"ALEXANDRU IOAN CUZA" UNIVERSITY OF IAŞI
FACULTY OF PHYSICAL EDUCATION AND SPORT
DOCTORAL SCHOOL IN SPORTS SCIENCE AND PHYSICAL EDUCATION
FIELD: SPORTS SCIENCE AND PHYSICAL EDUCATION

THESIS

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THESIS TITLE:

NEW PERSPECTIVES ON TECHNICAL TRAINING IN HURDLES RUNNING THROUGH PRISM BIOMECHANICAL ANALYSIS

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Content

INTRODUCTION

Regarding the current research on the technique of running hurdless, more precisely 110 meters, we believe that Romanian athletics needs a refresh of the means used in training athletes. The specialized studies regarding the aforementioned are limited in our country, which proves on the one hand the low interest in the development of this test, on the other hand the low number of specialists among coaches.

The doctoral thesis entitled New perspectives on technical training in hurdles running through the prism of biomechanical analysis is structured in two parts (a preliminary study and a main study) comprising 7 chapters. In Chapter 1, we discuss the importance of Romanian athletics and the importance of conducting scientific research in this direction through which we want to identify the needs and shortcomings of athletes. Therefore, the first chapter includes aspects related to the physical, technical but also psychomotor training of the guard athletes.

In chapter 2 entitled Biomechanical aspects in the fencing tests, we wanted to bring to everyone's attention the way in which such a test is carried out, respectively the running phases in the 110mg test.

The third chapter, The methodological approach of the preliminary study includes information about the purpose and objectives pursued in the preliminary research, as well as about the place and the stages carried out during this initial study.

Chapter 4 entitled Preliminary research on biomechanical analysis in the 110-meter hurdles confirms one of the hypotheses issued, namely that a biomechanical analysis on the technical structure of overcoming obstacles of Romanian athletes, through specialized equipment, compared to the model champion at the level gives us feedback on our issues.

Chapter 5 belongs to the physical training of performance athletes, by introducing a training program carried out over a period of 8 weeks, including different training methods and different exercises and means of training.

Chapter 6 represents the design of the main research by identifying the group of subjects to be tested and measured. We discuss the statistical methods used, the description of the exercises in the training program that we implemented over a period of 12 months. In addition to the exercises introduced in the training program, such as: exercises to improve muscle tone, exercises to develop muscle mobility, exercises to improve reaction speed, exercises to improve the technique of overcoming obstacles, etc., we implemented a device, which wants to streamline the action of the attack foot with a minimum consumption of effort, and an optimal yield.

About the effects and results of this training program, we discussed in Chapter 7 what is called Interpretation and data processing in the main research. In accordance with the hypotheses issued, we consider that we have managed to achieve our proposed objectives and to achieve an overview of what should be implemented in the future.

PART I - THEORETICAL BASIS OF SPECIALTY LITERATURE

CHAPTER 1. PHYSICAL-TECHNICAL TRAINING IN HURDLES TESTS

1.1. THEORETICAL ASPECTS REGARDING ATHLETICS

Athletics, as we well know, is the first branch of sport that was born in the 1100s when the first competitions organized by the English state were held, nicknamed the homeland of athletics which holds the "patent" of this sport. Athletics emerged thanks to schools that benefited students whose wealthy parents sent them to study in the West, in countries such as France, England, and to some extent in the United States.

The distance on which the hurdles test was run was 120 yards (109.7m), and at this distance the athletes had to overcome ten obstacles 1.07 m high. After a period of time, in 1888 in France it was decided that the official length of the sample should be 110 m, and in Germany (until 1907), unlike other countries, the hurdless were 1m high (Lipson, 2010).

In 1935, all the athletes from the hurdles test that knocked down the obstacles were eliminated from the competition, but if there were videos, it could be seen if the obstacles remained standing. Also in that year, the hurdless that were made in the shape of the letter "T" were replaced with those in the shape of "L" that favor their fall, just by a simple touch, therefore the risk of injury is reduced (Blauvelt, 2006) . The technique of running over obstacles with the general center of gravity at the level of the perch, without jumping over the hurdles and running at a pace of three steps, was first used by Olympic champion Alvin Kraenzlein in 1900 (Stubbs, 2011). The 110m hurdles event has been an Olympic discipline since the 1896's. Women have practiced this event occasionally since 1920. but this was never accepted. Since 1926 it has become a standard event for female athletes in the 80m distance, and since 1961 it has been run in the 100m distance, and in 1969 it has been an official event in competitions (Gori, 2004). In the 1900s and 1904, the 200m hurdles were introduced at the Olympics, and the International Association of Athletic Federations (IAAF) recognized and set world records for this event until 1960 (Matthews, 2003).

Although athletic performance is a difficult term to define, it is usually seen as a combination of skills such as agility, muscle strength, speed, balance, coordination, flexibility,

strength, specific muscular endurance, cardio-respiratory endurance, which lead to good physical condition (Bastos, 2012).

The ability of an athlete to sprint is an important factor in a number of athletic activities and in many situations can define success. Such an example can be seen in the 100 m event, where the fastest athlete can win the race (Gomez et al., 2013). We thus deduce the idea that physical training and especially the specific training of the test that the athlete practices is essential and must be adapted according to the proposed objective.To improve speed motor quality, some coaches implement various types of training (eg free, speed, endurance and plyometric training) (Cronin et al., 2008;Lockie et al., 2012).

1.2. PHYSICAL AND TECHNICAL TRAINING IN HURDLES TESTS

Studies on the impact of static stretching on performance usually use methods that do not accurately reproduce the specific setting of the competition day event (Power, 2004; Yamaguchi, 2005; Bradley, 2006; Stewart, 2007; Samuel, 2008; Sayers, 2008) . For this reason we used the stretching exercises in the days when the hurdles training represented the simulation of the races within the competitions in order to get acquainted with the new program structure.

The author Young (2007) demonstrated the effectiveness of static stretching, using viable protocols that reflect daily practice. Studies in the field demonstrate the problem of deficiencies caused by static stretching, using 2 minutes of static muscle stretching on each muscle group, as a process to address this deficiency (Young, 2007; Little, 2006; Taylor, 2009).

Research conducted in 2013 shows that static stretching has no positive influence on team sports athletes in terms of explosive strength, agility and speed (Bishop, 2013).

Execution speed is the most important parameter in the development of speed, given the fact that special attention is required to strength training for a good acceleration (Pisapia, 2019). According to the author, we believe that strength development training specific to a test or sport is one of the decisive factors in achieving optimal performance.

It is essential to direct the ability to exercise strength, but also the speed produced by muscle mass in endurance speed training, to maximize the athlete's performance (Altavilla, 2018; Altavilla, 2015; Altavilla, 2014). We support the above mentioned by the author Altavilla, as the efficiency of strength training and not only, can be capitalized only by its applicability in the training specific to the development of endurance capacity in the 110 mg test.

Psychomotor education

The effects of aquatic exercise on psychomotor skills improve the capacity of the motor sensor and intervene in maintaining a correct posture. It also has positive effects contributing to the improvement of muscle balance, control ability and good coordination in interacting with other subjects. Author Dong (2018) argues that the psychomotor exercise program and the psychomotor program in water have had positive effects on the development of agility and coordination (Dong, 2018).

Some experts recommend the use of aquatic training (especially during the centralized training period) due to the fact that it has a very low risk of injury during executions.

The purpose of psychomotor education is to develop the motor activity of the individual, taking into account the close relationship with psychological factors. The field of psychomotor skills is vast, because it can be said that any movement is psychomotor from the moment it has passed the reflex act. This is due to the fact that any movement is supported by motivation, desire and competence (Francisco, 2012).

In athletics, in the fencing event, this side is mainly used in pre-competition periods without being neglected, representing an important indicator in terms of performance.

PARTIAL CONCLUSIONS

In this chapter we wanted to highlight the data on the emergence of athletics, the evolution and the course that, especially the 110mg test has had over time, both internationally and nationally. I mentioned some notions of regulation that refer to issues related to the distance at which the hurdless are placed, their height and the changes that this test has gone through, since it was created.

At the same time, in Chapter 1 we wanted to touch on those topics related to technical and physical training in sprint fencing trials and to identify the means and methods that many authors have used in their various researches. Both stretching and mobility exercises, as well as speed and strength exercises, either static or dynamic, have been implemented by various specialists in the idea of improving performance at different age groups, in different fields of sport.

The psychomotor factor has a particularly important role in the training of hurdles runners through the multitude of effects and strengths that a performance athlete can have, described in Chapter 1. At the same time, we have identified in the literature some methods for improving motor skills. used by several specialists in the 110mg test on athletes.

CHAPTER 2. BIOMECHANICAL ASPECTS IN HURDLES TESTING

2.1. START AND LAUNCH FROM START IN THE TEST OF 110 METERS HURDLESS

Start biomechanics, defining aspects

Research in the field of high performance sports has highlighted the importance that specialists attach to optimizing reaction speed, which is justified by the values achieved today in obtaining high performance, especially during sprint events.

The starting block consists of a movable metal frame on which two blocks are applied, which can be changed between them (forward or backward) depending on the height and starting leg of each athlete. The metal frame has a set of metal targets on the front and rear, respectively, for fixing to the ground. Each athlete has a certain distance between the starting line and the two blocks, measured in the soles.

Numerous studies have been conducted in which the speed of reaction at the start made the difference between a champion and the winners of second or third place, especially those athletes who benefit from a good speed of reaction. The biomechanical approach can be considered as the application of physics to the study of forces generated or subjected to any living organism and their effects on its motion or deformation (Allard, 2012).

An optimal technique is a prerequisite for good performance, so it is difficult to identify which technique is the best, according to the sports test. The advantage of the qualitative analysis approach is that it can be learned quickly, without wasting much time and without restrictive methods characterized as contemporary. Unfortunately, these approaches have been overtaken by the number of quantitative analysis of biomechanics and an adequate framework for qualitative analysis has never been developed. Researchers later defined their own frameworks, but no agreed general convention emerged. "In this paper I will try to show that the basis of qualitative analysis of biomechanics begins with models of analysis, followed by principles of motion and concluding with a few remarks."(Payton, 2008).

Biomechanics has applications both in the medical field and physical recovery, as well as in sports, for the benefit of testing and improving motor skills (Budescu, 2013).

The technical starting position and the starting block are the same for both the hurdles runner and the sprint runner. The hurdles runner makes the transition to the vertical running

position ("high run") much faster than the sprint runner to prepare the step over the first hurdles (Rogers, 2000).

