Universitatea Transilvania din Brașov

INTERDISCIPLINARY DOCTORAL SCHOOL

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Experimenting with combined plyometric and coordination exercise programs to improve physical and technical capacities of U12 junior basketball players

SUMMARY

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BRAȘOV, 2024

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INTRODUCTION

The trends in modernizing sports training methodologies focus on identifying new ways to enhance the motor potential of athletes. Plyometric exercises and coordination exercises play an essential role in the physical preparation of athletes, aiming to optimize physical and technical capacities in various sports. Plyometrics, defined as a form of training involving fast and explosive exercises intended to improve muscular performance, is confirmed by numerous studies for its effectiveness in increasing power and speed (Chimera et al., 2004; Markovic, 2007). Similarly, coordination training, which includes exercises designed to improve the ability to perform controlled and precise movements, is crucial for developing technical skills in sports (Myer et al., 2006).

The existing literature provides considerable evidence of the benefits of plyometric and coordination exercises, yet there are unexplored aspects regarding the most effective methods and programs. For instance, the results of various studies on the impact of plyometric exercises on sports performance are often contradictory, with some indicating significant improvements while others find no major differences (De Villarreal et al., 2009; Sáez-Sáez de Villarreal et al., 2010). Additionally, how these exercises influence the technical skills specific to each sport or game requires a more in-depth and sport-specific analysis.

Studies conducted so far suggest that plyometric exercises significantly contribute to improving vertical jump capacity, sprints, and quick changes of direction (Ebben et al., 2008; Ramírez-Campillo et al., 2014). However, there is no expert consensus on the optimal duration of training programs and the necessary frequency to achieve maximum results. Moreover, research combining plyometric training with coordination training is extremely limited, thus requiring further investigation specific to the characteristics of the practiced sports activity to determine the possible synergies between the two types of training (Arazi et al., 2011).

Based on the critical analyses of the studies conducted, there is a necessity to develop training programs that combine plyometric and coordination exercises, tailored to the specificity of each sport. It is important to explore and document the impact of these programs on the technical skills specific to each sport, as well as to establish optimal training parameters, including volume, intensity, and frequency of exercises. Additionally, it is essential to investigate the effects of these programs on different groups of athletes differentiated by age categories, sports experience, type of sport practiced, etc.

The combination of plyometric and coordination exercises can lead to a significant increase in sports performance by integrating the improvement of muscular power with the development of coordination skills. This integrated approach can provide additional benefits compared to the isolated use of each training method. For example, athletes may experience greater increases in speed, agility, and the ability to perform complex and rapid movements, which are essential in most sports (Hewett et al., 2012; Young et al., 2001).

In this doctoral thesis, we will focus on delineating concepts such as muscular elasticity and the myotatic reflex, which are fundamental for understanding the mechanisms through which plyometric exercises enhance performance (Nicol et al., 2006). Additionally, theories regarding motor learning

and motor control will be essential to explain the impact of coordination training on the development of technical skills specific to sports activities (Schmidt et al., 2011). Integrating these theories will provide a well-founded basis for understanding how the combination of plyometrics and coordination can optimize the sports performance of junior basketball players.

By investigating and developing plyometric and coordination exercise programs, this thesis aims to contribute to the optimization of the physical and technical capacities of junior athletes practicing basketball. The study will clarify specific methodological aspects of combining plyometric with coordination exercises in basketball and offer innovative perspectives on integrated sports training.

RELEVANCE OF THE TOPIC

The improvement of young athletes' physical capacities and technical potential through plyometric and coordination exercise programs is a current research topic in sports science. Given the increasing performance demands in modern basketball, integrated approaches that combine different types of exercises are essential for achieving significant results and successes.

Basketball is a team sport characterized by complexity and technicality, continuously evolving in terms of physical and technical preparation, aligned with performance objectives specific to each training level. The interrelationship between the technical level and the physical capacity of the players provides the foundation for optimizing athletes' performance levels (Papla et al., 2022; Moanță et al., 2013). The use of portable sensor technology in basketball allows for the scientific quantification and monitoring of training and sports performance in terms of physical and technical parameters (Leidesdorf et al., 2022; Li B et al., 2021; Benson et al., 2020).

Advancements in science and technology have facilitated the diversification of portable sensor technology, which, through the data provided, contributes to optimizing the needs of athletes and coaches (Benson et al., 2020; Nickerson et al., 2020). The benefits of technology are undeniable in any field of activity, and sports represent a domain where the innovative implications of technology are continuously diversifying and specializing, having a major impact on future sports performances (Damji et al., 2021; Benson et al., 2021). Technology's contribution to sports is decisive in monitoring and evaluating performance parameters, and the specialization of these technologies facilitates the quantification of key physical and technical parameters in relation to the characteristics and specificity of different sports. The use of technology in the sports training process allows for real-time data collection and feedback, which can optimize training, especially in the initiation and junior stages specific to basketball (Yang et al., 2020; Hatif et al., 2022; Zhao et al., 2017).

In the last decade, numerous studies have focused on examining the impact of using various informational technologies and portable intelligent sensors in basketball, aiming to improve athletic performance and the physical and technical parameters of athletes (Yang et al., 2022; Ren et al., 2022; Bin et al., 2021). The use of informational technologies helps identify positive aspects and also aspects that disadvantage athletes, through execution errors or insufficient development of certain physical parameters (Yuzhou et al., 2018; Petway et al., 2020). Correcting and modeling basketball training require continuous updates to account for the particularities of athletes, sports experience, and training and performance objectives (Nae et al., 2022; Mohammed et al., 2021).

Recent studies highlight that plyometric training significantly contributes to the improvement of explosive strength and jumping abilities in athletes. A study conducted by Guo et al. (2022) demonstrated that a 12-week plyometric training program led to significant improvements in vertical jumps among young athletes. These findings are supported by another study that emphasized the importance of plyometrics in increasing muscular power and speed (Abdullah et al., 2023).

Coordination is an essential component of performance in team sports, contributing to the precision of movements and the efficiency of technical executions. Coordination exercises are particularly important in developing complex motor skills, which are crucial for athletes. The study by Borhannudin Abdullah and his collaborators (2023) highlighted that coordination training significantly improves balance and neuromuscular control in basketball players.

The combination of plyometric and coordination exercises is an innovative approach that can lead to superior results compared to the isolated use of each type of training. In a recent study, combined training showed efficiency in enhancing motor and technical performance, demonstrating significant improvements in balance, coordination, and explosive strength (Miller et al., 2023).

