20 subjects.

The place of the preliminary research was represented by the Tarlungeni Sports Base, Brasov County. The period in which the preliminary research took place consisting in the effective application of the microcycles of experimental preparation was between August 10 and September 20, 2020.

7.8.Research methods

The research was based on the analysis of a rich informative material, which was the basis for the elaboration of the experimental study.

The methodology of scientific research recommends, in the elaboration of such a work, a series of specific research methods, among which the following were used:

- Method of bibliographic study;
- The method of the scientific experiment;
- Method of measurements by samples and control tests;
- Survey method - questionnaire
- Statistical-mathematical and graphical method of data processing;

7.8.2.Method of the scientific experiment

Within this method of research, we proceeded to carry out the activities proposed and assumed in the tasks of the research. In this respect, it was started from the application of the initial testing at the level of the subjects of the two groups involved in the research, in order to know the level of the indices obtained at the control samples at the beginning of the research period. During the months of August – September 2020, the preliminary experimental program for the training of children aged between 10 and 12 years was applied. It was applied at the experimental group level on a group of 20 subjects. In the realization of the experimental program, we started from the interpretation of the answers obtained to the questionnaire addressed to the specialists, from the directions detached from the study of the specialized bibliography and materialized in the conclusions of the theoretical part of the work, as well as from the elaboration of the training plans with themes from proprioception (balance, coordination, skill), from motor qualities and from the basic technique of hitting the ball with the foot. The experimental program was made up during a mesocycle, being composed of 4 training microcycles, each of which contains 4 training sessions. At the end of this period, the final preliminary testing was applied in order to register the indices obtained at the control tests.

7.8.3. Method of measurements by trials and tests

The *sine qua non* condition for evaluating the efficiency of any scientific approach, and aimed at optimizing relevant aspects in the field, is the objective assessment of the dynamics of the level of somatic, functional, psycho-motor, physical, technical, tactical and, last but not least, psychological development.

In order to be able to carry out the proposed evaluations, as well as the objective conclusions for the present research, in the context of the experimental activity, we have applied four categories of samples and tests, as follows:

- I. Samples for somatic evaluation (height measurement test, weight measurement test, joint mobility measurement test);
- II. Samples for the evaluation of the motor potential (running test of speed on 40m, pentasalt sample, abdominal strength test, speed running test on the lines of the 6m square);
- III. Samples for the evaluation of technical skills (the test of keeping the ball in the air with the lace full, the test hitting the ball with the foot by the technical procedures with the width, with the inner lace, with the lace full, the test of the small gate in the big gate, the test of the vulnerable areas of the goalkeeper, the test shot at a fixed point).

- IV. Samples for the evaluation of proprioception (equilibrium–Matorin test, Flamingo test, skill–test for keeping the ball in the air with the leg width);

With the help of these tests and samples, it was aimed at assessing the level of psychomotor indices, the force of the lower limbs, coordination, control over the position of the body, balance, multidirectional control of the body and skill.

7.8.4. Method of the survey - questionnaire

The method of investigation - the questionnaire is the one that specifically follows the study of the opinions of arguments, attitudes, reasons or manners of making certain decisions, as well as the behavior of individuals or groups of individuals involved in the investigation.

Technicians from all over the country working or having experience in the echelon of children aged between 10 and 12 years took part in this study, their opinion being a basic constituent element in choosing the tests and evaluation samples that were used in the research.

The application of the questionnaire was done online, during June 2020, and the centralization and interpretation of the resulting data was meant to highlight the guidelines existing at the level of coaches in relation to the topic addressed in the research. The questionnaire was addressed to a number of 100 coaches working at the level of groups of children and juniors across the country and included a number of 18 questions.

7.8.5. Statistical-mathematical and graphical method of data processing

The statistical presentation and the graphic expression were used for the synthesis, interpretation and presentation of the research results, regarding the somatic, psychomotor, motor, biomechanical and techniques relevant to the researched activity. By means of the statistical-mathematical method, the presentation of the data acquires expressiveness, being suggestive for the presentation of the criteria under discussion.

In order to process the research indicators, a diverse range of samples and measurements with statistical-mathematical objectification was used. Through them, uniform reporting of the results was achieved, which led to the drawing of the conclusions of the preliminary research.

For this purpose, the statistical indicators were aimed at measuring the arithmetic averages, the differences in the averages between the tests, the standard deviation, the coefficient of variability, the size index of the Cohen'd effect as well as the T-Student test. We mention that the analysis was done using IBM SPSS Statistics statistical interpretation software.