We mention the fact that running up to the first obstacle can be done with eight or seven steps, respectively (depending on the height, speed and level of preparation of the athlete) and distinguishes two ways to place the blockstart. Placing the blockstart closer to each other to cause the pelvis to rise 5-10 cm above the "ready" control as opposed to track running, this causes a higher tension of the lower limbs, generating a push explosion. at the time of leaving the blockstart. As for the seven-step technique, the blockstart is placed at a greater distance (1-2 feet) from the starting line, and the pushing force is largely based on the front leg (placed second behind the starting line) in order to be able to perform a long step in such a way as to cover the predetermined distance to the first hurdles. When analyzing the start of the blockstart, we must keep in mind that these measures are affected by the number of steps that the athlete takes towards the first obstacle (Wilson et al., 2008).

Certainly, a short reaction time does not guarantee that the athlete will be the first to face the obstacle, and if this happens, it is due to the intervention of other factors. Thus, a combination of reaction time and time to the first obstacle (two "starting variables" that are closely related to each other) generates a horizontal force that ensures the passage over the hurdles. Training in this direction is important in order to achieve a fast reaction time as long as the starting technique is not compromised. In guard athletes, the front foot (first behind the line) is the trailer leg (in the case of the eight-step technique), more precisely the support leg before detaching from the ground. This variable depends on the number of steps taken up to the first hurdles and the attack foot of each athlete. Each start block can be adjusted to get a higher or lower position of the center of gravity.

Start-up commands

It should be noted that there are three main commands (valid in any competition regardless of the level at which it is practiced) when referring to a hurdles / sprint race: At the start, In places; Ready; The sound of the pistol.

Seat control is when the athlete's feet initiate contact with the starting block. The foot behind the start block is always placed first because it has the first contact with the ground after the moment of the click and is the furthest from the starting line. The ball is fixed in the support, the knee is positioned on the ground, and between the heel and the upper part of the block there will be a free space that will be covered when the torso rises, at which point the "ready" command will be announced. The knee of the front leg will be positioned at the elbow 5-6 cm behind the line, parallel to the ground. The arms are perfectly stretched and apart at the level of

the shoulders, the position of the hands, of the fingers placed on the ground behind the starting line (the regulation stipulates that the fingers do not touch the line) are those that will support the entire weight of the body when lifting the pelvis. The back is slightly arched, the chin on the chest, and the gaze is directed at 1 - 1.5 m in front. When no athlete moves, the referee is ready to announce the second order.

The "ready" command means that the athlete should lift the pelvis slightly so that it crosses the horizontal line and is positioned above the shoulder line. The sole of the back foot should be glued to the starting block just like the front foot. Both the front and the back flexed leg angle must be optimal in such a way as to provide the athlete with an efficient and strong forward momentum and not a vertical one. The gaze remains oriented at a distance of 1 - 1.5 m in front, the arms are extended maintaining all the weight of the athlete, but the most important aspect remains the ability to concentrate which allows a very fast reaction from the blockstart, but without leg movements, before transmits the departure signal (Ursanu, 2017).

Limiting factors for starting the blockstart

False start is any movement, touch, impulse in one of the blocks, initiated by the sportswoman, which would lead to a value of less than 0.100s, transmitted by a sensor implemented at each blockstart.

"Reaction time depends on the duration of information transfer between sensitive and motor areas that are able to start a command to perform a motor act" (Rață et al., 2011).

Reaction time is widely used to assess neuromuscular and physiological responses in such diverse fields as environmental safety, pharmaceuticals, and sports (Muller, 2004).

Auditory reaction time is one of the fastest reactions and is thought to be less than 0.100s (100 ms). We mention that in terms of performance this aspect is part of the athlete's training plan, using different methods to stimulate it: going to hear the click of the perch, the whistle, verbal command by positioning to the side or behind the athlete, in different conditions.

2.2. STRUCTURE OF THE STEPS TO THE FIRST GUARD

At the elite level, most hurdles runners use a seven-step approach to the first hurdle to the detriment of the eight "traditional" steps. The seven-step technique requires some changes in the amplitude of the first three steps, after starting from the blockstart realizing an obvious

advantage in terms of pushing capacity and the force generated by these steps. However, performing this technique decreases the frequency of steps as opposed to starting with eight steps, but, due to the impulse, it offers the chance to develop a higher frequency of steps after passing the first obstacle. For this reason, seven-step departure should be used by athletes with a high level of performance, and in order to reach the optimal flight phase,

We can say that the correct acquisition of the step over the hurdles is in a fairly large proportion conditioned by a very good mobility of the coxo-femoral joint and the spine. If we start from the starting block with seven steps, it is necessary to have an optimal mobility, due to the much more demanding effort, in order to be able to cover the distance of 13.72 m.

2.3. TECHNIQUE REGARDING CROSSING HURDLESS

According to the specialized literature, the four phases representative of running hurdless are:

- *starting and launching to the first hurdles;*
- *actual running (stepping over the hurdles / running between hurdless);*
- *the finish;*
- *the arrival.*

The result in terms of running hurdless depends on:

- *hurdles crossing speed;*
- *impulse angle in front of the hurdles;*
- *contact angle when landing behind the hurdles;*
- *speed of movement between hurdless;*
- *specific resistance (speed resistance.*

Regarding the running of hurdless, some authors claim that no matter how perfect the athlete's technique is, he can never reach high performances, having poor results in track running (Mihăilescu, 2005). We get the idea that a good athlete in the hurdles test must develop speed performance in track tests as well.

Features for running between hurdless

- the length of the steps increases progressively except for the last step before the hurdles which is shortened to design the general center of gravity;
- the impulse is energetic, the arms work ample, the contact with the ground is made only on the drop.

Running along the way is another phase where, unlike track running, the athlete encounters a number of ten obstacles placed at equal distances.

From a technical point of view, running along the hurdles trials consists of two sequences:

- *step over the hurdles (figure 2.4);*
- *running between hurdless.*

Three steps are required to cover the running distance between the hurdless. To achieve this step structure, the athlete has to modify the running technique to fit in the distance of 9.14m. In order to print an optimal rhythm, a fast action of the attack foot must be performed after crossing the hurdles and a shorter step length (Radcliffe, 2015).

Some authors have shown that the differences in overcoming obstacles are very small between world-class athletes and that the main difference may be related to achieving and maintaining an optimal horizontal speed for overcoming obstacles in the shortest possible time (Kuitunen, 2010).As in sprint running, the arms act to balance the body and intervene to counterbalance the rotations that may occur during running.

2.4. RESULTS AND DISCUSSIONS

"The angle from which the first impulse is executed at the start is about 42-45˚ for established runners and higher (48-50˚) for beginners" (Ursanu, 2017). The ones mentioned above by the author refer to the angle between the trunk - the impulse leg and the ground. Studies on the angle between the trunk and the thigh at the time of the first step in the blockstart have not been identified, but it is a benchmark for future research. In this chapter we have identified in the literature some technical aspects, in terms of the optimal way to cross the obstacle, the ratio between the axis of the shoulders and the direction of running.

PARTIAL CONCLUSIONS

After studying the specialized literature and the experience in the current field, I came to some general conclusions regarding this scientific research.

Many of the authors cited above have studied the problems they face in the last 10 years in world athletics, regarding the test of running hurdless. They considered the study of technical elements in depth, with the help of state-of-the-art resources. This demonstrates the interest in the current issue and how important it is to have a general approach to the rules of technology.

We believe that the minor details make the difference and they are neglected by some specialists, this having an essential role in achieving the high performance of athletes.

The departure from the blockstart, the number of steps to the first hurdles and the detachment before the hurdles, were studied by several specialists, each with a slightly different vision but all with the same goal to evolve and discover new trends in the field.

The positioning of the general center of gravity above the obstacle is also an intense topic discussed by specialists, who conclude that positioning at an optimal distance from the distance of the hurdles can promote a smooth passage of the athlete over the obstacle hurdles.

The parameters of the angles of force acting on the upper limbs, but especially on the lower ones in relation to the particularities of each athlete, are important values that we must take into account in the perspective of the evolution of this test.

PART II - PERSONAL CONTRIBUTIONS REGARDING RESEARCH

CHAPTER 3. METHODOLOGICAL APPROACH OF THE PRELIMINARY STUDY

3.1. PURPOSE OF THE PRELIMINARY STUDY

The purpose of the study was to analyzebiomechanical aspects on the start and the technique of running over hurdless of performance athletes, in the 110mg test, in parallel with the biomechanical study compared to the model of the world champion.

Also in the preliminary study we performed the analysis of the results obtained at the initial and final testing following the implementation of the physical training program for a period of eight weeks in order to improve the physical fitness indices.

We also want to establish the growth potential of certain indices in physical training, in parallel with the identification of other research results that have been conducted in this field.

3.2. OBJECTIVES OF THE PRELIMINARY RESEARCH

In order to achieve the purpose proposed in the preliminary research, we have listed several objectives related to the interconnection between the phases that follow in the hurdles test:

1. Identifying the positive and negative aspects of biomechanical and technical order in the pre-competitive and competitive period with the help of video technology;
2. Interpretation of speed indices acting on the whole body, especially in the lower limbs;
3. Comparative technical aspects between performance athletesand the model of the champion;
4. Argumentation regarding the importance of the phases of crossing the hurdless which can be a decisive factor in optimizing the performance.

3.3. TASKS

1. Documentation and deepeningscientific analysis of the issues addressed.
2. Selection of athletes that make up the grouptarget in the preliminary study.
3. Evaluation of the results obtainedfrom the perspective of anthropometric and biomechanical indices.
4. Implementation of the physical training program.
5. Initial and final testing following the application of the programphysical training.
6. Centralization, processing and interpretation of data obtained.
7. Formulation of some preliminary conclusions that can lead to the creation (drawing) of the final hypotheses regarding the main research.

3.4. PRELIMINARY STUDY HYPOTHESES

General hypothesis 1

We assume that the biomechanical analysis and reporting to the champion model will provide us with feedback on the technique of crossing the hurdless.

General hypothesis 2

We assume that the application of an individualized physical training program will optimize specific speed, strength and endurance, specific motor skills for running hurdless.

3.5. PLACE OF RESEARCH AND SUBJECTS OF THE RESEARCH

This experiment was attended by 5 national athletes with participation in international competitions (average age 25 ± 1.8 years; average height of1.77m± 0.76 meters; average body mass of 69.4 kg ± 3.78 kg). Subjects gained 8 years of experience ± 1.8 years of training in the hurdles test, and the average performance in running hurdless is 14.66 seconds ± 0.20 seconds, while the best performance is 13.92 seconds.

The preliminary research took place over a period of 6 months (June 15-November 15, 2020), the athletes participating in the National, International Championships and the Romanian Cup. The actual conduct of the research took place in the cities of Bucharest, Cluj, but also in the training centers of each athlete.

Experimental protocol

The written consent of the participants was obtained before the start of the study. All participants were informed about the experimental protocol and its potential risks and benefits before starting the study. Participants were allowed to withdraw from the study at any time without giving any reason.