JUSTIFICATION FOR CHOOSING THE TOPIC

The choice of the topic "Experimentation of combined plyometric and coordination exercise programs to improve the physical and technical capacity of U12 junior basketball players" is motivated by several relevant factors in the current context of sports science research. Firstly, there is a clear and constant need to improve the physical and technical performance of young athletes, who represent the future of team sports like basketball.

The level of technical skill and physical conditioning, combined with sports experience, are major components for ensuring success in basketball. The efficiency of basketball shots is conditioned by several parameters, such as coordination and physical conditioning: hand-eye coordination, hand-ball coordination, vertical jump parameters during shooting, shooting accuracy, etc. (Zhao et al., 2023; Zhao et al., 2021). During the initiation period in basketball, a major objective is the correct acquisition of execution techniques to make the shots more efficient and ensure an optimal level of physical conditioning (Paulauskas et al., 2011; Lavrin, 2017). Coordination in executing shots requires intersegmental control under conditions of movement, precision, spatial orientation, and opposition (Jerzy et al., 2014; Kamandulis et al., 2013). Coordination capacity is an essential component in the learning and improvement process of technical skills, comprising elements such as general coordination, rhythm, spatial orientation, precision, the ability to combine movements, and reaction time (Singh et al., 2017; Mocanu et al., 2021; Jerzy et al., 2014).

In basketball, shot efficiency is influenced by the context of the game (shooting under pressure, shooting after movement, jump shots, shooting from various distances from the basket, etc.) and the level of preparation of the players (Cojocariu et al., 2014; Demir et al., 2022; Kumar et al., 2018). The efficiency of jump shots is conditioned by jump height, the impulsive strength of the lower limbs, body posture and alignment during flight, execution technique, hand-eye coordination, and shooting accuracy (Ilham et al., 2020; Radenković et al., 2023; Radenkovic et al., 2018). Plyometric exercise programs have demonstrated their efficiency in achieving various basketball-specific technical skills

(De Villarreal et al., 2021; Selcuk et al., 2018). In sports training, all these aspects require special attention from coaches and athletes to maximize the physical and technical potential specific to basketball.

Specialized literature highlights the importance of early development of motor and technical skills specific to the sport, arguing that interventions at young ages can have a major impact on the future performances of athletes (Lloyd et al., 2014). Recent studies have shown that integrating plyometric and coordination training can lead to significant improvements in motor skills and technical performance among young athletes (Myer et al., 2018; Chaouachi et al., 2019).

Studies on the efficiency of shots, jumps, and jump shots in specific game conditions, such as those preceded by movement or other technical actions, have been the target of numerous researches (Cigerci et al., 2020; Chen et al., 2018). The results of these studies emphasize the importance of individualizing and adapting training based on characteristics such as age and level of sports experience (Hadi et al., 2020; Erčulj et al., 2015; Androutsopoulos et al., 2021).

Although there are studies that explore the benefits of plyometric and coordination exercises separately, research investigating the combined effects of these exercises is still limited. According to the study by Chaouachi et al. (2019), it is essential to conduct further research to fully understand the synergies between these types of training and how they can be optimized to maximize the performance of young athletes.

Combining plyometric and coordination exercises has proven to be an effective approach to improving athlete performance. Studies conducted by Borhannudin Abdullah and his collaborators (2023) have highlighted that combined training significantly improves balance, coordination, and explosive strength, which are essential aspects for sports like basketball. Additionally, Miller and his collaborators (2023) have emphasized that this type of training can lead to greater improvements compared to traditional training methods (Miller et al., 2023).

Studies identifying how the combination of plyometric exercises and coordination exercises adapted to the specifics of basketball contributes to the improvement of jump shots in training conditions are very few and do not cover the aspects of the present study. We believe that implementing a 6-month experimental program, combining plyometric and coordination exercises to improve the characteristics of jump shots in conditions similar to the game and adapted to age-specific particularities (10-12 years) and the level of sports training (U12 juniors, at least 3 years of sports experience), will contribute to optimizing sports performance in basketball.

The use of advanced technologies for monitoring and evaluating athletes' performance is an emerging trend in the sports field. Recent studies emphasize the importance of technologies such as optoelectronic measurement systems in improving the accuracy and efficiency of training (Guo et al., 2022). Integrating these technologies into training programs can provide real-time feedback and contribute to personalizing training according to each athlete's sports potential and specific needs.

Based on the arguments mentioned before, we consider that the novelty of our study lies in the design and implementation of a combined plyometric and coordination exercise program using the MyVert sensor (Petway et al., 2020) to improve the technical level of players with a focus on jump shots performed in conditions adapted to basketball (shots combined and preceded by other

technical actions). Additionally, we designed and applied 3 tests to evaluate jump parameters, power, and efficiency of jump shots, tests that were adapted to the specifics of basketball (the jump shot was preceded by different technical actions).

CHAPTER V - CONCLUSIONS OF THE THEORETICAL FOUNDATION

Below, I will present some main ideas, relevant information, and conclusions from the first part of the theoretical foundation of the doctoral thesis.

Motor capacity

Motor capacity can be optimized through exercise under both standard and varied conditions, being dependent on the complex factors of human physical and psychological development. Motor capacity, with its two components: general and specific, requires development in accordance with age and sports-specific characteristics and requirements. Motor capacity in basketball is dependent on general motor capacity, targeting motor skills in specific exercises and competitive conditions.

Basketball game

Basketball is a complex and multifaceted sport that combines various cyclic and acyclic movements: rapid and dynamic movements, with and without the ball (Erčulj et al., 2007). Among the most frequent movements in basketball are: sprints (a few steps long or over distances of more than 20m), sudden stops, quick changes of direction, accelerations, various vertical jumps, rapid dribbling, and, of course, different types of shots and various forms of passing the ball (Erčulj et al., 2004; Zwierko et al., 2007; Abdelkrim et al., 2007).

Sport performance in basketball mainly depends on the following motor and energy-producing abilities: jumping power, shooting power, agility with and without the ball, coordination, speed of executing cyclic and acyclic movements, lactacid and alactacid anaerobic capacity, shooting accuracy, and ball control ability (Brack, 1985; Erčulj, 1998; Jukić, Milanović et al., 2005; Stone, 2007; Erčulj et al., 2007). Applying appropriate plyometric exercises, correctly dosing them, paying attention to the correct execution, and having adequate rest between sets and repetitions can bring significant improvements in the explosive capacity of basketball players, which is one of the essential conditions for success in basketball.

Plyometrics

Plyometrics is a type of training that uses exercises designed to produce quick and powerful movements, aimed at improving the functions of the nervous system and sports performance. This type of training is used to increase the speed and force of muscle contractions, often with the primary goal of increasing jump height. Plyometrics involves the muscle's ability to reach maximum force in the shortest possible time, a skill known as explosive strength/power.