7.9. Results of preliminary research and their interpretation

7.9.1. Results of somatic assessment trials

The preliminary study focused on the statistical processing, the graphical representation and the interpretation of three anthropometric parameters: height, weight and anterior mobility in the frontal plane of the spine of the subjects from the experiment group and the control one.

7.9.2. Results of motor potential evaluation trials

The second category of evaluation instruments included in the preliminary study included 4 motor tests applied to the subjects of the experiment group and the control group, namely: speed running on 40m, pentasalt, abdominal force, speed running on the lines of the 6m square of the football field.

7.9.3. Results of technical skills evaluation trials

For the preliminary research we designed and applied a number of 5 technical tests, the main results of which we have processed, graphically represented and interpreted, respectively the sample of keeping the ball in the air with the lace full, the test of hitting the ball with the foot by the technical procedures with the width, with the inner lace, with the full lace, the small gate sample in the big gate, the vulnerable areas of the goalkeeper sample, fixed-point shot sample

7.9.4. Results of proprioceptive evaluation tests and trials

For the last category analyzed in the research, the data related to the 3 sets of tests and samples applied to the subjects were graphically and statistically processed, namely the Matorin test, the Flamingo test and the test of the ball in the air with the leg width.

7.10. Results and interpretation of the questionnaire on the use of computer technology in the training of juniors aged between 10 and 12 years old

In the preliminary research, one of the objectives was to know the opinion of the coaches on the use of computer technology in the training, which directed us to the use of a questionnaire.

After the information was centralized, we came to the conclusion that "a tool is safe and consistent when the items of which it is composed, correlate, both between them and each of them, with the additive result of all items (scale, overall score)". Given the non-standardization of the questionnaire developed, in order to know its validity, a pre-test was made with the help of the Alpha L.J. Cronbach coefficient, on a number of 100 coaches, from different clubs in the country, the purpose being to establish its fidelity.¹⁰

Following the processing of the answers given by the 100 coaches, and after analyzing them, we further highlight their opinion. We specify that all coaches have filled in the answers to all items.

After the data were centralized and collected, the internal consistency of the questionnaire was obtained using the Alpha L.J. Cronbach coefficient. The resulting coefficient certifies both the consistency of the items mentioned and the validity of the questionnaire as a whole.

7.11. Preliminary research conclusions

In the preliminary research, in order to obtain the necessary information to state objective opinions, confirming the preliminary research methodology used, we considered it opportune and efficient to design and use research tools such as: the preliminary experimental mesocycle intended to optimize biomechanics in the game of football at the age of 10-12 years, the questionnaire for coaches working at this age level and the four batteries of tests used in research.

¹⁰<https://ro.scribd.com/doc/97271214/24/Analiza-de-consisten%C5%A3%C4%83-intern%C4%83-Cronbach-alfa>

At the end of the preliminary research, we formulated conclusions arising from the experimental framework used and which concern the issue of biomechanical optimization in the game of football at the level of children aged 10–12 years.

Following the use of the preliminary experimental program, we found the following:

- The somatic assessment control samples did not show significant differences between the initial and final tests, as they were carried out with the aim of identifying the size and weight parameters of the subjects;
- The second battery of tests, in order to assess the motor potential, revealed significant differences between the two tests, initial and final, within the experimental group, which entitles us to state that the means selected and used in the research were correct;
- The samples for the evaluation of technical skills revealed the existence of a significant statistical difference between the two experimental groups (experiment group and control group) in the initial and final tests respectively;
- The samples for the evaluation of proprioception identify a significant progress within the experiment group between the results of the final test and those of the initial test;

The results of the preliminary tests found in the formulation of the conclusions of the second part of the work, confirm the first hypothesis of the preliminary research.

From the analysis of the answers received to the questions of the questionnaire, a few conclusions are required, which in turn confirm the second preliminary hypothesis:

- The use in the process of preparation of means intended to educate proprioception on its components (balance, coordination and skill) influences the level of biomechanics of kicking the ball at the age of 10–12 years;
- Coaches who work at the level of the echelon of age 10–12 years, consider that one of the priorities of the training process in the game of football is represented by the consolidation of the technique of basic procedures such as: hitting the ball with the wide, with the inner lace and with the lace full.
- Most of the surveyed specialists agree that the use of computer technology to optimize the biomechanics of kicking the ball at the age of 10–12 years is a necessity and a priority of the training process;

The experimental training model, proposed in the research, led to the optimization of biomechanics specific to the game of football, in juniors aged between 10 and 12 years (balance, skill and coordination).

