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STUDY ON IMPROVING COORDINATION SKILLS IN WOMEN'S BASKETBALL GAME

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Abstract. *The purpose of this research is to highlight the effectiveness of the proposed motor programme for the improvement of coordination skills in female basketball players aged 13-15 years. The implementation of a motor programme focused on the development of coordination skills leads to their improvement and could have a significant impact on future results/performance. The participants in this study were 68 female basketball players who were divided into two groups, an experimental group (n = 36) and a control group (n = 32). The following tests were applied to assess the development level of their coordination skills: Tapping test, Rope jumping test, Alternate hand wall toss test, Square test and Kinaesthetic test. Both groups were assessed at the beginning of the competition season and at the end of the 6 months of specific motor programme. The programme proposed and applied to the experimental group consisted of: slalom circuits, elastic rope jumping, static and dynamic balance exercises, eye-hand, hand-foot and eye-foot coordination exercises, throwing and catching objects and rhythm-building exercises. The following research methods were used: literature review, experiment method, test method, mathematical and statistical method, graphical method. The results of the study showed that the experimental group recorded improved values in the final test compared to the results obtained by the control group. In conclusion, the proposed motor programme has proven its effectiveness as regards the improvement of coordination skills in female basketball players aged 13-15 years.*

Keywords: *basketball, coordination skills, training, tests.*

Introduction

In recent years, the game of basketball has developed significantly at world level, which has led to the improvement of sports performance. The permanent adaptation of training methods, the use of high-tech auxiliary equipment (FITLIGHT motion sensor, balance plate, dribbling glasses, training ladder, LED cable, etc.) and the implementation of technology in sport are factors that have contributed to achieving outstanding performance, which was hard to imagine a few years ago.

It has lately been found that specialists in the field are extensively concerned with standardising the sports training process and implicitly developing original tests to identify solutions in this regard, but also with modifying the competitive system to ensure increased efficiency in the game of basketball (Oancea & Bondoc-Ionescu, 2015).

One of the basic characteristics of basketball, namely the rapid alternation between offensive and defensive situations, allows players to display their technique but also fantasy and creativity, passion to compete, acrobatic shots, desire for affirmation and recognition (Krause & Nelson, 2018). Most basketball players have an impressive technical background, 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, along with competitive activity, involves a high level of coordination skills, which leads to the efficient adaptation of players' technical and tactical skills to the concrete game conditions (Bădău, 2006).

Dragnea and Mate-Teodorescu (2002) define coordination skills as a complex of predominantly psychomotor qualities that require the ability to quickly learn new movements as well as rapid and efficient adaptation to various conditions specific to different types of activities by restructuring the existing motor background. According to Tudor (1999), coordination ability is a psychomotor quality that relies on the correlation between the central nervous system and skeletal muscles during the execution of a movement.

Regarding the definition of coordination skills, several opinions have been expressed but, regardless of formulations, specialists in the field highlight that this psychomotor component is determined by the quality of the central nervous system. The coordination process refers to the individual's ability to match what is intended to be achieved with what is actually achieved (Potop et al., 2013). Therefore, the improvement of coordination skills should place emphasis on the ability to combine and connect movement, spatiotemporal perception and other specific qualities that are found in specific motor reactions such as perception of the opponent on the field, perception of distance or perception of the moment when the motor action begins (Erculj et al., 2010; Mishyn et al., 2018).

Sadowski et al. (2014) state that the most important components of coordination ability include kinaesthetic differentiation, movement adjustment, reaction time, rhythm, spatiotemporal orientation, movement coupling and balance.

Candra (2019) emphasises that one of the components of coordination ability that is often encountered in the game of basketball is related to eye-hand coordination; thus, the eye as a visual organ provides information, while the hand performs the task. In order to solve game tasks such as dribbling, shooting or passing the ball, cooperation is needed "in the nervous system of the hands and eyes" (Candra, 2019, p. 864).

Coordination skills are known to significantly influence the level of sports performance, but more specifically, one can say that their individual level of development directly influences the player's technical background. Therefore, the main method of developing coordination skills is to practice, provided that exercises with progressively increased complexity are used (Bompa & Buzzichelli, 2002). When using a proper combination of coordination, intermediate and conditional skills, sports performance is optimal (Boccolini et al., 2013; Sevreza & Bourdin, 2015).

Conditional skills (such as speed, endurance and power) are based on the metabolic efficiency of body systems and muscles, while coordination skills are based on the ability to receive and process the information received through optical, acoustic, vestibular, tactile and kinaesthetic analysers, which are involved in both movement and the development of motor skills. Instead, intermediate skills (such as suppleness) have limited effects on movement regulation.

Taking into account the aforementioned aspects, we aimed to determine in our research the connection between basketball-specific technical and tactical elements and coordination skills, which is highlighted in Table 1.