3.6. PRELIMINARY RESEARCH STAGES

Between June 2020 and January 2021, a study was conducted on the preliminary analysis of the biomechanics of running hurdless, which aimed at the following aspects:

- June 15 - July 15

Identification of subjects and somatic and anthropometric indices in order to obtain data as concrete as possible in relation to the objectives of the research conducted. All subjects agreed by signing an opinion before the study began. They were informed about the experimental protocol and the potential risks of this study, giving them permission to withdraw at any time and at any time without giving any reason.

- August 15 - September 15

Going through a video material regarding the analysis of the hurdles running technique during the competition period that took place in Bucharest and Cluj County. The data obtained was made using SONY DSX digital cameras. The images were captured from different angles in such a way as to eliminate as many limiting factors as possible that could influence the final results. The start, the launch from the start, the steps to the first hurdles, the passage and the landing after the obstacle were the main objectives in the evaluation of the technique. Each athlete benefited from individual video analysis due to the specific test in several competitions, to see if there are differences in terms of technical behavior.

- October 5 - November 28, 2020

The chosen period represents the time in which the athletes carry out their training in order to accumulate physical loads (for the competitive period), a favorable moment for the implementation of the training program.

Also during this period, we monitored the development in optimal conditions of the implemented program by sending video materials to the subjects in order to make it easier for them to complete the tasks they had to perform.

- December 1, 2020 - January 1, 2021

- We interpreted the video with the help of Dartfish / Kinovea software in order to identify the positive and negative aspects of a technical and biomechanical nature, without which this research could not have been created.
- We made individual comparisons between athletes (nationally),between Romanian athletes and the model of the world champion.

3.7. RESEARCH METHODS

Bibliographic study method

In this research we used the bibliographic study, a method that highlighted the topicality of the topic and the large-scale involvement in showing interest in the development of this segment. All the reference publications in this report have made a significant contribution to consolidating and building on issues that are not very clear about the importance of this topic.

Video method

Video captures were taken from different anglesat optimal distances to capture the right frames for our research, with the help of the SONY DSX camera, and then downloaded to the software platform.

Software analysis method

Regarding the computer technology required in the study, we used the DARTFISH platform, after which we obtained angular values at the level of the lower limbs, at the level of the coxo-femoral joint, at the level of the knee joint and the ankle joint. The angle between the trunk and the thigh relative to the ground level both at the moment of detachment from the blockstart, in the flight phase above the hurdles, and at the moment of landing after the obstacle, provided essential details in the methodological approach of this research.

Mathematical statistical methods and techniques of data processing

Statistical method:

I used severalstatistical indicators as follows:

- Descriptive statistics
- Paired Samples T Test

3.8. TESTS AND MEASUREMENTS

The tests performed aimed at identifying possible significant results following the application of the individualized training program. The speed test was performed on the

distance of 60m track, 60mg, 80mg, 150m track (test that represents the verification of the specific resistance for the 110mg stroke) and the measurement of the vertical relaxation, to identify the degree of force developed.

To establish the anthropometric data of the subjects, we measured the waist, the height of the bust, the wingspan and the height of the lower limbs, using a rangefinder and a metal square. Body weight was measured using a body analyzer. The tests applied to identify the speed consisted in mounting the infrared cells on the distances of 60m track, 60mg, 80mg and 150m track, both at the starting line and at the finish line. To identify the trigger, we used the myotest device, which was mounted at the level of the pelvis with a velcro belt, which determined the height of the vertical detachment measured in centimeters.

3.9. RESEARCH VARIABLES

In the preliminary research that consisted of monitoring the starting technique and the starting steps after the start-up launch and the execution of the obstacle course, we also implemented an eight-week training program, conditioned by the program of competitions and limitations. imposed by the athletes' coaches. Thus, table 1 presents the dependent and independent variables of the research.

Table 1. Research variables

PRELIMINARY RESEARCH VARIABLES	
INDEPENDENT VARIABLES	DEPENDENT VARIABLES
Means for improving explosive force	Biomechanical analysis parameters
Exercises to improve muscle strength (abdomen, back, arms)	Vertical expansion Horizontal expansion
Means for improving the speed of repetition and movement	Travel speed
	Specific resistance

CHAPTER 4. PRELIMINARY RESEARCH ON BIOMECHANICAL ANALYSIS IN THE 110 METERS HURDLES TEST

4.1. BIOMECHANICAL ANALYSIS IN 110MG TEST

GENERAL HYPOTHESIS TESTING 1

BIOMECHANICAL ANALYSIS REGARDING THE GUARD ATTACK

We performed a biomechanical analysis of the attack foot and the impulse before detaching over the obstacle by identifying the angles in several situations in which the athlete is at the time of this action.

Table 2 shows the data on limb angleslower in the impulse impulse phase and the relationship between the trunk and the thigh before detachment to the obstacle.

Table 2. Values of the angles regarding the hurdles attack

No. crt	Subjects	Length of the last step at the general center of gravity before detachment (degrees)	Small angle. impulse to detachment over hurdles (degrees)	Small angle. impulse at the moment of detachment (degrees)	Angle tr. versus vertical before detachment (degrees)	Angleimpulse foot before detachment (grade)	Thigh angle - attack thigh before detachment (degrees)	Angle gn. pic. attack before detachment (degrees)
1	AA	66.3	28.5	142.6	12.7	90.7	92.3	39.6
2	AD	72.8	40.3	149	9.7	76.7	87.4	44.6
3	RR	59.7	28.1	145.5	30.3	83.6	44.7	90.4
4	yl	53.9	29	152.7	21.1	82.5	55.9	47.9
5	SG	52.8	27.9	147.1	24.2	86	60	65.9
6	The model of the champion	-	-	*156.9*	*10.1*	-	*116.5*	*41.9*

In figure 1 we identify a series of values regarding the analysis of the last step at the level of the general center of gravity, before the detachment towards the obstacle, of each evaluated athlete. We identify a considerable difference between the values expressed by the athletes who approached the technique with seven steps and those with eight steps (after leaving the blockstart). We identify a value of 72.8˚ of the last step performed by the DC athlete, it means a slow moving speed and involves a detachment to the vertical and not to the front (horizontal). Athletes SG, II, RR and AA approached the technique with eight steps, identifying close angular values, which leads to the statement that the value of the angle of the DC athlete

is not optimal.

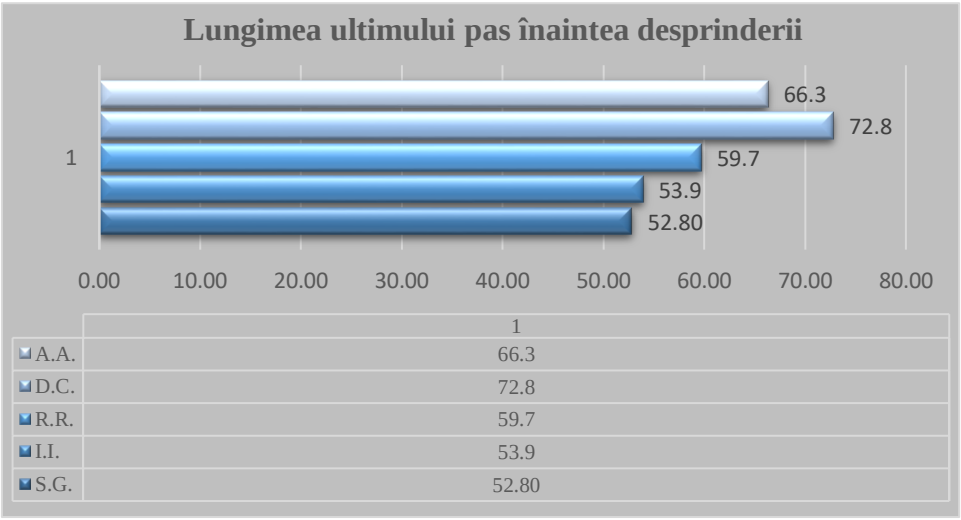

Figure 1. Values of the angle of the length of the last step before detachment

At the level of performance athletes, in the 60 mg races, the subjects performed fewer steps per unit of time materialized in short contact on the ground; the shorter step length near the first hurdles allowed them to obtain a shorter landing after the obstacle (González Frutos et al., 2019). From this statement we can deduce the idea that for a good acceleration to the first hurdles and an optimal landing, it is necessary a small angle of the step (the last step before the hurdles).

We present the values of the angles expressed in degrees on the length of the last step before detachment over the obstacle by measuring the angle at the general center of gravity (at the moment of contact with the ground of the impulse leg and until the moment of detachment over the obstacle). We identify a number of four results out of a total of five, with optimal values in terms of preparation for the hurdles attack. Next to the DC athlete is mentioned an angle of (40.3˚) by about 12˚ compared to the average of the others, which results in a higher amplitude of the step before detaching over the obstacle, due to the fact that the number of steps to the first hurdles is in number seven. These high values of the analyzed angle will have consequences on the flight over the hurdles with a negative effect on the movement to the next hurdless.

BIOMECHANICAL ANALYSIS REGARDING CROSSING HURDLESS

In table 3 we have introduced the results of the biomechanical analysis of angleslower limbs and torso obtained after the interpretation of the video captures, which refer to the moment of passage (flight) and landing after the obstacle. These results were subsequently converted into percentages in order to easily identify the level at which each athlete is in relation

to the champion model.

Table 3. Values of flight angles and landing after the obstacle

Nr. crt.	Subjects	Angle tr - thigh attack (above the hurdles) b (˚)	Thigh angle - attack (above the hurdles) (˚)	Ankle Attack Angle (Above Hurdles) (˚)	Angle of attack and ground on landing behind hurdles (˚)
1	AA	21.7	132	79.9	104.1
2	AD	31.2	139.2	86.8	98.7
3	RR	25.5	145.2	97.9	94.3
4	yl	19.8	133.5	98	90.7
5	SG	22.3	145.9	91.5	98.1
6	Model Champion	*57.0*	*179.7*	*128.8*	*92.7*

From the point of view of energy consumption, time spent in the air and landing after the obstacle, it is mandatory for the attack to pass the hurdles hurdles as smoothly as possible. An optimal value of the angle between the thigh and the leg (180˚) gives the athletes a vertical trajectory and not a horizontal detachment.

The values obtained in Figure 2 were transformed into percentages to achieve a hierarchy of each athlete in relation to the model of the champion and the differences in technique between the athletes evaluated. The results obtained after the interpretation of the video material, where the values are expressed in degrees, on the biomechanics of the attack foot compared to the ground. In order to initiate the forward movement from a static position, it is necessary for the center of mass to be positioned anterior to the lower limbs (Brown, 2004). As the important author states, it is how we prepare for the next obstacle so that the orientation of the trunk is optimal. The moment of contact with the ground after crossing the hurdles is the stage of preparation of the second or third hurdles. The most representative values are recorded by DC athletes with 94%, II with 98% and RR with 98.40% with very close performance indices. The lowest (negative) values are close, with indices of 88.60% and 94.60%.