Based on the experimental research, quantified in the results of the samples and control tests, we can say that the hypotheses of the experimental research have been fully validated, which gives veracity to the proposed research approach.

THIRD PART

8. METHODOLOGICAL APPROACH OF THE FINAL RESEARCH: THE EXPERIMENTAL STUDY ON THE OPTIMIZATION OF BIOMECHANICS IN THE FOOTBALL GAME WITH THE HELP OF INFORMATION TECHNOLOGY

8.1. Prerequisites of the final research

Starting from the premise that the football trainings of children aged 10-12 years are mostly based on explanatory and demonstrative methods, through which the coach transmits the respective information and offers solutions for solving verified in time, within the framework of the final experimental research, we proceeded to the use, during the training, of specific means, designed to optimize the biomechanics of kicking the ball. These were corroborated with the use of computer technology, the necessity of which was imposed by the results of the questionnaire applied to the coaches. Through the experimental program used in the final research, it was tried to educate proprioception, as a determining factor in optimizing the biomechanics of kicking the ball, in the football game, at the age of 10–12 years.

During the training process at the level of children age 10–12 years, we tried to combine the classical training methodology, represented by the proposed experimental program, with modern IT technological means, these being represented by the use of Xsens DOT sensor, the video analysis software Dartfish_10 Pro and the DeepMotion 3D animation software.

The design of the training programs used in the final research, aimed at optimizing biomechanics in the game of football at the age of 10–12, materialized in an objective, as bold as it was pretentious. Thus, the use of computer technology was attempted during the training sequences aimed at strengthening the basic technical procedures for kicking the ball. The subjects of the research were also requested from the point of view of mental capacity, through ideomotricity, which was part of the training methodology used during the final experimental research period.

The methodology used in the preparation was based on the correction in real time, through voluntary, conscious action of the biomechanics of the execution of the main technical procedures used in training. In addition, the premises of the experimental research also focused on the knowledge of the level of expression of the coordinative abilities that influence the biomechanics of kicking the ball in the game of football, at the age of the juniors of 10–12 years and the development of their indices.

8.2. Objectives of the final research

The final research aims to address the following objectives:

- The main objective of the research is represented by the optimization of biomechanics in the football game, at the age of 10–12 years, with the help of computer technology;
- Establishment of control samples, on the four categories of samples and tests proposed, in correlation with the use of modern information technology.
- Optimization of the biomechanics specific to the football game, at the age of 10 to 12 years, by means of the education of proprioception, developing, in this respect, its constitutive elements (balance, coordination and skill);
- The use, in the eight-microcycle preparation process, of the proposed IT technologies and the correlation of the data collected through them with the results obtained in the control samples.

8.3. Purpose of the final research

The aim of the research aims to identify and use, within the training process of children aged 10–12 years, of efficient means (experimental training model) to optimize biomechanics in the game of football, with the help of information technology.

8.4. Tasks of the final research

For the organization and conduct of the proposed experimental research, we consider it opportune to establish the following tasks:

- Establishing the subjects participating in the experiment;
- Determination of the samples and tests used in the experiment;
- Application of the control samples established in the tests carried out;
- Elaboration and implementation of the experimental training program based on action systems specific to the education of proprioception in the football game, at the level of children age 10–12 years;
- Conducting trainings, observing and recording the data of the experimental group;
- Presentation of the information technology used in research;
- Centralization of the obtained data;
- Interpretation of research results;
- Formulating the conclusions and proposals drawn from the experiment;

8.5. Reviews of the final research

Assumption 1. We assume that the development of coordinative capacity (balance, skill, coordination), based on the experimental model of training, will lead to the optimization of biomechanics specific to the game of football, at the age of 10 to 12 years (pendulum to the back, pendulum forward, angular values in the joint of the lower limb).

Assumption 2. The use in the process of training of selected computer technologies will produce the development of general and specific force, the speed of hitting the ball (acceleration) and accuracy in the game of football, in juniors age 10 to 12 years.

Hypothesis 3. With the help of computer technologies, the biomechanics of hitting the ball with the foot (correction of the angle in the ankle and hip joint, the amplitude of the pendulum movement) will be corrected.