Plyometrics focuses on developing muscle explosiveness through intensive and rapid loading of the muscles. This loading is necessary to prepare the muscle to generate greater force than intentionally achieved, subsequently utilizing this load for the main action. In other words, plyometrics helps the

muscle generate more force, which can be used to perform various movements faster, farther, and higher. This aspect is essential in sports games, where speed and explosiveness are key elements.

Analyzing plyometric mechanisms aimed at developing explosiveness, it is essential to understand the different types of muscle contractions: eccentric, isometric, and concentric.

In eccentric contraction, the muscle lengthens during contraction. This type of contraction occurs when the external force is greater than the force generated by the muscle. As a result, the external force lengthens the muscle as it tries to resist the movement but fails. Eccentric contraction is sometimes called yielding contraction because the muscle yields to the external force and lengthens. Most athletes can lower eccentrically a weight 40-50% greater than they can lift concentrically.

In isometric contraction, the muscle contracts without producing movement. The muscle fibers shorten, but because the external force is extremely high, it cannot be overcome, and no movement occurs. Isometric contraction is also known as static or holding contraction. It is important to note that in this type of contraction, the force exerted is 10-15% greater than that exerted in concentric contraction.

In concentric contraction, the muscle shortens during contraction. In this case, an external resistance (weight) is overcome, and movement occurs over a certain distance, with the muscle contracting and shortening to produce the movement. This type of contraction is known as overcoming contraction because the muscle overcomes the used weight.

The main target in plyometrics is to achieve maximum eccentric contraction, which develops maximum muscle tension, and then to train the nervous system to transform this contraction into a concentric one, producing the desired movement. It is important to note that the force produced during eccentric contraction is greater than that produced voluntarily.

Thus, the development of explosive power, the main result of plyometric exercises, consists in transforming eccentric contraction into concentric contraction. This is controlled by the nervous system, which is why much of plyometric training focuses on training the nervous system, not just the muscles.

A fundamental example of plyometric action is a runner's step cycle. When an athlete touches the ground with each step, the muscles of the involved leg rapidly lengthen due to the force with which the athlete's body is drawn to the ground by gravity. The eccentric actions of the thigh and calf muscles prevent the athlete from collapsing, slowly resisting the stretching of these muscles.

Besides preventing excessive lowering of the body's center of gravity, the eccentric actions of the muscles cushion the landing impact. Eccentric contractions of the lower limbs, thighs, and torso work together to absorb the shock on the body, minimizing the impact of excessive forces on the connective tissues and skeletal structures.

Stretch-shortening cycle

The combination of muscle actions, neurological involvement, and connective tissue elasticity, which facilitates effective plyometric actions, can be further explained by analyzing the stretch-shortening cycle. The collective mechanisms involved in the stretch-shortening cycle include the stretch reflex,

tendon elasticity, preactivation, and potentiation (Fukutani, Kurihara, and Isaka, 2015). There is ongoing debate about the contributions of these different mechanisms, but no consensus has been reached (Komi, 2000).

The stretch reflex, or myotatic reflex, is a fundamental mechanism for the stretch-shortening cycle and the production of power in plyometric exercises. The primary purpose of the stretch reflex is to monitor the magnitude of muscle stretch as a safety measure to prevent excessive stretching and damage.

Phases of plyometric exercises

Plyometric exercises are described in three distinct phases: the initiation or eccentric phase, the damping phase, and the concentric response phase.

Eccentric or initiation phase begins when the athlete mentally prepares for the activity and lasts until the initiation of the stretch stimulus. The duration of this phase is determined by the degree of impulse desired to facilitate the contraction.

The second phase of the stretch-shortening cycle is the *amortization phase*. This represents the time between the beginning of the eccentric contraction and the initiation of a concentric force. By definition, it is the electromechanical delay between eccentric and concentric contractions, during which the muscle must transition from the first phase to the third.

The final phase of the stretch-shortening cycle is the *concentric response phase*. In this phase, the athlete focuses on the effect of the exercise and prepares for the initiation of the next repetition. The response phase is the summation of the initiation and damping phases. This phase is often referred to as the resultant phase due to the enhanced concentric contraction.

Indications for using the plyometric method

The plyometric method is based on the principle of progression and the rule of patience, as these exercises must be performed over a longer period to achieve the best results. A solid prior preparation in terms of strength, accumulated in previous years, will facilitate the rapid progress of athletes who use plyometric exercises. To ensure healthy progression, it is recommended that low-impact plyometric exercises be introduced in the training of juniors for several years.

Various benefits can be obtained through plyometric training:

- variation in the levels of innervation;
- predominant recovery of motor units and associated muscle fibers;
- activation of the frequency of impulses transmitted efferently by motor neurons;
- muscle strength is converted into explosive power;
- optimization of the nervous system to react with maximum force during muscle stretches, resulting in rapid, optimal, and powerful contractions;

- optimization of the fatigue phenomenon specific to plyometric training. Increased contact time indicates fatigue (Gollhofer et al. 1987).

Plyometrics in basketball

The most frequently used movements by basketball players during a game are sprints, jumps, and changes of direction, all of which are adapted according to needs. One of the most effective ways to improve these essential movements is by integrating plyometric exercises into the training program. When combined with a strength and coordination program, plyometric exercises provide players with the necessary tools to achieve superior performance. Thus, in basketball, it is beneficial to use plyometric exercises that develop the explosive power of the lower body.

Plyometrics involves the use of various types of jumps, thereby contributing to increased vertical jump, improved take-off time, and enhanced lower body stability. It is important that the types of jumps performed are as similar as possible to those during the game, both in form and intensity.

Coordinative capacities

The term "coordinative capacities" is almost unanimously accepted by contemporary authors, as it is much more comprehensive, covering all aspects and implications of coordination within general and sports-specific motor skills.

In the game of basketball, all components of coordinative capacities are essential, facilitating the improvement of physical potential and specific technical skills to ensure sports success. In basketball training, coordinative capacities intercondition and interrelate to enhance sports performance.

Impact of coordination in basketball

Basketball is a team sport that requires multiple skills, which largely depend on the players' ability to act quickly, jump, and dribble the ball with coordinated movements of the lower and upper limbs. To achieve successful performance, basketball players must use proper techniques for shooting, dribbling, and rebounding under time pressure, establishing precise synchronization between the movement of their feet, hands, and eyes in relation to the ball and opponents. Most basketball players have impressive technical training, easily use both hands (ambidexterity) during the game, and perform technical actions at high speed.