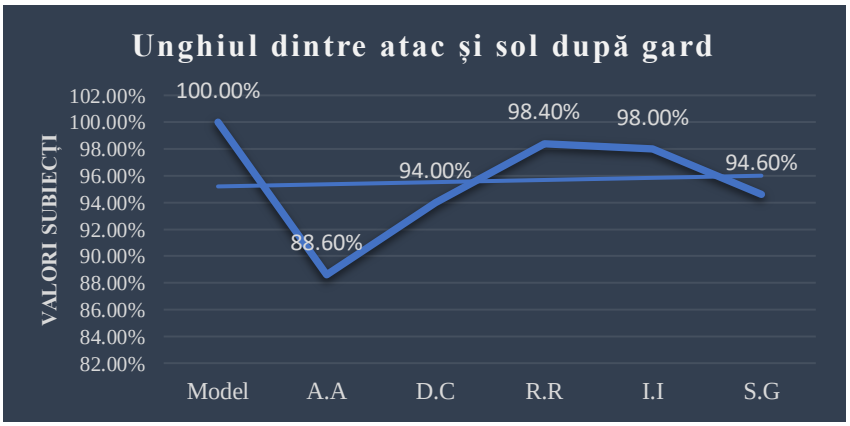

Figure 2. The values of the angle of the attack foot to the ground behind the hurdles

4.2. RESULTS AND DISCUSSIONS

Over the last twenty years, there has been a growing interest in the use of different observational methods in sports, in training or action structures in training or competition, which will be analyzed and subsequently recorded (López del Amo, 2018).

Biomechanical analysis can be primarily a qualitative process, which occurs when the examination of movements takes place in a single plane (two-dimensional or 2D) with data obtained through a single chamber (Garhammer, 2013).

The purpose of a quantitative analysis of movements, techniques and exercises through video recordings is to capture a detailed analysis of the subjects' movement patterns (Payton, 2008), without endangering the injury of athletes (Bartlett, 2014). Although video cameras provide 2D sequential images in terms of movements, at certain time intervals, depending on the quantitative speed of the camera, the analysis can be two-dimensional or three-dimensional (McGinnis, 2013). This approach, known as motion video capture, involves more complicated video recording and analysis, procedures that require high-performance equipment, and complex software (Young et al., 2015).

The introduction of biomechanical analysis or a complex motor action on a digital device, through measurable parameters, using analysis software, results in those biomechanical parameters of the subject's action (Nechita, 2010).

Some authors have studied the kinematic parameters of the technique of crossing two hurdless, through video recordings with two digital cameras placed next to them and concluded that the aspects that must be taken into account for optimal technique are the angle of detachment, flight distance , landing angle and height of the general center of gravity over the obstacle. The studies also showed that all these parameters represent the success in the performance of the hurdles (Sidhu, 2015).

According to the statement made by some authors regarding the 180˚ angle of the attack leg between the thigh and the leg (Rogers, 2000) we can say that none of the analyzed athletes meets this condition of maintaining the angle during flight, above the hurdles.

PARTIAL CONCLUSIONS

Regarding the biomechanical aspects, we notice notable differences in most of the technical elements analyzed in parallel with the sample model. When we discuss the vertical

torso angle before detaching from the ground in front of the hurdles, the differences are about 15-20˚ compared to the champion model. The lowest values were obtained by small athletes with a percentage between 79% and 89% compared to 100%. These results are based on the other values of the angle of the impulse foot before detachment to the obstacle which shows that the angle between the foot and the ground is closer to 90˚(straight torso) than an angle oriented towards moving forward. The angle between the torso and the thigh indicates the particular way of attacking the hurdles against the champion model. The lowest value has a percentage of 28.20%, and the highest has a value of 75.80%. We claim that the athlete with the highest weight is at a fairly high level of performance, as opposed to the average of the results of other athletes, in terms of results at the National Championships. In direct relation to the previously identified results is the angle of the attack leg between the thigh and the leg, which means that the obstacle is approached with the foot (more precisely the tip of the foot) and not with the knee. We can say that the weakest value is identified next to the SG athlete, and the best value is found next to the athlete with the best results (AA). We claim that the athlete with the highest weight is at a fairly high level of performance, as opposed to the average of the results of other athletes, in terms of results at the National Championships. In direct relation to the previously identified results is the angle of the attack leg between the thigh and the leg, which means that the obstacle is approached with the foot (more precisely the tip of the foot) and not with the knee. We can say that the weakest value is identified next to the SG athlete, and the best value is found next to the athlete with the best results (AA). We claim that the athlete with the highest weight is at a fairly high level of performance, as opposed to the average of the results of other athletes, in terms of results at the National Championships. In direct relation to the previously identified results is the angle of the attack leg between the thigh and the leg, which means that the obstacle is approached with the foot (more precisely the tip of the foot) and not with the knee. We can say that the weakest value is identified next to the SG athlete, and the best value is found next to the athlete with the best results (AA). In direct relation to the previously identified results is the angle of the attack leg between the thigh and the leg, which means that the obstacle is approached with the foot (more precisely the tip of the foot) and not with the knee. We can say that the weakest value is identified next to the SG athlete, and the best value is found next to the athlete with the best results (AA). In direct relation to the previously identified results is the angle of the attack leg between the thigh and the leg, which means that the obstacle is approached with the foot (more precisely the tip of the foot) and not with the knee. We can say that the weakest value is identified next to the SG athlete, and the best value is found next to the athlete with the best results (AA).

With regard to the last analysis at the time of contact with the ground after passing over the obstacle the angle between the support leg and the ground must obtain a maximum value of 90˚ so that the general center of gravity is positioned before contact with the ground. The closest value (relative to the optimal one) is recorded by athlete II, while athlete A. A obtains an angle of 104.1˚.

CHAPTER 5. PRELIMINARY RESEARCH ON OPTIMIZING PHYSICAL TRAINING

5.1. PLACE OF RESEARCH AND RESEARCH SUBJECTS

This experiment was attended by 5 finalists of the Romanian national championships, both indoors and outdoors, some of them participating in international competitions. An average age of 25 ± 1.8 years was recorded, with a height of 1.77 ± 0.76 meters and a body mass of 69.4 kg ± 3.78 kg. Athletes have an experience of 8 years ± 1.8 years of training in the hurdles test, and the average performance in running hurdless is 14.66 seconds ± 0.20 seconds, while the best performance is 13.92 seconds.

The current research was carried out over a period of two months (October 2 - November 28) with five athletes, participants in the National, International Championships and the Romanian Cup. The actual conduct of the research took place in the cities of Bucharest, Cluj, but also in the training centers of each athlete.

5.2. PHYSICAL TRAINING RESEARCH STAGES

The implementation of the training program took place between October 5 and November 28, 2020physics. The chosen period represents the moment when the athletes carry out their activity in order to accumulate some physical loads of volume (for the competitive period), a favorable moment for the implementation of the realized program.

The research stages are:

- Performing initial tests.
- Implementation of the physical training program and monitoring of this period.
- Performing testsfor identifying performance progress, interpreting results and drawing conclusions.

5.3. RECORDING AND PROCESSING OF ANTHROPOMETRIC INDICES

In terms of anthropometry, the following measurements have been made leading tocreating an overview of the homogeneity and differences between the research subjects.

- *waist*
- *The weight*
- *bust*
- *Wingspan or opening of arms*
- *Length of lower limbs*

importantwhich are found in table 4 highlight the most important anthropometric characteristics in order to establish correlations on possible significant results from the preliminary study.

Table 4. Anthropometric values of the tested athletes

Nr. crt.	The name and first name	The year birth	Waist (m)	Bust (cm)	Upper limb wingspan (m)	Lower limbs (m)	Weight (kg)
1	AA	2000	1.80	75	1.79	1.05	67
2	AD	1994	1.88	75	1.80	1.13	74
3	RR	1993	1.77	77	1.72	1.00	73
4	yl	2000	1.67	69	1.66	0.98	67
5	SG	2001	1.75	73	1.75	1.02	66

In table 5 we identify the results of anthropometric measurements on the height of the investigated subjects, which has an average value of 1.77 m, while the standard deviation has a value of ± 0.76 around the average.

Table 5. Subject size - anthropometric data

Statistical indicators	result
Mediate	1.77m
Median	1.77m
Standard deviation	± 0.76m
Minimum	1.67 m
Maximum	1.88 m

Figure 3 shows both the results of the athletes' height measurements and their total average. We identify the highest height (1.88) in the subject DC, and the lowest (1.67) in the athlete II

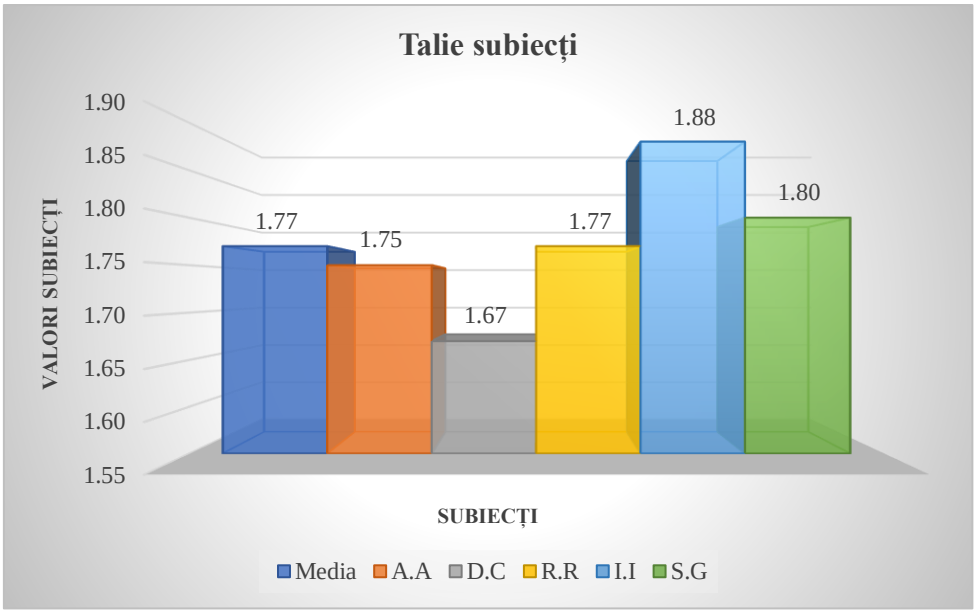

Figure 3. Mean height values of the subjects

5.4.INSTRUMENTS USED IN PRELIMINARY RESEARCH

The initial tests consisted of a set of tests specific to the sport in order to identify the level of training of athletes and to be able to make a comparison (with the results obtained in the final tests), on the evolution of the results obtained during the research.

In order to establish and identify precise results in the preliminary research we used a set of specific tools for each sample as follows:

ALGE - TIMMING digital stopwatch-we identified the distance to cover the distances for the following tests: 60m, 80m, 150m sprint and 60mg.