8.7. Period, place and subjects of the final research

The research took place between April and November, of 2021, this being carried out at the Tărlungeni Sports Base, where both the proposed experimental program and the samples and control tests used in the final experiment were applied.

The subjects involved in the research were 160, representing children aged 10–12 years who work at several football clubs in Brasov County. The subjects constituted two groups, one experimental and one control, each of which totaled 80 children.

The experiment group was represented by the subjects who constitute the teams of children age 10–12 years of the CS Coltea 1920 club from Brasov. We mention that this club is among the largest sports entities in Brasov, which is why it has several groups of children at this age.

The control group brought together, within it, the children aged 10 and 12 years, who activate at four clubs in Brasov County: Codlea Municipal Sports Club Association, Corona Municipal Sports Club, Olympic Sports Club Cetate Rasnov, Făgăras Municipal Sports Club.

8.8. Research methods used

The research was based on the analysis of a rich informative material, which was the basis for the elaboration of the experimental study.

The methodology of scientific research recommends, in the elaboration of this type of study, a series of specific research methods, among which we used:

- Method of bibliographic study;
- The method of the scientific experiment;
- The method of biomechanics analysis by computer technology;
- Statistical-mathematical and graphical method of data processing.

8.8.2. Method of the scientific experiment

Within this research method, we proceeded to carry out the activities proposed and assumed in the tasks of the final research. In this respect, it was started from the application of the initial testing at the level of the 160 subjects who composed the two groups involved in the research. 80 of the subjects constituted the experiment group that worked within the teams belonging to the CS Coltea 1920 Braşov club. The control group was composed of 80 subjects belonging to a number of 4 teams from Brasov County, each of them containing a number of 20 players. These teams are: Codlea Municipal Sports Club Association, Corona Brasov Municipal Sports Club, Râşnov Fortress Olympic Sports Club and Făgăraş Municipal Sports Club. During May – July 2021, the final experimental program for the training of children aged between 10 and 12 years was applied. The program was achieved by selecting and using specific means aimed at optimizing the biomechanics of kicking the ball at this age. The content of the experimental program was spread over 2 training mesocycles, each of which contained 4 weekly microcycles, which were in turn composed of 4 trainings. The themes and objectives targeted during the experimental trainings aimed at optimizing the biomechanics of kicking the ball by developing specific motor qualities and balance, as well as by strengthening the technique of the main processes of hitting the ball and coordinative capabilities at the age of between 10 and 12 years. It was applied at the experimental group level on a group of 80 subjects. Based on the interpretation of the responses obtained to the questionnaire addressed to the specialists, it was carried out to use information technology in the proposed training program. The computer technology was based on the use of Xsens DOT sensors, Dartfish 10_Pro video analysis software and Deepmotion 3D animation software. At the end of this period, the final experimental testing was applied in order to record the indices obtained in the control samples after the application of the experimental program.

8.8.2.1. Applied intervention in experimental research

The implementation of the experimental program was achieved by using a number of 32 training plans, materialized in two training mesocycles comprising eight weekly training microcycles. The themes of

the 32 training plans were aimed at strengthening the individual technique, developing proprioception on all three of its constituent elements, balance, coordination, skill and the development of motor quality indices that intervene in optimizing the biomechanics of kicking the ball in the football game. During the entire period of the experimental research, the neuromotor training sequence was used during the preparation, this having a duration of 15 to 20 minutes per training, with a frequency totaling 18 repetitions during the final experiment. Based on the neuromotor training sequence, it was proceeded to visualize, explain and correct the main identified technical errors and their effects staggered at the level of the constituent elements of proprioception, balance, coordination and skill.

The design of the training process based on the use of computer technologies is based on the use of Xsens DOT sensors, to measure the angular values of the ankle joint, the general and specific force of hitting the ball and the pendulum (hitting) speed. By means of the video analysis software Dartfish 10_Pro, the measurement of the angular values in the coxo-femoral and knee joints was carried out, as well as the amplitude of the execution leg movement. Deepmotion 3D animation software was used in the final experimental research to correct the posture of the subjects before and after the moment of hitting the ball.

8.8.3. Method of biomechanics analysis using computer technology

This approach represents a personal, original and innovative method, through which we used, in preliminary research, the XsensDot computer technology, the Dartfish 10 Pro video analysis software and the Deepmotion animation software, version 3.5.2.