Drinkwater et al. (2008) state that speed, agility, and power are essential for basketball players. Therefore, specific physical training, alongside competitive activity, requires superior parameters of coordinative capacity, determining the efficiency of players' technical and tactical skills in the actual game conditions (Bădău, 2006).

The coordination process targets the individual's ability to align intentions with effective actions (Potop et al., 2013). Therefore, improving coordination skills should emphasize the ability to combine and connect movement, spatio-temporal perception, and other specific qualities, which are found in

motor reactions such as opponent perception on the court and spatio-temporal perception for initiating motor actions (Erčulj et al., 2010; Mishyn et al., 2018).

Sadowski et al. (2014) state that the most important components of coordination capacity include kinesthetic differentiation, movement adjustment, reaction time, rhythm, spatio-temporal orientation, coupling of movements, and balance.

The game of basketball requires good intersegmental coordination, intramuscular coordination, and hand-eye coordination.

Intersegmental coordination involves the unified synchronization of the actions of body segments during the execution of a motor movement, being dependent on the complexity of the tasks and the variable conditions of manifestation.

Intramuscular coordination depends on the number of muscle fibers activated in a muscle during a movement. The more muscle fibers react, the better the intramuscular coordination. This is optimally trained through fast and explosive movements.

Hand-eye coordination is crucial in basketball for actions such as dribbling, passing, and shooting. It involves visual synchronization with hand movements, ensuring precision and efficiency in technical executions.

Hand-eye coordination is a complex form of coordination, resulting from the interaction between sensory and motor fields. It is essential for controlling and perfecting gestures. Through the connection between the eyes and hands, the surrounding environment is structured, and spatial orientation is improved.

Actions used in basketball specific to each type of coordination are:

- *intersegmental coordination*: sprints, jumps, changes of direction, accelerations, stops;
- *intramuscular coordination*: catching, passing, shooting, dribbling;
- *hand-eye coordination*: shooting, dribbling, catching, passing, defending.

PART II – PRELIMINARY RESEARCH APPROACH AIMING TO EXPERIMENT WITH COMBINED PROGRAMS OF PLYOMETRIC AND COORDINATION EXERCISES TO IMPROVE THE PHYSICAL AND TECHNICAL CAPACITY OF U12 BASKETBALL PLAYERS

CHAPTER VI – METHODOLOGY OF THE PRELIMINARY RESEARCH

VI.1. Premises of specialized studies on the research topic - preliminary research

The starting point in choosing the topic of the doctoral thesis aimed at preliminary research was the interest in discovering a new method to optimize the physical and technical capacity of basketball players. Numerous studies have demonstrated the beneficial effects of plyometric exercises and coordination exercises on players.

This research aims to combine the two types of exercises to develop a more efficient training method. By designing and implementing a training program that includes both plyometric and coordination exercises, adapted to the age-specific characteristics of the subjects, we aim to achieve significant improvements in the physical and technical capacity of the players.

Shooting is the most important aspect in basketball, and one of the most common types of shots is the jump shot. To execute an efficient jump shot, the player must perform an effective jump under conditions of specific and complex coordination. Therefore, to help players master the technique of the jump shot, we have designed a training program that combines plyometric exercises with coordination exercises.

An innovative aspect of the preliminary research is the application of specifically designed tests for our research to highlight the efficiency and impact of the proposed preliminary experimental training program.

In basketball, the jump shot can be executed from various game situations, such as: shooting preceded by a pass, shooting with a stationary take-off, and shooting preceded by dribbling. For each of these situations, we have designed a test to help evaluate the players' level of preparation (Jump Shot Test Preceded by Pass, Jump Shot Test with Stationary Take-off, Jump Shot Test Preceded by Dribbling). Additionally, the Volleyball Against the Board Test was developed based on the Hand-Eye Coordination Test but adapted to the specifics of basketball and the requirements and needs imposed by the research theme.

Thus, the innovative aspects of the preliminary research include the combined approach of plyometric and coordination exercises within the same basketball-specific training program, as well as the validation of the designed tests to evaluate the proposed training program using informational technologies and smart sensors used for testing:

- OptoJump Next;
- MyVert sensors.

The development of sports performance requires the use of updated methods and means according to modern trends in training approaches, as well as the implementation of innovative training

programs that utilize informational technologies to enhance the skill and efficiency of basketball players. Due to the increased interest in optimizing training and the desire to achieve optimal results in a short time, researchers have studied the effects of plyometric and coordination training on basketball players.

In basketball, the ability to generate a maximum level of force in a very short period (explosive power) is considerez an essential factor for achieving a high level of sports performance (Hedric, 1993).

Plyometric training helps improve jumping, movement speed, the speed of changing directions, balance, and muscle strength, regardless of the age and sex of the subjects (Rodrigo et al., 2020).

Specialists have also focused on developing new training methods to improve coordination. In basketball, the coordination of the upper and lower limbs must be adjusted to meet the specific demands of locomotor tasks (M. van Leeuwen et al., 2019).

Shooting requires excellent intersegmental coordination. The way players control each segment involved in the biomechanics of shooting is an essential aspect for achieving superior performance (Han YC et al., 2006).

Sports performance involves adapting to new programs, methods, and innovative means implemented in the training program. In basketball, physical and technical preparation are two essential components for improving players' skills. When making a shot, the player must jump, coordinate the upper and lower limbs, and fix their target (the basketball hoop). Performing these actions simultaneously requires well-developed muscle strength, explosive power, and coordination for the shot to be successful (Putra et al., 2020).

This research aims to identify an optimal training program that includes both plyometric and coordination exercises, with the goal of improving physical and technical capacity in basketball.

VI.2. Objectives of the preliminary research

O1. Design and implement a preliminary experimental training program that combines plyometric exercises with coordination exercises to achieve a positive impact on players' technical skills.

O2. Validate the testing instruments, utilizing equipment, informational technologies, and smart sensors, designed and applied within the preliminary research.

O3. Achieve higher indices of speed-strength and general coordination as a result of implementing the preliminary experimental program.

O4. Develop intersegmental coordination through the execution of specific exercises under game-like conditions and achieve good efficiency in shots performed in conditions similar to those in basketball games (from various situations).

VI.3. Purpose, tasks, and hypotheses of the preliminary research

VI.3.1. The purpose of the preliminary research is:

- to develop and implement a preliminary experimental program that combines plyometric and coordination exercise systems to achieve higher indices of technical skills and motor performance in U12 junior basketball players;
- to validate the evaluation instruments designed and applied within the preliminary research using informational technologies and equipment.