Metric roulette - wheel type: is a device equipped with an indicator clock with 4 dials with optimal accuracy, used to measure the length of the jump on the spot.

Miotest -is a device) that allows the measurement of power, force, speed, but also for determining the height of the vertical jump.

5.5. RECORDING THE RESULTS OBTAINED IN THE INITIAL TESTING

In this subchapter we graphically present the values obtained by the tested subjects in terms of preliminary research, in a series of representative tests to identify the level of speed, strength and endurance, specific to the 110m hurdles test.

In table 6 we identify according to the results obtained after the initial test, a series of values of the speed tests (60m track, 80m track, 150m track, 60m hurdless) of the long jump from the spot and the vertical detachment.

Table 6. Values of initial tests

Nr. crt.	Subjects	Running speed 60 m (s)	Running speed 80 m (s)	Running speed 150 m (s)	Running hurdless 60 m (s)	Long jump from the spot (m)	Vertical detachment - relaxation (cm)
1	AA	6.2	8.52	15.82	8.38	2.38	45.4
2	AD	6.6	8.45	15.88	8.52	2.41	43.5
3	RR	6.4	8.65	15.78	8.45	2.36	48.2
4	yl	6.3	8.38	15.64	8.40	2.43	44.5
5	SG	7.2	9.25	16.80	8.55	2.55	42.7

We see in table 7, the average of the results of the initial tests in the 60m sprint with a result of 6.54 seconds, the median recording a value of 6.40s, and the standard deviation of ± 0.39s around the average.

Table 7. 60m track running

Statistical indicators	result
Mediate	6.54s
Median	6.40s
Standard deviation	± 0.39s
Minimum	6.20s
Maximum	7.20s

Figure 4 shows the individual results of the athletes and their average. The best performance measures a time of 6.20 seconds for the AA athlete, and the poorest (SG) performance of 7.20 seconds. Results between 6.30 and 6.60 seconds in the 60m track test are identified in the other researched subjects (DC, RR, II).

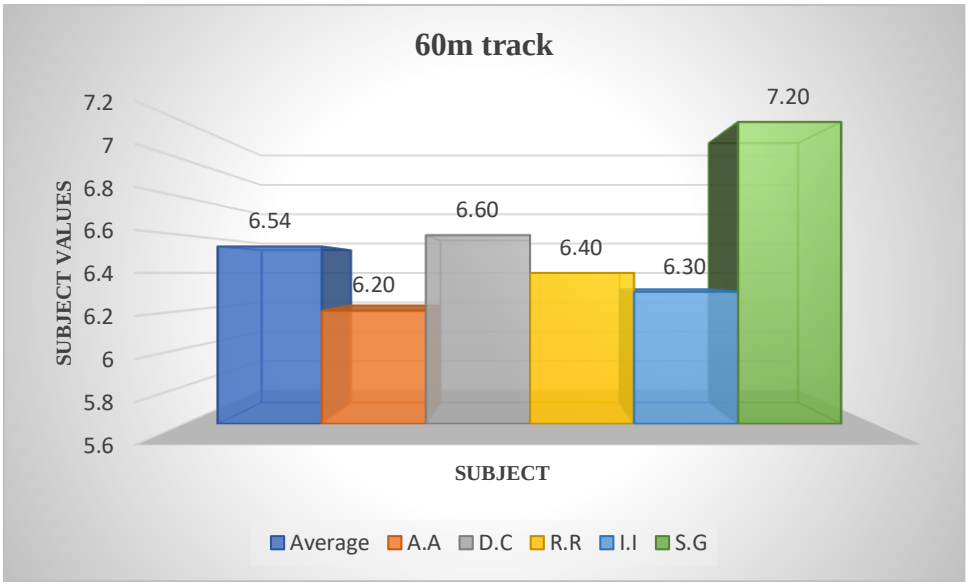

Figure 4. Results and average values - 60m track

5.6. PHYSICAL TRAINING PROGRAM APPLIED

The training methods used in the implemented training program, which aimed to improve the physical performance of the subjects involved in the research are the following:

- Repetition method
- *Interval method*
- *Alternation method*
- *Explosive effort method*
- *Circuit work method*
- *Segmental effort method*
- *Isometric stress method*
- *Competitive method*

In the intervention plan described, we introduced in addition to the exercises for the development of speed, the specific resistance of the hurdles test and plyometric force exercises.

A plyometric exercise is a quick movement against another movement that involves a stretching action and at the same time shortening the muscle. It is well known that by using the lengthening-shortening action the muscle-tendon structure can exert a higher load and / or strength, compared to concentric contractions, due to the increased time of the neural impulse reflex (Voigt et al., 1998), semi-isometric contraction of muscle fibers and aelastic tendon

movement(Kawakami et al., 2002; Kurokawa et al., 2003) with a view to developing contractile force (Bobbert et al., 1996).

The training program applied in this preliminary research was individualized according to the level of performance of each athlete in the research. Please note that the number of repetitions, the intensity and the volume of the load were observed for each subject. The training programs presented part of a mesocycle carried out over a period of 8 weeks divided into two stages: 5 - 31 October and 2 - 28 November 2020 respectively.

5.7. STATISTICAL DATA ON INITIAL AND FINAL TESTING OF ATHLETES

To test the general hypothesis 2 we applied the statistical-mathematical method, performed with the help of the IBM SPSS V.20 program, using the statistical test Paired Samples T Test

In the table 8 I have entered the results obtained both in the initial test and in the final test following the application of the training program for a period of two months, to have an overview of the whole operation, for all six tests performed on subjects involved in the research. preliminary.

Table 8. Valuesobtainedat the initial and final tests in the physical tests

Nr. crt.	Subjects	Running speed 60 m (s)		Running speed 80 m (s)		Running speed 150 m (s)		Running hurdless 60 m (s)	
		tESTING initial	tESTING the final	tESTING initial	tESTING the final	tESTING initial	tESTING the final	tESTING initial	tESTING the final
1	AA	6.2	5.9	8.52	8.48	15.82	15.58	8.38	8.37
2	AD	6.6	6.4	8.45	8.39	15.88	15.63	8.52	8.48
3	RR	6.4	6.2	8.65	8.58	15.78	15.71	8.45	8.41
4	yl	6.3	6.1	8.38	8.34	15.64	15.41	8.40	8.37
5	SG	7.2	6.6	9.25	8.92	16.80	16.32	8.55	8.51

Nr. crt.	Subjects	Long jump from the spot (m)		Detachable vertical detachment (cm)	
		tESTING initial	tESTING the final	tESTING initial	tESTING the final
1	AA	2.38	2.55	45.4	47.2
2	AD	2.41	2.56	43.5	43.5
3	RR	2.36	2.53	48.2	50.2
4	yl	2.43	2.50	44.5	47.6
5	SG	2.55	2.60	42.7	50.0

According to table 9 in the 60m track test the test "t" has a value r = 0.936, an index t = -3,873, and the significance threshold p = 0.018, indicates that there are significant differences between the initial and final testing by improving performance. initials.

Table 9. Differences between initial and final results obtained by athletes in the 60m track event

Statistical indicators	Speed 60m track	
	Initial testing	Final test
Mediate	6.54s	6.24s
Median	6.40s	6.20s
Standard deviation	± 0.39s	± 0.27s
"T" test	t = 3,873; r = 0.936; p = 0.018	

** p <0.05*

Figure 5 shows the averages of the results obtained, both in the initial test and in the final test, in order to have an overview of the performance improvement in the six tests. We notice that in all the tests there were improvements of the performance indices with significant values (p <0.05) previously identified, with the mention that also on an individual level there were improvements in each of the six tests. We cannot say that the training plan had a beneficial effect on the hurdles technique, as it was implemented towards the end of the biomechanical analysis period.

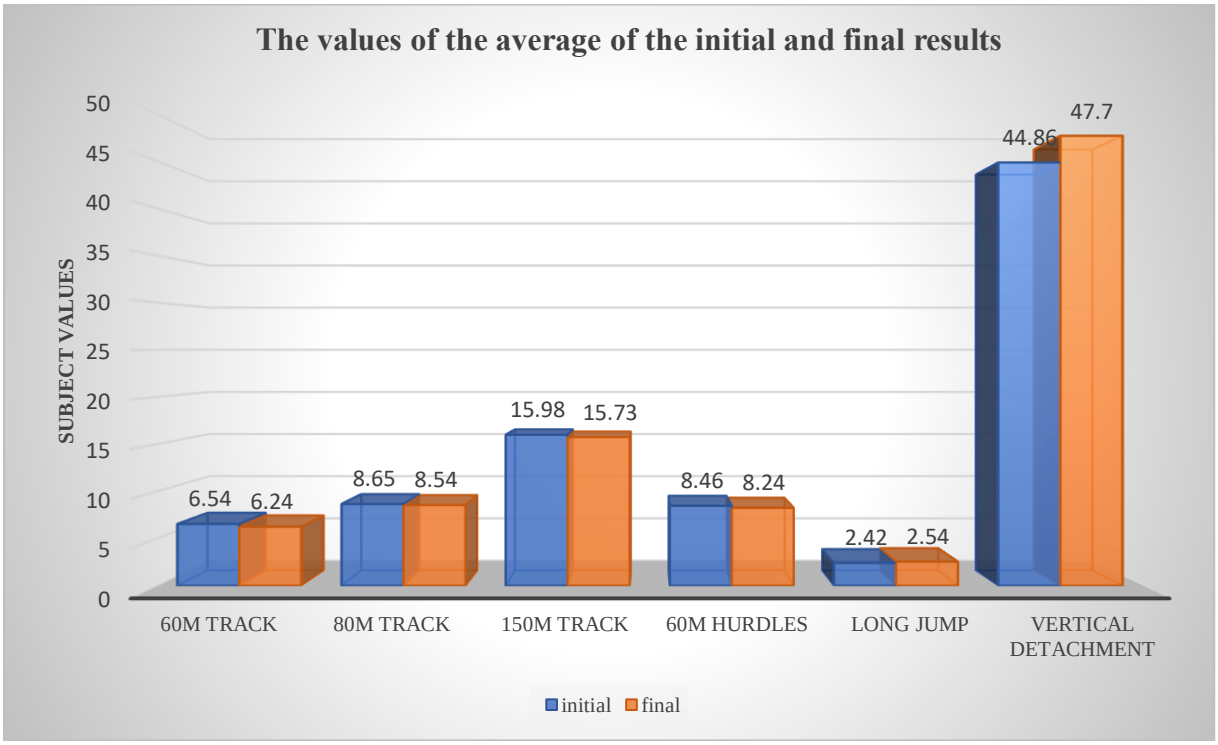

Figure 5. Mean values for initial and final test results

GENERAL HYPOTHESIS TESTING 2

Following the evaluation of the statistical analysis regarding the initial and final testing performed before and after the application of the physical training program, we identified a series of significant values on the differences between the two tests. In view of the above, we agree with the general hypothesis 2.