Xsens DOT is a portable sensor development platform that incorporates 3D accelerometers, gyroscopes and magnetometers to provide precise 3D orientation. The processor built into the sensor, manages data collection, calibration, inertial data integration and the basic Xsens Kalman Filter (XKFCore) algorithm for sensor fusion. Via bluetooth 5.0 wireless data transmission, the Xsens DOT offers real-time 3D orientation, calibrated 3D linear acceleration, and the angular value of lower limb segments.

Through the Xsens Dot technology, we try an original and personal approach with proposed applicability for the purpose of investigating/measuring the specific indices, (the hitting force of the ball) that intervene in the biomechanics of kicking the ball.

The Video Analysis Software Dartfish 10_Pro was used to analyze the angle in the coxo - femoral joint and measure the arc on which the foot moves while performing the pendulum movement.

Through the DeepMotion video animation software we have graphically highlighted the differences in execution between the initial and final tests of the subjects as well as the actual visualization of their degree of correction. In addition, we have complied with the legislation in force regarding the GDPR, not having the consent to use public videos.

8.9. Battery of trials and tests

In Part III of the paper, the battery of samples and tests was selected and applied in correlation with the training methodology specific to the age of 10–12 years.

In order to be able to carry out the proposed evaluations, as well as the objective conclusions for the present research, in the context of the final experimental work, we have applied four categories of



samples and tests, presented below. The precise and accurate determination of the values recorded in the final tests was mainly due to the use of computer technology in the tests for the evaluation of technical skills.

- I. Samples for somatic evaluation (height measurement test, weight measurement test, joint mobility measurement test);
- II. Samples for the evaluation of the motor potential (running test of speed on 40m, pentasalt sample, abdominal strength test, speed running test on the lines of the 6m square);
- III. Samples for the evaluation of technical skills (the test of keeping the ball in the air with the lace full, the test hitting the ball with the foot by the technical procedures with the width, with the inner lace, with the lace full, the test of the small gate in the big gate, the test of the vulnerable areas of the goalkeeper, the test shot at a fixed point).
- IV. Samples for the evaluation of proprioception (equilibrium–Matorin test, Flamingo test, skill–sample maintaining the ball in the air with the leg width);

9. PRESENTATION, ANALYSIS AND INTERPRETATION OF RESULTS

9.1. Analysis and interpretation of the results obtained from the final research

The experimental methodology included the training sessions, during which the relevant data for the research were recorded, theoretical sessions, through which the visualization of the execution by each subject was made, in part, and the correction of the biomechanics of hitting the ball with the foot, after which the execution was resumed.

The visualization and correction of biomechanics was done in real time, based on the neuromotor training sequence proposed by us in the research.

9.1.1. Final research results for somatic evaluation trials

As in the case of the preliminary study, the statistical processing, the graphic representation and the interpretation of three anthropometric parameters: the height, weight and the anterior mobility in the frontal plane of the spine of the subjects in the experiment group and the control one.

9.1.2. Final research results for motor potential evaluation trials

In the case of the final study of the research, a number of 4 motor samples were included (the 40m speed running test, the pentasalt test, the abdominal strength test, the speed running test on the 6m square lines) that were applied to both the subjects in the experiment group and those in the control group.

9.1.3. Final research results for technical skills evaluation trials

During the final research, a number of 5 technical tests were designed and applied (the test of keeping the ball in the air with the lace full, the test of hitting the ball with the foot through the technical procedures with the width, with the inner lace, with the lace full, the test of the small gate in the big gate, the test of the vulnerable areas of the goalkeeper, the test of the shot at a fixed point), the results of which we have processed, plotted and interpreted.

9.1.4. Final research results for proprioceptive evaluation test and trials

For the last category analyzed in the research, the data related to the 3 sets of tests and samples applied to the subjects were graphically and statistically processed, respectively for balance – the Matorin test, the Flamingo test, and for the skill – the test maintaining the ball in the air with the leg width.

10. CONCLUSIONS AND ELEMENTS OF ORIGINALITY DRAWN FROM THE FINAL RESEARCH

10.1. Elements of originality and innovation derived from the final research

An element of originality of our scientific approach is the elaboration of an experimental training program that respects the peculiarities of training in the football game, aiming to optimize the biomechanics of hitting the ball of players aged 10-12 years. The originality of this approach is represented by the use within the experimental model of the information technology intended to achieve the purpose and objectives of the research. The design of the experimental training programme based on the use of information technology has the following characteristics:

- the use of Xsens DOT sensors to measure the angular values of the ankle joint, the general and specific strike force of the ball and the pendulum (hitting) speed.
- by means of the Video Analysis Software Dartfish 10_Pro, the measurement of the angular values in the coxo-femoral and knee joints was carried out, as well as the amplitude of the movement of the execution leg.
- Deepmotion 3D animation software, was used in the final experimental research to correct the posture of the subjects before and after the moment of hitting the ball.