VI.3.2. Tasks of the preliminary research:

- studying and analyzing the specialized literature in the field;
- establishing research hypotheses;
- defining the objectives and methods of research;
- determining the samples, the location, and the period of conducting the preliminary research;
- developing a preliminary experimental program for sports training that includes plyometric and coordination exercises;
- setting and conducting initial tests;
- implementing the developed training program within the experimental group;
- conducting final tests;
- processing and interpreting the results obtained from the initial and final tests, performing a comparative analysis between them;
- formulating the conclusions of the preliminary research, as well as recommendations and proposals for the final research.

VI.3.3. Hypotheses of the preliminary research

Main hypothesis of the preliminary research

We started with the assumption that by designing and implementing a preliminary experimental training program that combines plyometric exercises with coordination exercises, adapted to the age and training level of the subjects, there will be an improvement in the speed-strength indices and intersegmental coordination under conditions of technicality specific to the game of basketball.

Secondary hypotheses of the preliminary research

H1. By implementing the training program that includes specific plyometric exercises, which represent an efficient means of improving vertical jump performance, the subjects will achieve superior results in terms of vertical jump.

H2. The proposed and applied training program can contribute to the development of intersegmental coordination, leading to a significant increase in player performance.

H3. By combining specific plyometric and coordination exercises, basketball players will achieve superior indices in terms of physical and technical preparation.

VI.4. Stages of the preliminary research

The preliminary research was conducted from October 10, 2022, to December 17, 2022, and was structured as follows:

- october 10, 2022 - October 16, 2022: initial tests were conducted;
- october 17, 2022 - December 11, 2022: the preliminary experimental training program was implemented in the experimental group, consisting of plyometric and coordination exercises. The program lasted two months, during which a total of 16 training sessions were conducted, with two training sessions per week;
- december 12, 2022 - December 17, 2022: final tests were conducted.

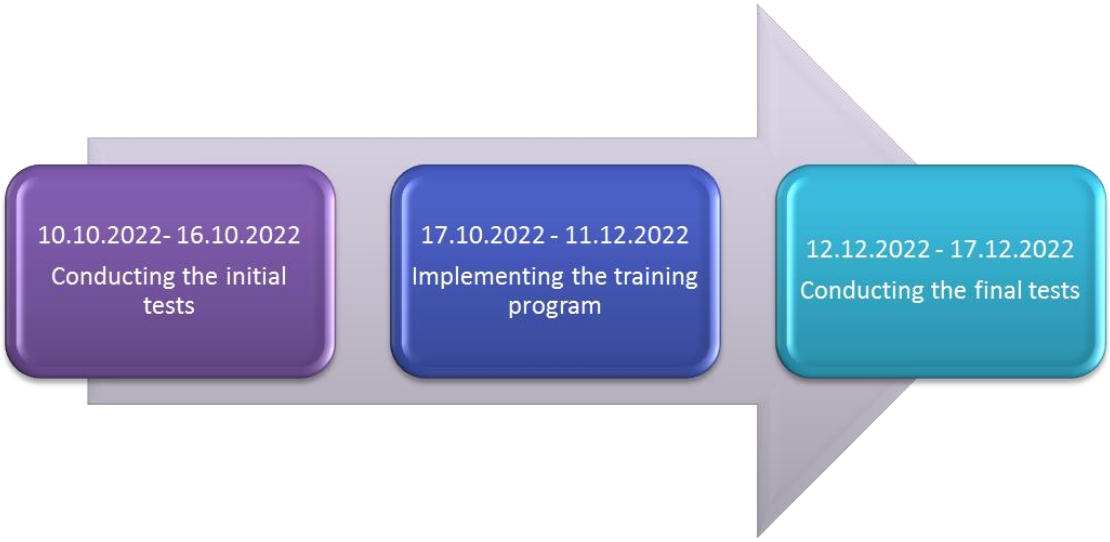

Figure 10. Stages of the preliminary research

VI.6. The sample, location, and organization of the preliminary research

The sample and location of the preliminary research

The research included a total of 19 athletes (Appendix 1), all part of a single group, namely the experimental group. This group consists of athletes from the basketball team of the School Sports Club Sibiu, aged 10 - 12 years (U12). The preliminary research was conducted in the gym of the School Sports Club Sibiu.

Organization of the preliminary research

Over the two months of training, the athletes performed exercises aimed at developing strength under speed conditions and coordination, within two training sessions per week, each lasting 90 minutes. In addition to the two mentioned training sessions, the athletes also carried out 2-3 training

sessions per week according to their coach's schedule. The training program was structured using three types of exercises in each training session:

- coordination exercises, accounting for 20% of the fundamental part of the training;
- plyometric exercises, accounting for 20% of the fundamental part of the training;
- combined plyometric and coordination exercises, accounting for 60% of the fundamental part of the training.

VI.7. Equipment and technologies used in the preliminary research

- OptoJump Next System;
- Vert Device.

VI.8. Measurements and tests conducted in the preliminary research

Measurements conducted in the preliminary research include:

- Height;
- Body weight.

Tests conducted in the preliminary research include:

- Squat Jump Test;
- Drop Jump Test;
- Stiffness Test;
- 15 Seconds Jumps Test;
- 30 Seconds Jumps Test;
- Jump Shot Test preceded by a pass;
- Jump Shot Test from a stationary position;
- Jump Shot Test preceded by dribbling;
- Panel Volley Test.

CHAPTER VIII - CONCLUSIONS OF THE PRELIMINARY RESEARCH

Following the conduct of the preliminary experiment and the processing and interpretation of the obtained results, the main conclusion drawn is that the primary preliminary hypothesis was confirmed. The selection and implementation of a preliminary experimental training program, consisting of plyometric and coordination exercises, adapted to the age and training level of the subjects, led to the improvement of explosive strength and intersegmental coordination indices specific to the game of basketball.

By analyzing the data obtained from the preliminary tests, the secondary hypotheses of the preliminary research were also confirmed: the subjects achieved better results in the final test compared to the initial test in terms of vertical jump performance, as well as in the Squat Jump Test, Drop Jump Test, Stiffness Test, 15 Seconds Jumps Test, and 30 Seconds Jumps Test. The subjects recorded a higher number of successful shots after applying the program, due to the specific exercises for developing overall coordination, in all four coordination tests. Due to the combination of plyometric and coordination exercises, the results indicate that the subjects achieved superior indices in terms of physical and technical preparation.

The training program that utilized the Optojump Next system and MyVert sensors contributed to the improvement of essential jumping parameters in performing basket shots, such as flight time and take-off height, determining the progress of the experimental group in terms of plyometrics. Regarding coordination and the combination of plyometrics and coordination, the program was validated with the help of the testing instruments used.