5.8. RESULTS AND DISCUSSIONS

Pliometric training is a fairly popular training, often introduced in training programs for athletes in various sports. The effects of lower train plyometrics have been studied in numerous studies over the last three decades (Sugisaki, 2014).

Several studies have introduced and investigated the effects of eight weeks of plyometric training (2 x per week) and short distance sprints in the training of U19 footballers. Despite the effective nature of plyometric and sprint training in improving athletic performance, this limited amount of research has focused on the effects of combined training: plyometrics, sprinting, jumping, the ability to change direction during sprinting and the ability to coordinate in U19 football. One reason for this limited number of studies could be the increased degree of injury due to the high intensity of these means and methods of training (Aloui et al., 2021).

Thus, the author states that by implementing sprint and plyometry training in the basic training of footballers, the performance on the ability to detach from the ground, the ability to accelerate, to change direction and the coordination capacity can be improved.

PARTIAL CONCLUSIONS

During the preliminary research, we identified a series of conclusions, highlighted below.

A number of values were improved, both at group level and at individual level in the physical, initial and final tests, the highest percentage at group level being 23% (in the 60 m track test), and at the individual level there was an increase of 33% (in the 80 m track test) among the lowest in terms of performance. The aforementioned tests with the corresponding

percentages represent an average of performance optimization, both at group level and at individual level.

The most obvious increase is identified in subjects with poorer results in competitions in the 110mg test, where there is a deficit of physical training. This aspect is a good one for our research, because it gives us confidence in the future, regarding the possibility to improve their performances even more, and the access is easier in order to apply the novelty aspects, in the technical preparation process. In all the tests in which they were tested, they obtained significant results by identifying a series of values, which offers the premise that physical and technical resources can be improved and adapt to the information received, reacting positively to novelty elements. At the level of the top athlete we also identify increasing values in all the tests listed in this chapter,

CHAPTER 6. MAIN RESEARCH DESIGN

6.1. PURPOSE AND OBJECTIVES OF THE RESEARCH

The aim of the research is to identify ways of efficiency through which we can achieve the objectives of current research.

We believe that in order to achieve results, the implementation of a centralized training program and the creation of a mechanism to streamline the movement of the attacking leg will be a possible remedy for the current problems in sports performance.

The main objective of this research is to implement a system of means and methods to improve sports performance in the 110 mg test aimed at senior athletes. In the following will be presented some clear directions aimed at improving the quality of driving force, being closely related to the technique of overcoming obstacles:

- Development of the muscles of the lower limbs by specific means of the test;
- Development of arm-leg attack coordination;
- Create and implement a device specific to the movement of the attack foot.

During the study of the level of performance of the athletes in the country and of the methods and means used in training, we identified the lack of equipment with specialized equipment and the use of such tools.

This result led to the creation of a device designed to support athletes by simplifying technical exercises based on high energy consumption, with the effect of improving the biomechanics of crossing hurdless (angles between the lower limbs in different phases of passing over obstacles).).

To the same extent, we performed a series of initial and final tests through which we were able to identify statistically significant differences in order to identify changes in physical parameters. The study of the literature was the basis of the entire analysis process by accumulating new current information on current trends implemented in performance athletes.

6.2. RESEARCH HYPOTHESES

General hypothesis 1

We claim that the use of an individualized physical and technical training program leads to the optimization of athletes' performance, materialized in the final result obtained in competitions.

Specific hypothesis 1.1

We believe that the speed of reaction of the arm opposite the attacking leg can be improved through a wide range of exercises.

Specific hypothesis 1.2

We assume that the "Just heat" device improves the action of the attack foot and contributes to the improvement of some biomechanical parameters in the 110 meter hurdles test.

Specific hypothesis 1.3

We believe that an individualized training with a focus on the action of the attack foot, will determine the optimization of strength indices.

General hypothesis 2

We assume that psychological factors (cognitive anxiety, somatic anxiety and self-confidence) can improve sports performance and thus the final result of the test.

6.3. RESEARCH LOT

The subjects that constituted the research group in this paper are seven in number, all performance athletes running 110 mg outdoors and 60 mg indoors at the senior level.

The sports clubs to which the athletes involved in the research process are entitled are: CSM Bucharest, CS Politehnica Iași, CS Rapid Bucharest, CSM Onești, CS Farul Constanța and CSM Timișoara. The tests and the implementation period of the individualized training program took place between June 2020 and May 2021.

6.4. PLACE AND INSTRUMENTS USED

The centralized training of the athletes took place in several centers in the country, approved by the Romanian Athletics Federation or in the training centers within the clubs where they are entitled (Bucharest, Constanța and Iași).

The subjects included in the research program received a 12-month training program (May 2020 – June 2021), and the initial and final tests were applied before the end of the program implementation period and at the end, both physical and and technical ones.

The materials needed for the research were the following:

- *Bosch GLM 80 rangefinder*- In his paper the author uses this tool to establish anthropometric characteristics in order to assess potential differences (Cheng et al., 2014).
- *Bosch GLM 80 flexometer + rangefinder* -In a study, the author aimed at how performance indicators, anthropometric and physical, contribute to better accuracy in the selection of rugby players (Vaz et al., 2021).
- *Metallic square*- to identify the height;
- *Body composition scale*(Omron BF511) - is based on 6 functions with which several indices can be measured depending on age, height and weight;
- *Dynamometer*- to identify muscle tone;
- *GoPro Hero 7 silver 4K camcorders*;
- *Sony HDR Camcorder - CX405*- Several studies have shown a beneficial effect of these methods of technical interpretation through video in various physical activities, but only a few have analyzed sporting events, with a significant impact on educational technology on learning technical skills in athletes (Baudry, 2006; Boyer , 2009; Clark, 2007; Eery, 2000; Guadagnoli, 2002; Hodges, 2003; Laguna, 2000; Parsons, 2012; Weir, 2009; Wulf, 2007; Wulf, 2001).

6.5. RESEARCH VARIABLES

In the present research, the independent variables are the means of training introduced in the training program to optimize certain functional indices for optimizing the hurdles technique, and the dependent variables are somatic, motor and psychological factors, according to table 10.

Table 10. Main study research variables

MAIN RESEARCH VARIABLES	
INDEPENDENT VARIABLES	DEPENDENT VARIABLES
Means for improving muscle tone in the lower limbs	Biomechanical analysis parameters
Means for improving the speed of reaction on the lower and upper limbs	Travel and reaction speed
Optimizing the specific movement of the attack foot using the "JUST HEAT" device	Dynamic and static force
Exercises to increase the mobility of the spine and lower limbs	Mobility
	Psychological factors: Cognitive anxiety Somatic anxiety Self-confidence

6.6. MEASUREMENTS AND TESTS APPLIED

The tests were aimed at identifying the level of performance before the research program, and anthropometric and somatic measurements provided information that may positively or negatively influence performance. Improving sports performance through motion analysis simulation software, Human Motion Bulider, SkillSpector and Kinovea, has developed technical performance in most athletes (Adashevskiy, 2014; Harvey, 2014; Stoicescu, 2012; Wilson, 2008; Tofan, 2006; Durey, 1995).

- *Psychological testing* -The scale used is Competitive State Anxiety Inventory -2 CSAI-2 (Martens, Vealy & Burton, 1990). This self-assessment scale contains 27 items and is structured on 3 sub-scales.

- *T - reaction*- Represents a software designed to analyze the speed of reaction in the upper and lower limbs; The aim of this study was to identify the reaction times for the upper limbs in beginners and advanced practitioners of martial arts Qwan Ki Do as well as to analyze the differences between the subjects investigated in this study (Cojocariu, 2011).

- Trac Tronix wireless speed test - Thanks to the laser timing we have identified the intermediate times for each obstacle in the 110 mg race as well as the flight times from the moment we cross the obstacle.

- *Dynamometer*digital FB200 - Identification of strength indices in the lower limbs.

- *Body analysis* -Identification of body weight, visceral fat, body mass index (BMI), muscle mass and basal metabolic rate (RMB).

6.7. STATISTICAL METHODS USED

The statistical analysis used in current research aims to obtain relevant information from available data, in order to discover information and relationships between them.

- *Arithmetic mean;*
- *Standard deviation*- This indicator means the variation of the results of each subject analyzed compared to the group average.
- *Standard average error*- Means the estimation of the variation of the statistical value between two groups or samples.
- *Median*- Represents values that signify the position on a percentage scale of the values distributed in ascending order.
- *Minimum / Maximum*- Minimum and maximum value recorded from the analyzed data
- *Confidence interval.*

Tests performed on the basis of data obtained from subjects, help us in the process of identifying significant results. The methods used are as follows:

- *Student Test*
- *Alpha Cronbach's coefficient* -is a scale that can be used to identify the internal consistency of the items in a questionnaire.

CHAPTER 7. INTERPRETATION AND PROCESSING OF RESULTS

7.1.STATISTICAL ANALYSIS OF THE RESULTS OBTAINED BY SPORTSMEN IN THE FENCING RACES CARRIED OUT IN THE PERIOD 2020-2021

GENERAL HYPOTHESIS TESTING 1

During the evaluation of the final times obtained in the 110mg races during the training sessions from the training period of 2020 and 2021, we identified a series of statistically significant results ($p < 0.05$) in the case of 6 athletes out of a total of seven.

According to table 11, a number of six significant results are identified out of a total of seven athletes. You can see the differences in performance during the training sessions, materialized in the results obtained in the competitions in which they participated before and after the implementation of the training program. It should be noted that the efficiency of the action of the attacking foot had a special role and importance in establishing the significant results in table 11. The results obtained in the various competitions in which the athletes involved in the research process participated only strengthen the results obtained, after the implementation of a set of training means specific to the 110 m test. The differences identified between the times obtained in the competitions of 2020 and 2021 are found in the case of each athlete, with differences between 16.09 and 14.83s, in the case of the athlete SD We must also remember that two results of AA and DC athletes compared to 2020 , is below the level of 14 seconds (13.85 and 13.94 respectively). We believe that the more important is the performance achieved as a result of this training program and less the differences between the years 2020-2021.

Table 11. Statistical results regarding the performances obtained by athletes in the 110mg test - 2020/2021

Name surname	110mg	Standard deviation	T	Degree of freedom	p
AA	Initial-Final	0.0556	13,218	3	.001 *
AD	Initial-Final	0.0469	13,644	3	.001 *
SD	Initial-Final	0.0994	6,585	3	.007 *
RR	Initial-Final	0.0704	6,385	3	.008 *
FD	Initial-Final	0.0639	8,832	3	.003 *
your	Initial-Final	0.199	2,461	3	.091

Name surname	110mg	Standard deviation	T	Degree of freedom	p
CV	Initial-Final	0.1181	4,484	3	.021 *

**p <0.05*

GENERAL HYPOTHESIS TESTING 1

In view of these performances obtained in the 110m hurdles, we can say that the results obtained by athletes, certify and are in accordance with the general hypothesis 1.