Table 1. *Coordination skills specific to the technical elements and practices used in the game of basketball (personal contribution)*

No.	Training content	Highlighted coordination skills
1	Holding, catching, passing	kinaesthetic differentiation, spatiotemporal orientation, balance
2	Dribbling	kinaesthetic differentiation, rhythm, motor reaction, movement transformation
3	Stopping	balance, spatiotemporal orientation, motor reaction, movement transformation
4	Pivoting	motor reaction, rhythm, balance, spatiotemporal orientation
5	Shooting	motor reaction, balance, spatiotemporal orientation
6	Travelling	motor reaction, movement transformation, balance, spatiotemporal orientation
7	Blocking	motor reaction, balance, spatiotemporal orientation, kinaesthetic differentiation, movement transformation

Purpose

This study aims to verify whether the implementation of a specific motor programme has positive effects on the development level of coordination skills in the game of basketball.

Objectives

- Designing a specific motor programme for the improvement of coordination skills in female basketball players aged 13-15 years;
- Determining the initial and final development levels of coordination skills in athletes from both groups (experiment and control).

Tasks

- selection of research groups;
- selection of tests/assessments;
- initial testing of research groups;
- development and implementation of the intervention programme;
- final testing of research groups;
- processing, analysis and interpretation of recorded data;
- drawing final conclusions.

Hypothesis

The implementation of a motor programme focused on the development of coordination skills has a significant impact on performance in the case of tests assessing these motor skills.

Methodology

Participants

The participants in this study were 68 female basketball players aged 13-15 years, who were divided into two groups, an experimental group (n = 36) and a control group (n = 32).

The experimental group is made up of athletes from three basketball teams, and the control group consists of athletes from two basketball teams. The average age of the experimental group is 14.5 years, and the standard deviation is .94. For the control group, the average age is 14.6 years, and the standard deviation is .87. It should be mentioned that the athletes included in this research have been practising the game of basketball for a minimum of 3 years and a maximum of 5 years.

Instruments

In assessing the development level of coordination skills, the interrelation between tests and the components of coordination skills was taken into account, which is highlighted in Table 2 and Figure 1.

Table 2. *Interrelation between tests and the components of motor skills (personal contribution)*

No.	Assessment	Name of the test	Components of the targeted coordination skills
1.	Coordination skills	Tapping test	• quick reaction ability
2.		Rope jumping test	• ability to combine movements (arms-feet)
3.		Alternate hand wall toss test	• ability to combine movements (eye-hand)
4.		Square test	• spatiotemporal orientation ability
5.		Kinaesthetic test	• kinaesthetic differentiation ability