The results of the preliminary research validate the tests applied in the study, which were designed to be adapted to basketball, the objectives of the study, and the age and training levels of the subjects in the experimental group.

All data obtained from the tests lead us to the conclusion that training activities in basketball can be improved by implementing a training program that combines plyometric and coordination exercises and uses smart technologies and sensors, having a beneficial effect on the physical and technical preparation of the players.

For the final experiment, we will focus on the relevant information extracted from the preliminary study, with the aim of systematically applying combined plyometric and coordination training at the level of athlete preparation. These training sessions can lead to longitudinal research, paving the way for new methods and techniques in basketball player training.

Based on the preliminary results, we have decided to retain all the evaluation tests applied in the preliminary research, except for the 30 Seconds Jumps Test. Additionally, the preliminary experimental training program will be expanded with new specific exercises.

PART III – FINAL RESEARCH REGARDING THE EXPERIMENTATION OF COMBINED PLYOMETRIC AND COORDINATION EXERCISE PROGRAMS TO IMPROVE THE PHYSICAL AND TECHNICAL CAPACITY OF U12 BASKETBALL PLAYERS

CHAPTER IX – ORGANIZATION OF THE FINAL RESEARCH

IX.1. Premises of specialized studies on the research topic - final research

In the context of sports games, basketball is a significant team sport due to its complex physical and technical demands and its easy and attractive mode of organization. The current technical requirements demand integrated training from players, where plyometric and coordination exercises can be implemented separately but especially through their combination in specific training and game conditions. Plyometric and coordination exercises are essential for improving the performance of basketball players, giving them the advantage of executing quick and precise movements on the court.

Plyometric exercises are known for their ability to develop explosive power and overall athletic performance. Studies have shown that plyometric training can significantly improve vertical jumps, sprints, and quick changes of direction, which are crucial in basketball. For example, a study conducted by Villarreal et al. (2009) demonstrated that plyometric training improved jump performance and explosive strength in elite basketball players.

Motor coordination is essential for the efficient execution of complex movements in basketball, such as dribbling, passing, and shooting. Coordination exercises help develop these fine motor skills, thereby improving technical performance. A study by Chaouachi et al. (2009) demonstrated that training programs including coordination exercises can significantly enhance the agility and reaction speed of basketball players.

Integrating plyometric and coordination exercises into a training program can have a synergistic effect on athletic performance. A study by Ramírez-Campillo et al. (2014) evaluated the effects of a combined plyometric and coordination training program on basketball players. The results showed significant improvements in physical and technical performances, such as vertical jumps, change of direction speed, and shooting accuracy.

In basketball, plyometric and coordination exercises are essential for developing a solid physical and technical foundation. These exercises contribute to improving players' performance on the court, providing the competitive edge needed to excel. Studies have shown that basketball players who follow training programs that include these types of exercises exhibit significant improvements in their overall performance, including vertical jumps, speed, and agility (Matavulj et al., 2001; Kotzamanidis, 2006).

The premises of specialized studies suggest that plyometric and coordination exercises are valuable and effective tools for optimizing the physical and technical capabilities of basketball players. Integrating these exercises into a well-structured training program can bring significant benefits, contributing to superior athletic performance and achieving competitive goals.

A distinctive aspect of the research involves the design, adaptation, and application of specially conceived tests to evaluate the effectiveness of our program from the perspective of motor capacity and shooting execution technique. In basketball, jump shooting is essential. To evaluate and improve this technical procedure, we created specific tests for various game situations: the Jump Shot Test preceded by a pass, the Jump Shot Test from a stationary position, and the Jump Shot Test preceded by dribbling. Additionally, the Panel Volley Test was adapted to measure coordination in the specific context of shooting.

In the final research, we highlighted the simultaneous approach of plyometric and coordination exercises within the same training session, providing an innovative perspective on athlete preparation. The development of athletic performance requires adaptation to new training programs and methods, and our research fits this pattern, aiming to achieve a higher level of basketball players' skills.

Thus, through this research, we aim not only to identify but also to implement an optimal training program that efficiently integrates plyometric and coordination exercises using specialized technologies (Optojump System, MyVert Sensors, and SIQ Ball), significantly contributing to the optimization of physical and technical capacity in basketball.

IX.2. Objectives of the final research

O1. Measure and compare the improvement in technical skills and motor capacity of the players in the experimental group after participating in the final experimental training program, compared to a control group that did not follow this program.

O2. Integrate state-of-the-art equipment and technologies to monitor athletes' performance in real-time during plyometric and coordination exercises.

O3. Evaluate and analyze the impact of the final experimental training program on speed strength and overall coordination by applying the proposed tests to the players in the experimental group and comparing the results with the control group.

O4. Evaluate the progress regarding the intersegmental coordination of the groups participating in the study.

O5. Assess the efficiency of jump shots in the evaluation tests and compare the results between the initial and final tests and between the study groups.

IX.3. Purpose, tasks, and hypotheses of the final research

IX.3.1. Purpose of the final research

The purpose of the final research is to design, implement, and evaluate a final experimental program of plyometric, coordination, and combined exercises to improve the parameters of jumping and coordination in shooting specific to the game of basketball for U12 junior female players.

The aim of the final research is to enhance the physical and technical capacities of U12 junior players, focusing on improving their vertical jump, precision, stability, and shooting efficiency through the

implementation of a final experimental training program that combines plyometric and coordination exercises under basketball-specific technical conditions.

The research seeks to provide a comprehensive perspective on the impact of this program on various aspects of training and potential athletic performance, integrating modern technologies for monitoring and adapting to the specifics of U12 junior basketball training.

IX.3.2. Tasks of the final research:

- study the specialized literature to identify current trends and directions in sports training in basketball and the most effective plyometric and coordination exercises specific to the game of basketball;
- develop a comprehensive final experimental training program, integrating plyometric and coordination exercises into a plan adapted to the age and training level of the basketball players included in the final research;
- integrate modern equipment and technologies to monitor and evaluate the real-time performance of players during exercises;
- apply the final experimental training program to the experimental groups;
- collect and process data regarding changes in strength, speed, coordination, and shooting accuracy following participation in the training program;
- conduct a detailed analysis of the obtained data against the specific requirements of the game of basketball to assess the practical relevance of the recorded progress;
- interpret the relevant results and develop practical conclusions and recommendations for specialists and athletes.

IX.3.3. Hypotheses of the final research

Main hypothesis of the final research

We started with the assumption that implementing a final experimental training program that combines plyometric and coordination exercises within the preparation of junior basketball players will lead to significant improvements in muscle strength parameters, agility, precision, coordination, and shooting efficiency, thereby contributing to the enhancement of the physical and technical capabilities specific to the game of basketball.