7.2. STATISTICAL ANALYSIS OF SPORTS T - REACTION RESULTS

TESTING THE SPECIFIC HYPOTHESIS 1.1

Following the application of the T-reaction test, a series of interpretations were performed, both individually and in pairs with respect to the upper limb and the lower limb (left and right) through the "t test" analysis in pairs within the SPSS platform. v.20.

The CV subject (according to table 12), achieved a number of 5 significant values (p <0.05) next to column 8 with a total of 5 errors compared to the initial tests, with the best result of the reaction speed of 78ms, and the weaker 3188ms. The best value of the average reaction speed is 269.33ms and the weakest 606.45ms. The 6 improved values are found next to test 1 and 2 on the left arm with 20 and 40 repetitions, respectively on the test of both lower limbs, test 3.1 and 4.1 with 20 and 40 repetitions, respectively, but also on tests 7 and 8 of the lower limbs. with 20 repetitions.

Table 12. Paired statistical analysis of the T-reaction test - topic 1

Nr.	Member sup. Member inf.	Nr. repeat	Media ± Dev. Std.		Min / Max		t	p	I / F error
			initial	**final**	**initial**	**final**			
1	Test both m *Initial / End- left.	20	402.77 ± 117.96	269.33 ± 116.12	281/672	78/375	2,847	0.022 *	1/0
1.1	Test both m *Initial / Final-dr.	20	357.55 ± 43.89	336.11 ± 75.71	281/391	78/375	1.37	0.208	1/0
2	Test both m *Initial / End- left.	40	370.15 ± 65.52	299.73 ± 60.90	265/484	190/375	3,191	0.005 *	
2.1	Test both m *Initial / Final-dr.	40	341.30 ± 66.77	366.69 ± 69.75	265/484	281/484	-1,234	0.241	
3	Test-both bit Initial / Final - left.	20	386.22 ± 51.37	344.44 ± 52.42	281/484	281/391	1,819	0.106	
3.1	Test - both Initial / Final bit - dr.	20	390.44 ± 77.61	319.88 ± 56.55	281/484	265/391	2,322	0.049 *	
4	Test-both bit Initial / Final - left.	40	412.05 ± 67.31	407.15 ± 55.71	375/578	375/578	0.448	0.66	

Nr.	Member sup. Member inf.	Nr. repeat	Media ± Dev. Std.		Min / Max		t	p	I / F error
			initial	**final**	**initial**	**final**			
4.1	Test - both Initial / Final bit - dr.	40	371.84 ± 56.40	334.42 ± 51.65	265/484	266/391	2.09	0.051	1/0
5	m. * dr. Initial / Final	20	606.45 ± 643.76	445.80 ± 190.90	281/3188	375/985	1,139	0.269	
6	m. * stg. Initial / Final	20	525 ± 281.69	398.66 ± 75.06	281/1188	281/500	1,839	0.083	2/0
7	pic. stg. Initial / Final	20	541.94 ± 178.77	426.47 ± 116.22	282/1172	278/594	2,162	0.044 *	1/0
8	pic. dr. Initial / Final	20	360.1 ± 120.38	305.1 ± 64.35	172/593	172/393	2,604	0.017 *	

** p <0.05; I-initial, F-final*

TESTING THE SPECIFIC HYPOTHESIS 1.1

By the total cumulation of results obtained from the interpretations on the indices of the tested subjects regarding the reaction speed, we can state an important number of significant and relevant results regarding the testing of the specific hypothesis 1.1

7.3.STATISTICAL ANALYSIS OF SPORTS ACHIEVEMENT RESULTS IN THE FLIGHT PHASE

TESTING THE SPECIFIC HYPOTHESIS 1.2

In this chapter we analyzed the flight times over the obstacles in the 110mg test. Thus, according to the results regarding the flight times over obstacles during training, before and after the implementation of the training program, we identify improvements in the initial values in each of the seven athletes. We can say that the action of the attack foot has a special influence in reducing the time spent in flight by accelerating its pressing movement, immediately after the hurdles. This was due to the specific nature of the attack, with the help of the device created for this purpose. In the study conducted by the author (Milan, 2019) on female athletes in the 100mg test, the results showed that the time interval from detachment to flight phase is 0.31s, and the actual flight time and landing after the obstacle is 0.10s and 0.09s, respectively (Milan et al., 2019). Thus, according to the results regarding the flight times over obstacles during training, before and after the implementation of the training program, according to table 13, we identify improvements in the initial values in each of the seven athletes.

Table 13. Interpretation of the results regarding the flight times over obstacles

Nr.	Name surname	Mediate	Deviation Std.	MAX	Min	p
1	AA - initially	0.58	0.0537	0.65	0.5	*.000 **
1.1	AA - final	0.42	0.0377	0.49	0.39	
2	DC -initial	0.56	0.0356	0.61	0.5	*0.004 **
2.1	DC - final	0.48	0.0451	0.53	0.39	
3	CV -initial	0.66	0.0442	0.72	0.58	*.000 **
3.1	CV - final	0.58	0.0492	0.65	0.51	
4	SD -initial	0.66	0.0506	0.74	0.58	*.000 **
4.1	SD - final	0.58	0.0417	0.63	0.52	
5	RR -initial	0.72	0.023	0.76	0.69	*.000 **
5.1	RR - final	0.66	0.0185	0.68	0.64	
6	DV -initial	0.59	0.0492	0.65	0.52	*0.002 **
6.1	DV - final	0.53	0.0365	0.58	0.48	
7	FD -initial	0.58	0.0414	0.64	0.51	*0.002 **
7.1	FD - final	0.53	0.0337	0.58	0.48	

** p <0.05*

TESTING THE SPECIFIC HYPOTHESIS 1.2

Given the results obtained during the flight times over obstacles in the races of 110m hurdless, we believe that the action of the attacking foot played an important role. Therefore, we agree with the specific hypothesis 1.2 which assumes that the optimization of the action of the attack foot contributes to the decrease of the flight time over obstacles.

7.4. STATISTICAL ANALYSIS OF THE RESULTS OBTAINED BY ATHLETES IN THE MUSCLE STRENGTH TEST

TESTING THE SPECIFIC HYPOTHESIS 1.3

The data on the level of muscle strength of the researched subjects reveal information on the maximum value of the muscles of the posterior thigh. The test protocol (referred to in Chapter 6) involves performing with the attack foot and the trailer foot in flexion and extension, a movement of pressing and then hitting, to record the values at different times when the athlete is when crossing the hurdless.

In table 14 regarding the pair analysis of the values obtained after the strength test, we obtained five significant values (p <0.05).

The difference between the static force and the explosive force of the attack foot after the application of the training program (final test) and of the trailer foot is a significant one (p <0.05), which represents an improvement of the force, compared to the trailer foot. It should be

noted that no specific means of training has been taken into account with regard to the trailer leg.

Likewise, in the case of the comparison regarding the strength of the attack foot before and after the training program, we identify significant values ($p < 0.05$).

The analysis between the explosive force of the attack leg (in the extension phase as well as in the flexion phase) and the force of the trailer leg in the initial test, brings to attention an insignificant result, which means that the force of the lower limbs is equal. Note that the action of the attack leg is different from that of the trailer leg, characterized by a pressing motion, hitting the ground after the flight phase.

The relationship between the strength of the attacking foot (explosive and static) at the final test and the strength of the towing foot, highlights a significant difference ($p < 0.05$), which means that the training program implemented had positive effects on increasing the strength of those two lower limbs.

By analyzing the strength of the attack leg in extension, and then in flexion (in the initial and final phase), we found a significant result ($p < 0.05$), meaning that the implementation of the training plan had a significant contribution to the development of strength between testing initial and final.

Table 14. Lower limb strength analysis

Nr.	Force lower limbs	Mediate	Deviation Std.	Er. Std. of the average	*t*	p
1	pic_atac_final - pic_remorcă_final	7,231	6,543	0.782	9,246	***0.00 ****
2	pic_attack_initial - pic_trailer_initial	-0,728	5,513	0.659	-1,106	0.273
3	pic_atac_initial - pic_atac_final	-7.96	4,161	0.497	-16	***0.00 ****
4	Fe_pic_attack_extension_final - Fe_pic_ attack_flexie_final	-0.631	14,033	2,372	-0.266	0.792
5	Fe_pic_ initial_extension_attack - Fe_pic_ initial_flexion_attack	-2.191	5,209	0.88	-2,489	***0.018 ****
6	Fe_pic_ attack_extension_initial - Fe_pic_ attack_extension_final	8.74	4,888	0.826	10,577	***0.00 ****
7	Fe_pic_ initial_flexion_attack - Fe_pic_ attack_flexie_final	7.18	11,078	1,872	3,834	***0.001 ****

** p <0.05*

TESTING THE SPECIFIC HYPOTHESIS 1.3

Due to the results obtained from the application of an individualized training program, specific to the action of the attack foot over obstacles, we consider that the specific hypothesis 1.3 has been tested.

7.5.PRESENTATION OF THE RESULTS OF THE PSYCHOLOGICAL QUESTIONNAIRE

GENERAL HYPOTHESIS TESTING 2

Regarding the testing of general hypothesis 2, we want to highlight the influence (positive or negative) that the psychological factor can have on performance, results, either in competitions or training and what information can all three give us -scale. In the questionnaire we find a number of 27 items with 4 answer options.

As we can see in Figure 6, we obtained a series of percentage values in terms of the results obtained from the application of the questionnaire and its interpretation. The sum of all the results obtained at the three subscales was realized: cognitive anxiety, somatic anxiety and self-confidence, both in the training period and in the competition period. The reference values that represent the ideal of the athlete's psychological profile are scored between 9 (anxiety / low confidence) and 36 (anxiety / high confidence).