Analyzing these essential elements, we consider that the use of information technologies is innovative, through the effects it has in the preparation process, under the conditions of the possibilities of implementation and development in the trainings of the football game. Through this approach, a perceptive motor fund favorable to the development of proprioception (coordination, skill and balance) is created, which provides the player with the specific tools for solving the different situations that arise during the competition.

Another element both original and innovative is the conception and use of the neuromotor training sequence, through which the biomechanical execution mistakes manifested by the subjects of the experiment group were corrected. The novelty was represented by the fact that this correction was made in real time, even during the trainings.

By means of these biomechanical corrections, in addition to increasing the accuracy of the blows, the correction of the position of hitting the ball was also achieved.

10.2. Conclusions

The evaluation system composed of the four batteries of samples and control tests, through which we wanted to carry out a more accurate investigation of the parameters specific to football training, which intervene in the process of optimizing the biomechanics of kicking the ball, at the age of 10-12 years, has proven its efficiency, through the values recorded at each control test. We mention the fact that the subjects involved in the final research have totaled the same duration of the training process, materialized in the number of trainings per week and the duration of experimental time, regardless of their belonging, to the experimental group, or the control one.

On the basis of the above, we would like to point out that in the experimental research, the two groups of subjects involved in it started from an approximately similar level of training, with no statistically significant differences in this respect. As a result, the confirmation of the research hypotheses was

strictly conditioned by the content of the applicative intervention with which we operated within the research.

The main objective of the research, represented by the optimization of biomechanics in the game of football at the age of 10–12 years, with the help of computer technology, was achieved, an aspect that results from the significant differences recorded by the subjects of the experiment group in the test of hitting the ball with the foot by the process with the wide, with the inner lace and with the lace full, in the small gate test in the big gate and in the test of keeping the ball in the air.

The objective of optimizing the biomechanics specific to the game of football at the age of between 10 and 12 years, through the education of proprioception, was achieved, being relevant, in this respect, the results that recorded significant differences, in the case of the subjects of the experiment group, in the samples vulnerable areas of the goalkeeper, the maintenance of the ball in the air, the Matorin test and the Flamingo test.

The objective of using the proposed IT technology in the preparation process and correlating the data through it with the results obtained in the control samples was achieved as a result of the use, within the eight experimental microcycles, of the neuromotor training sequence. This led to significant differences in the control samples, in the final testing, by the subjects of the test group, compared to those of the control group.

The experimental training model proposed in the research led to the optimization of the biomechanics specific to the game of football, in juniors aged between 10 and 12 years (balance, skill and coordination).

The use, within the experimental research, of the selected information technology produced:

- Development of the general force of the subjects – in the case of technical processes of hitting the ball with the inner lace and the lace full; in the case of the technical element, the hitting of the ball with the wide, the general strike force of the ball does not register significant increases
- The development of the specific force of hitting the ball increases, in the case of technical processes of hitting the ball with the inner lace and with the lace full; in the case of the technical element, the hitting of the ball with the wide, the specific strike force of the ball has an irrelevant increase, increasing instead the accuracy of the strikes
- The development of the speed of hitting the ball (acceleration), in the case of technical processes of striking with the inner lace and the lace full, registers higher values, and in the case of the technical process of hitting the ball with the wide side, the acceleration registers a slight decrease, increasing instead the accuracy of the strikes.

The combination, within the final research, of the proposed experimental training model, of the selected information technologies, as well as of the neuromotor training sequence contributed to the optimization of the biomechanics of kicking the ball in the football game at the age of 10–12 years.

Based on the final research, quantified in the results of the samples and control tests, we can say that the hypotheses of the final research have been fully confirmed, which gives veracity to the proposed research approach.

11. DISSEMINATION OF RESULTS AND LIMITS OF RESEARCH

11.1. Dissemination of results

The research carried out within the experimental framework for optimizing the biomechanics of kicking the ball in the game of football at the age of between 10 and 12 years have resulted in the realization of scientific research articles. They have been presented at international scientific conferences and published in scientific volumes indexed in the international databases of these scientific events.