Secondary hypotheses of the final research

H1. Plyometric exercises will have a significant impact on the players' jumping ability, thereby improving the height and accuracy of their shots.

H2. Coordination exercises will contribute to the development of more precise movements of the upper and lower limbs during shooting, leading to increased stability and efficiency.

H3. Performing plyometric and coordination exercises will positively influence performance in various game situations, such as shots preceded by a pass, shots from a stationary position, and shots preceded by dribbling.

H4. The use of modern technologies in performance monitoring during exercises will provide precise and relevant data for evaluating athletes' progress and continuously adjusting the training program.

IX.4. Stages of the final research

The final research was conducted from May 8, 2023, to November 5, 2023, and was structured as follows:

- may 8, 2023 - May 14, 2023: initial tests were conducted;
- may 15, 2023 - October 29, 2023: the experimental training program was implemented. The program spanned a period of 6 months, during which a total of 48 training sessions were conducted, with 2 specific training sessions per week, each lasting 90 minutes and including plyometric and coordination exercises;
- october 30, 2023 - November 5, 2023: final tests were conducted.

Figure 38. Stages of the final research

IX.6. The sample, location, and organization of the final research

The sample and location of the final research:

The sample consisted of 117 athletes, who were divided into two groups. The experimental group included 60 athletes (51.29%), while the control group included 57 athletes (48.71%). The experimental group was composed of athletes from the School Sports Club in Sibiu, and the control group was composed of athletes from the Gladiu Târgu Mureș Club. All subjects participating in the experiment were aged between 10 and 12 years. The research took place in the gym of the School

Sports Club Sibiu and the Polivalent Hall in Târgu Mureș, both providing an adequate environment for evaluating the athletes' physical and technical abilities.

Organization of the final research:

The study was conducted over a period of 6 months, during which the athletes participated in a specially designed training program for developing strength under speed conditions and coordination. The training program included 2 training sessions per week, each lasting 90 minutes. In addition to these 2 sessions, the athletes carried out 3-4 additional training sessions per week according to their coach's schedule. The training program was structured using three types of exercises in each training session:

- coordination exercises, accounting for 15% of the fundamental part of the training;
- plyometric exercises, accounting for 15% of the fundamental part of the training;
- combined plyometric and coordination exercises, accounting for 70% of the fundamental part of the training.

IX.7. Equipment and technologies used in the final research

- OptoJump Next System;
- Vert Device;
- SIQ Ball.

IX.8. Measurements and tests conducted in the final research

Measurements conducted in the final research include:

- Height;
- Body weight.

Tests conducted in the final research include:

- Squat Jump Test;
- Drop Jump Test;
- Stiffness Test;
- 15 Seconds Jumps Test;
- Jump Shot Test preceded by a pass;
- Jump Shot Test from a stationary position;
- Jump Shot Test preceded by dribbling;
- Panel Volley Test.

X.3. Conclusions and recommendations of the final research

Following the conduct of the research and the rigorous analysis of the data obtained through the tests performed, the experiment results confirmed the main hypothesis, highlighting that the implementation of a well-structured training program that combines plyometric and coordination exercises significantly contributes to the improvement of muscle strength, agility, precision, and coordination of basketball players. This holistic approach to athlete preparation led to the optimization of their physical and technical capacities, essential for performance in basketball.

The detailed analysis of the effects of plyometric exercises, according to secondary hypothesis H1, revealed a significant improvement in the athletes' ability to perform jumps, which was reflected in greater height and accuracy of basketball shots. Additionally, secondary hypothesis H2 was confirmed, with observations of more precise movements of the upper and lower limbs during shots, leading to increased stability and effectiveness. These improvements were highlighted by the progress recorded in the applied tests, indicating an efficient synergy between plyometrics and coordination exercises.

The secondary hypothesis H3 was also validated by the results, which demonstrate that the combined training had a positive impact on performance in various game situations, improving the effectiveness of shots preceded by a pass, from a stationary position, and preceded by dribbling. This improved adaptability to the dynamic and variable conditions of the basketball game underscores the relevance of the training program for developing sport-specific skills.

Additionally, secondary hypothesis H4 was confirmed through the use of modern monitoring technologies, which provided valuable data for evaluating athletes' progress. These technologies enabled precise and detailed performance analysis, facilitating adjustments tailored to the individual needs of each athlete, thereby contributing to the effectiveness of the training program.

The research highlighted that the selection and implementation of a training program composed of plyometric and coordination exercises, tailored to the athletes' specificities, led to notable improvements in explosive strength and coordination indices, demonstrating a positive influence on the physical and technical preparation of basketball players. These findings validate not only the main hypothesis of the study but also the secondary hypotheses, providing a solid foundation for developing effective training programs aimed at maximizing athletic potential in basketball.

The experimental group, which benefited from targeted training programs adapted to the specific needs of basketball, showed notable progress compared to the control group, which did not receive the same specific orientation. These improvements were consistently highlighted by the increase in average performance, reduction in variation between subjects' results, and, in some cases, changes in the statistical distribution of results, indicating improved performance and increased consistency.

The results of the experimental group demonstrated significant increases in the tested parameters, reflecting the effectiveness of personalized training and the rigorous structuring of the training program. In contrast, the control group showed limited and inconsistent progress, highlighting the importance of specific and adapted training in the optimal development of athletic skills. These findings confirm the value of the well-planned and executed implemented program, resulting in quantifiable and significant improvements in sports performance.

Statistically, the significant differences between the experimental group and the control group were supported by t-test values and narrow confidence intervals, confirming the improvements recorded by the experimental group. The large effect sizes observed in the experimental group, compared to the small ones in the control group, underscore the positive impact of specialized training on sports performance.

These findings highlight the importance of well-planned and executed training that focuses on the specific development of skills required in the respective sporting context. By applying adapted training methods and focusing on improving key aspects of performance, athletes can achieve higher levels of performance and maximize the effectiveness of their training time.

Thus, well-structured interventions, based on the specific needs of athletes and the sport practiced, have demonstrated superior efficiency in developing the essential skills for competitive success. Implementing scientifically oriented and validated training programs significantly contributes to optimizing sports performance and achieving individual and team objectives.

In conclusion, the results of the analysis confirm the hypothesis that plyometric and coordination training are essential for improving sports performance. These findings emphasize the need for a scientific approach in designing and implementing training programs to ensure optimal athlete development and maximize their potential in sports competitions.