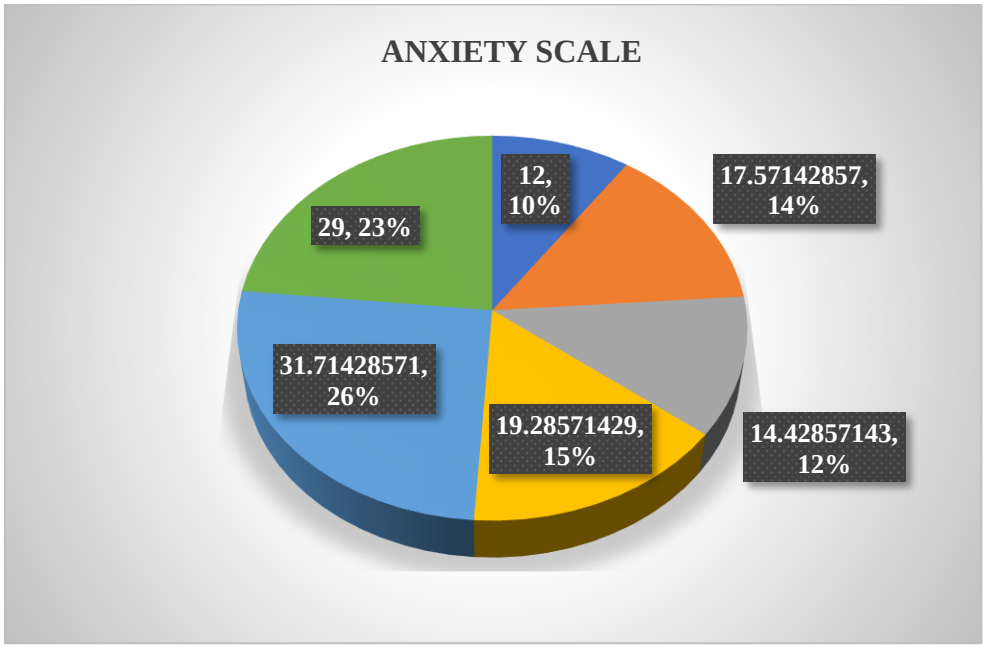

Figure 6. Percentage representation of results-Anxiety scale

The highest percentage values obtained in the averages are found next to the self-confidence scale, both in training and in competition (23 and 26% respectively).

In the case of cognitive and somatic anxiety, the percentage values are at an average level to a minimum (between 10 and 14%), with no visible improvements from the state of training to the state of competition.

To test general hypothesis 2, we want to make some connections between psychological factors (cognitive anxiety, somatic anxiety and self-confidence) and the results obtained in the 110mg test of athletes involved in the main study, to determine if there are links between these two elements.

Next to the subject SD we identified balanced scores with close values between the training period and the competition period without lags in terms of cognitive and somatic anxiety and self-confidence. Despite the fact that the scores are at an average level on the scale of minimum and maximum values, the athlete has a value of the significance threshold $p = 0.007$, with differences between the performances obtained between 2020 and 2021 of approx. 1, 1.5 seconds. We assume that he has managed to achieve an emotional balance and an intrinsic motivation so that he can perform, and at the same time, with remarkable results.

We state that the DV athlete did not make significant progress in the 110mg races during the training period. The fact that the experience of the competitions regarding this test is also missing and the fact that he is a runner in the 400mg test, led to the lack of significant results. An important role can be played by the major difference between the scores obtained on the psychological component of somatic anxiety (9 in training and 26 in competition), without being able to manage emotions and anxiety when tested in a 110mg test.

The CV athlete recorded a value of the significance threshold ($p < 0.05$) during the testing of the 4 hurdles races after the training period, but we can say that it was influenced by the cognitive anxiety component, due to fluctuations in values during the training period and competition, between 11 and 17.

GENERAL HYPOTHESIS TESTING 2

Given the above mentioned on the role of psychological components in the performance of athletes, in the 110m hurdles, both during training and during competition, we agree with testing the general hypothesis 2.

7.6. STATISTICAL ANALYSIS OF BIOMECHANICS ON FENING

GENERAL HYPOTHESIS TESTING 2

Regarding table 15, we identified and presented a number of seven angles of the technique of crossing over obstacles, on the athletes included in the main research.

In order to identify the differences between the values of the angles, in terms of overcoming obstacles in the 110mg test, we used the statistical test Paired Samples T Test, according to table 15. Out of the total angles analyzed, a number of five values were found below the threshold. of significance, which means that there were differences between the initial and the final values.

Table 15. Statistical analysis of biomechanical angles in the hurdles test

Nr. crt.	Analyzed angles	Average (grade)	Standard deviation	Standard average error	t	p <0.05
1	Small angle. impulse to the ground before detachment - Initial / Final	5.3142	7.8210	2.9560	1,797	.122
2	Angle tr. versus vertical before detachment - Initial / Final	4.4285	6.8866	2.6029	1,701	.140
3	Thigh-leg angle bit. attack before detachment - Initial / Final	3.3220	3.3220	1.2556	6,337	***.001 ****
4	Thigh-angle attack above the hurdles- *Initial / Final*	5.0394	5.0394	1.9047	-6,127	***.001 ****
5	Thigh-leg angle attack above the hurdles- *Initial / Final*	12.6623	12.6623	4.7859	-3,712	***.010 ****
6	Ankle joint ankle foot attack above the hurdles- *Initial / Final*	2.7945	2.7945	1,0562	5,166	***.002 ****
7	The angle between the attack and the ground when landing behind the hurdles- *Initial / Final*	2.1248	2.1248	, 8031	9,072	***.000 ****

** p <0.05*

In order to achieve these results, the exercises in the training program, specific for the development of strength in the lower limbs but also the use of the device called "Just heat", with a role in streamlining the fast and energetic action of the attack foot, contributed in a positive way. , after the flight phase. Also in the exercise mentioned above, ("Just heat") we would like to state that this contributed to a significant threshold (p <0.05) in terms of the angle between the tip of the attack leg and its leg, measured at the joint. of the foot.

Please note that when improving the angle between the attack foot and the ground, when landing after obstacles, we find the same grounding movement in the movement used on the device created by us. At the same time, we note that the exercises in the training plan used to

optimize the technique over the hurdless, played a key role in reducing the flight over obstacles and the razor-sharp passage over the hurdles hurdles.

7.7. RESULTS AND DISCUSSIONS

In a study by Chin-Shan (2020), it was identified that all biomechanical parameters analyzed in a hurdles race (angle of support leg and ground before detachment, height of the general center of gravity, distance from landing behind the hurdles) they had linear regression, except for the landing distance. The subjects managed to accelerate from the start and reached the maximum speed between hurdless five and six, and up to hurdles ten they slowed down progressively.

Changes in travel speed were also identified in terms of hurdles attack distance, flight time, measured time between obstacles, time taken from one hurdles to another, height of the general center of gravity and angle of detachment.

In order to combat certain limits imposed by the anthropometric characteristic and to obtain positive effects on performance in the 100m sprint, the role of the coach is to try to plan workouts in order to increase the strength, strength and neuro-muscular system of an athlete (Raiola, 2013; Raiola, 2014). From this conclusion reached by those mentioned by the author Raiola (2013, 2014), we deduce the idea that, in addition to a very good acceleration speed, the force development capacity must be permanently stimulated in order to improve the push to the first hurdles and after obstacles 6 and 7 respectively.

Other research has highlighted the effects of six weeks of proprioceptive training on the balance, strength and speed of athletes in sprint events. The six-week training program included 30 minutes a day of proprioceptive training using the balance ball (BOSU) and fitness ball. Before and after the training program, horizontal and vertical stabilometric tests were performed, as well as the squat-to-squat jump, the counter-jump and the 30-meter sprint. The conclusion was that the exercise program improved postural balance and led to moderate increases in force on detachment from the ground, but had no impact on speed (Romero-Franco et al., 2017).

Previous studies show that the exercises used in static stretching are not oriented towards the objectives of pre-competitive training (Power et al., 2004; Yamaguchi, 2005; Bradley et al., 2006; Stewart et al., 2007; Samuel et al., 2008; Sayers et al., 2008).

The author Young (2007) emphasized the importance of researching the role of static stretching by using the protocols we find in everyday practice. Other studies prove the

shortcomings of static stretching by initiating a protocol that involves stretching at least two minutes of the total time given to stretching on each muscle group (Little, 2006; Young, 2007; Taylor et al., 2009).

Given the above mentioned by many authors, we motivate by the conclusions they reached, the importance of introducing static stretching in the training program, for good muscle elasticity, especially at the front thigh of the attack leg.

PARTIAL CONCLUSIONS

We can conclude that almost all athletes (6 in number) obtained significant results after a period of about 12 months of physical and technical training in this research compared to the training performed so far. We also state that during the competition period the results are significantly better as opposed to the same period a year ago (2020), but we also want to mention the importance of the psychological factor in the training of athletes.

Another feature that should be highlighted is that the test times of 110mg can vary by a few hundredths, from one measuring device to another, being influenced by the degree of accuracy offered by each device.

In the future, more in-depth research and more attention to the psychological component may provide much better performance. We state that no athlete who has been involved in this research process has followed and is not following a sports psychological counseling program or support.

GENERAL CONCLUSIONS

The interpretations made following the analysis of the results obtained by the athletes involved in the research program revealed some positive aspects related to the evolution within the implemented training program. Regarding the results obtained in the T-reaction test, we can say that we identified a total of 45 differences, both in the lower limbs and in the upper limbs, between the initial and final testing. Most of the differences obtained were achieved by subjects 3, 6 and 7 with 9, respectively 8 significant results from a total of 12 tests.

The strength of the lower limbs increased between the initial and the final test, but also between the values between the attack and the trailer in terms of static and dynamic force. In table 7.13 on the individual analysis using the "t" test of the lower limbs in the initial test we identified a number of 7 significant results out of a total of 28 tests performed between the attack foot and the trailer and between static and dynamic force. . Based on these results, we considered it useful to implement the individualized training program only for the attack foot, and in the final test we will identify the significant differences recorded. Five of the seven interpretations were significant ($p < 0.05$) for explosive force and static force between the attack foot and the towing foot, but also between the attacking leg in flexion and extension in terms of explosive force. The significant results show us that the implemented program is in accordance with the specific hypothesis 1.2 by the fact that it positively influences the technique of overcoming obstacles.

We maintain that the implementation of a physical and technical training program must take place over a period of at least 4 years in order to ensure an optimal load of the training volume.

Due to the large number of significant results obtained, given the variety of tests applied, following the implementation of methods and means of physical training, we can say that there is a need for a change in the training of athletes at senior level, but applicable from junior age. We refer to the fact that when physical training is individualized and focused on cause and not effect, then we can say that we will perform globally.

RESEARCH LIMITS

During the research we encountered some limitations such as:

- The small number of bibliographic resources specific to the 110 mg test tests;
- The appearance of the Sars-Cov virus 2 reason why it slowed down the research process and limited the physical contact with the subjects involved in the process;
- Lack of athletes in as many as possible, 110 mg runners at the senior level.

In the future, we intend to extend the limits of research and apply these means and methods of training to as many athletes as possible, at junior level.

FUTURE RESEARCH DIRECTIONS

Regarding the future research directions, we have identified some aspects that can generate the following study perspectives.

1. Applying the training program to athletes in the junior category.
2. A larger range of subjects that can be part of the following research design.
3. Optimizing the action of the trailer leg.
4. Possibility of applying training programs to other athletics events.

DISSEMINATION OF RESULTS

The results of this research were disseminated through a series of published scientific articles, the presentation of research reports and the participation in various scientific events.

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