Articles published in the international stream indexed BDI:

1. RĂZVAN SANDU ENOIU, ŞTEFAN TERIŞ, " **Study regarding proprioception in football between age 10 to 12 years old**", Bulletin of the Transilvania University of Brasov, Vol 12(61), No. 1–2019, Series IX–Sciences of Human Kinetics, pp 53–60, ISSN 2344–2026(Print), ISSN–L 2344–2026(Online), ISSN 2344–2034(CD-ROM);
2. ENOIU RĂZVAN SANDU, TERIŞ ŞTEFAN, " **Experimental study on components of proprioception in football for children age 10 to 12**", Science Movement and health, Volume XIX, ISSUE 2–Supplement 2019, Ovidius Univeristy of Constanta, pp. 222–227, ISSN 2285–777X, ISSN–L 2285–777X
3. ENOIU RĂZVAN SANDU, BĂDĂU DANA, TERIŞ ŞTEFAN, " **Developing Coordination As A Determinant Factor Of Proprioception In Football**", Sport and Society, Interdisciplinary Journal of Phisical Education And Sports, Volume 19, Issue 1(2019), "Altius Academy" Foundation Faculty of Physical Education and Sports "Alexandru Ioan Cuza" University of Iasi, Romania, pp. 84–90, p–ISSN 1582–2168, e–ISSN 2344–3693
4. TERIŞ ŞTEFAN, ENOIU RĂZVAN SANDU, " **Experimental study regarding development of speed, coordination and balance in football game for children age 10–12 years**", Ovidius University Anals, Series Physical Education and Sport/Science, Movement and Health, Volume 21, Issue 2–Supplement 2021, Ovidius University of Consanta, pp 512–519, ISSN 2285–777X, ISSN–L 2285–777X

11.2. The limits of research

The data obtained with the help of computer technologies, in particular the Xsens DOT sensor and the video analysis software Dartfish 10_Pro are relevant research tools in the investigation of the parameters used to correct the biomechanics of kicking the ball in the football game. However, as is clear from the questionnaire applied to technicians, there are resources with a high acquisition cost and a medium to high degree of use, which leads to the statement of the premise that they will not be introduced in practice in the form of tools constantly used in the context of the lack of an assumption on the part of the clubs of the training of coaches in this direction.

Another limitation of the research is related to the difficulty of using the information technology used above in the competitive and training process of footballers aged between 10 and 12 years.

Abstract

The thesis follows the methodological indications specific to the doctoral field, being structured in three parts. The first part of the paper deals with its theoretical substantiation, based on the identified and studied bibliographic references. The second part of the thesis addresses the preliminary research, presenting the premises, objectives, purpose, tasks and hypotheses of the preliminary research. The third part of the thesis contains the methodological approach of the final research, starting from its premises, objectives, purpose, tasks and hypotheses. The battery of control tests used in the research is structured into four categories, including tests for somatic assessment, tests for assessing motor potential, tests for assessing technical skills and tests for assessing psychomotor skills at the age of 10-12 years.

The main objective of the research is to optimize biomechanics in the game of football at the age of 10-12 years, through the use of information technology. The experimental research program is based on the use of XSens Dot technology, Dartfish_10 Pro analysis program and DeepMotion 3D animation software, which together with the specific means selected and used in the training process, represented the research tools. The application of the experimental program started from the identification of the main biomechanical errors present in the execution of the basic technical procedures, the observation of their effects and the use of the means intended to correct these technical deficiencies. The experimental program contains 16 training microcycles, which are applied in the training of subjects aged 10-12 years, during two mesocycles, during the period for final experimental research.

The author's personal contributions are represented by the specific methodology used to optimize the biomechanics of hitting the ball at this age, through the use of information technology. Another contribution is the use in the preparation of the subjects of the means based on the correction of the execution errors, in correlation with the neuro-motor training sequence, on the basis of which the main mistakes were visualized, realized and corrected in due time. of biomechanics identified on the experimental echelon under investigation.

The research results were capitalized by the practical implementation of the experimental program in the preparation of the 80 subjects who made up the experimental research group. These results highlighted the progress of the indices recorded by the members of the experimental group in the

control tests they took, having as main consequence the consolidation and improvement of the level of their basic technique. Another use is the dissemination of research results by presenting them at national and international scientific conferences in the field and by publishing them in journals indexed in the flow of international databases.

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