Furthermore, integrating scientifically validated training methods tailored to the specifics of each sport contributes to significant progress in key performance parameters. A rigorous and well-structured training approach is crucial for optimizing physical and technical skills, ensuring athletes not only short-term improvements but also the sustainability of performance in the long term.

CHAPTER XI. ORIGINAL CONTRIBUTIONS, RECOMMENDATIONS, FUTURE RESEARCH DIRECTIONS, LIMITATIONS, AND DISSEMINATION OF RESULTS

XI.1. Original contributions specific to the thesis

This thesis makes significant and innovative contributions to the field of sports science and physical education, particularly in the context of using plyometric and coordination training to enhance sports performance. The novelty of this research is highlighted by the following essential aspects:

- rigorous methodology: an important point of the study is the use of a rigorous and well-defined methodology, including the controlled design of the experiment and the use of advanced technologies for objective measurement of sports performance. This ensures a high degree of reliability and validity of the results;
- innovation in training: the study introduces an innovative training approach, integrating plyometric and coordination exercises that have proven effective in improving sports performance. This provides valuable insights for coaches and physical trainers in optimizing training programs;
- integration of plyometric and coordination methods: one of the innovative aspects of this thesis is the integration of plyometric and coordination methods into a coherent and well-structured training program. Unlike most existing studies that focus either on plyometric training or coordination training, this thesis proposes a holistic approach that combines both methods to maximize the physical and technical benefits for basketball players;
- design and implementation of the experimental program: the program uses modern technologies and equipment, comprising 22 coordination exercises, 29 plyometric exercises, and 15 combined plyometric-coordination exercises, logically structured in terms of dosing, working formations, and equipment used.;
- plyometric exercises: these exercises are essential for developing explosive power and include multiple and varied jumps. Plyometric training is designed to improve the muscles' ability to generate force quickly, a crucial aspect of sports performance;
- coordination exercises: coordination exercises focus on improving movement synchronization, balance, and motor control. These include agility ladder drills, complex dribbling exercises, and ball exercises, which help develop basketball-specific technical skills;
- combination of exercises: combining these methods into an integrated program offers additional benefits compared to using them separately. For example, improving coordination can amplify the effects of plyometric training, as athletes can apply explosive force more effectively in a controlled and synchronized manner. This synergy results in significant improvements in sports performance, as demonstrated by the experiment results;
- design and validation of specific tests: specific evaluation tests were developed to assess jumping parameters, shooting accuracy, and coordination, performed under technical conditions specific to the game of basketball and adapted to the age and training level of the athletes (U12);

- use of modern technologies for monitoring and evaluation: another innovative aspect of this thesis is the use of advanced technologies for monitoring and evaluating athletes' performance. Modern technologies allow for a detailed and objective analysis of progress, providing precise data that supports the efficiency of the proposed training program. Benefits of Using Modern Technologies (Optojump, Vert Sensors, SIQ Ball): The accuracy of the data provided by these technologies enables detailed monitoring of progress, rapid identification of any issues, and immediate adjustment of the training program. This ensures maximum training efficiency and contributes to injury prevention by adjusting the training load to the individual capacities of the athletes;
- contribution to specialized literature: the study makes a significant contribution to the existing literature, providing new evidence on the effectiveness of combining different types of exercises in sports training. This can serve as a foundation for future research and the development of training practices;
- final experimental program: This can serve as a best practice guide for basketball experts and athletes. The design and description of the exercises are easy to understand, detailing the arrangement and actions of the performers;
- structured weekly/monthly training program: the program includes details regarding exercise codes, dosing, working formations, and the materials and equipment used. It can be easily applied and adapted to the requirements of each group of athletes and according to the objectives of the coaches.

These novel aspects highlight the value and originality of the thesis, demonstrating the importance of an interdisciplinary and personalized approach in sports training. The proposed research offers new and valuable perspectives for optimizing sports performance, significantly contributing to the theoretical and practical development in the field of sports science and physical education.

XI.2. Recommendations and directions for future research

Based on the results obtained and the conclusions formulated in this thesis, the following recommendations and research directions for future studies can be made:

- extending the research to other age categories and training levels: it is recommended to develop similar studies that include athletes from other age categories and training levels to evaluate the effectiveness of plyometric and coordination programs in various contexts. This will help determine if the proposed approaches are universal or if specific adaptations are needed;
- developing studies on boys for gender comparisons: since all subjects in this study were girls, it is important to develop similar studies on male athletes. This will allow for comparative gender analyses to identify any differences in response to plyometric and coordination training;
- analyzing the impact of the experimental program in competitive game conditions: to truly evaluate the effectiveness of the proposed training program, it is necessary to study its

impact in real competitive game conditions. This will help determine if the improvements observed in controlled training conditions translate into superior performance during competitions;

- including other variables of interest in future research: it would be useful to include other variables of interest in future studies, such as psychological, nutritional, or recovery parameters. These can provide a more comprehensive picture of the factors influencing sports performance and lead to the development of even more effective training programs;
- long-term evaluation of training effects: it is important to conduct longitudinal studies to evaluate the long-term effects of plyometric and coordination training. This will help determine the sustainability of the improvements achieved and identify any necessary adaptations throughout the athletes' sports careers.

These research directions will contribute to consolidating existing knowledge and developing more scientifically grounded training practices, with the potential to optimize the performance of athletes across various disciplines and age categories.

XI.3. Limitations of the final experiment

- sample size: one of the main limitations of the study is the relatively small sample size, which, although sufficient to highlight significant trends, may limit the generalization of the results. Larger samples could provide a more comprehensive picture of the impact of training on broader groups of athletes;
- exclusion of other training categories: the study did not include other training categories such as U14 or U16;
- exclusion of U12 boys groups: the study did not include U12 boys groups for comparative gender analysis;
- limited duration of the training program: another limitation is the limited duration of the training program. Although the observed improvements in sports performance are encouraging, longer studies could offer deeper insights into the sustainability of the improvements over the long term;
- post-experiment monitoring: the impact of the final experimental program was not monitored and analyzed at various time intervals post-study;
- influence of unassessed external factors: although the study attempted to control for external variables, there is always the possibility that unassessed external factors (e.g., diet, stress, quality of sleep) could influence the athletes' performance. This can affect the clarity with which improvements can be attributed exclusively to the training program;
- lack of competitive performance evaluation: the study did not include an evaluation of the experimental group's performance under competitive conditions as a result of implementing the final experimental program using information technologies, equipment, and smart sensors;

- focus on basketball performance: the study focused on improving performance in basketball, which may limit the direct applicability of the results to other sports disciplines. Different sports may require different training approaches to optimize performance.

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