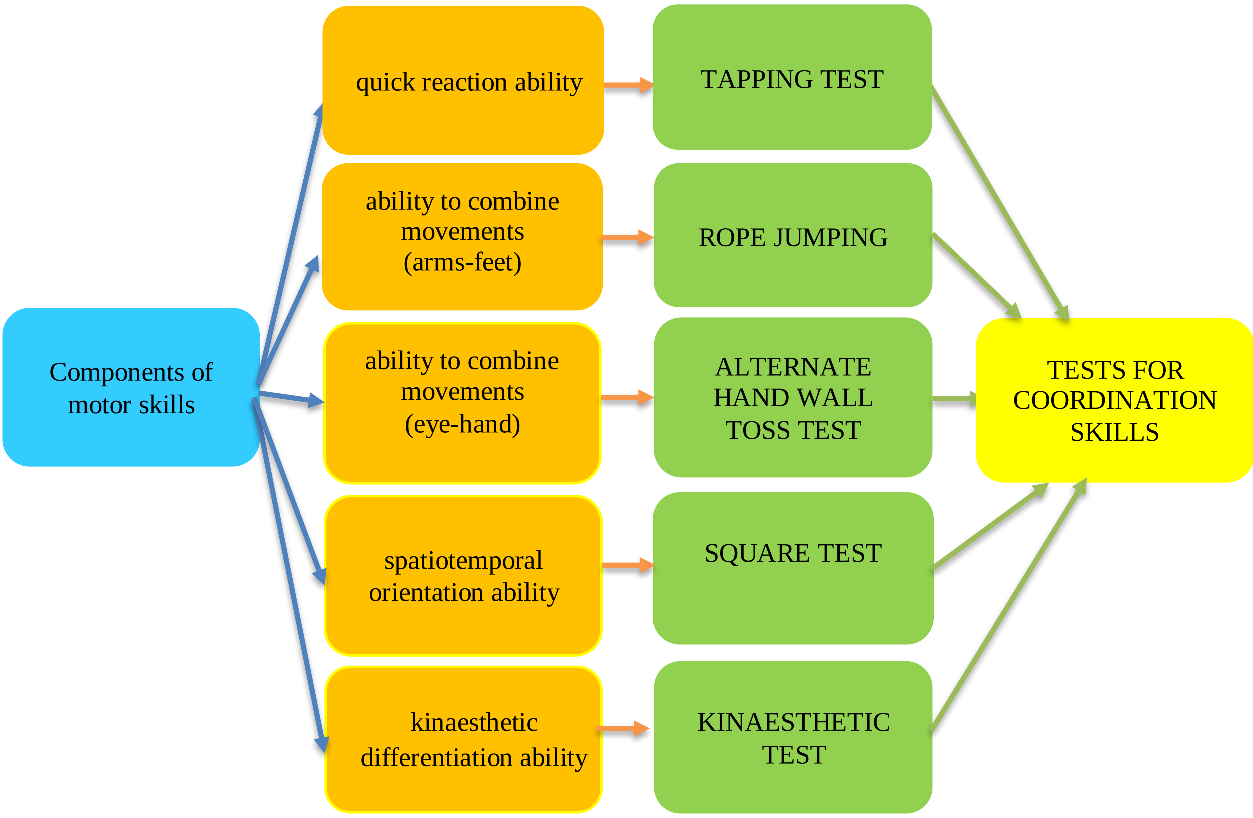

Figure 1. Graphical representation of the interrelation between tests and the components of motor skills (personal contribution)

To determine the level of coordination skills of the research participants and to collect data about the progress of the experiment group upon completion of the proposed specific motor programme, the following tests were used:

- *Tapping test*

The main purpose of this test is to assess the speed and coordination of the upper limbs. This test is part of the Eurofit Test Battery. To perform the measurement using this test, the following equipment is needed: a table, two yellow discs of 20 cm in diameter, a rectangle of 30 x 20 cm, measuring tape, stopwatch. The test requires the participant to stand in front of the table with feet apart at shoulder width, their non-dominant hand resting in the middle of the rectangle and their dominant hand touching the yellow disc on the same side. The two yellow discs are placed with their centres at a distance of 60 cm. At the "go" command, the participant must keep both feet on the ground and move their dominant hand on either side of the rectangle to touch the yellow discs as quickly as possible. The timer is stopped when the participant has completed 25 full cycles (50 touches). The test is performed only once.

- *Rope jumping test*

The main purpose of this test is to assess the ability to combine arm-foot movements. The following equipment is required to perform the measurement by means of this test: rope, stopwatch. The test consists in performing normal straight jumps with the rope from both feet to both feet for 60 seconds. The test is performed only once.

- *Alternate hand wall toss test*

The main purpose of this test is to assess the ability to combine eye-hand movements. The following equipment is required to perform the measurement with the help of this test: tennis balls or baseballs, a solid wall, marking tape, stopwatch. The test involves placing a mark at a certain distance from the wall (for example, 2 meters). The participant stands behind the line facing the wall. The ball is thrown with one hand in an underarm action against the wall and an attempt is made to catch it with the opposite hand. The ball is then thrown back against the wall and caught with the initial hand. The test can be performed for a set number of attempts or a set period of time (for example, 30 seconds, as in the present study). The number of catches is recorded. Through the constraint of a set period of time, the factor of working under pressure is also added. The test is performed only once.

- *Square test*

The main purpose of this test is to assess spatial orientation ability. The following equipment is required to perform the measurement by means of this test: meter, chalk, stopwatch. The test involves drawing on the ground a square of side 90 cm, which is divided into 9 squares of 30 cm. On the opposite sides, two more squares of the same size are drawn. From the square "0", the participant must perform jumps on both feet in ascending order, in the shortest possible time and without stepping on the dividing lines. The execution time is recorded and the number of errors is counted. For each error, 0.5 seconds are added to the final time.

- *Kinaesthetic test*

The main purpose of this test is to assess the kinaesthetic differentiation ability. Size 5 and size 7 basketballs are required to perform the measurement using this test. The test consists of free throws with balls of different sizes (in women's basketball, the official ball is size 6).

Participants must perform 10 free throws by alternately using size 5 balls (500 g) and size 7 balls (620 g). The final result is given by the number of points scored in the 10 attempts.

Procedure

The research was conducted during the 2018-2019 competition season. In this period, athletes performed five workouts per week, and each workout lasted between 60 and 90 minutes. The proposed specific motor programme was applied to the experimental group and took 15-20 minutes of the total training time, while the control group performed training sessions in the classic manner of the coach. The specific motor programme was implemented over a period of 6 months. The content of the specific motor programme was based on action systems leading to the development of coordination skills, to which auxiliary equipment (FITLIGHT motion sensor, balance plate, dribbling glasses, LED cable, ball accessory - square up, ball accessory - gloves, ball accessory - plastic bag, extender ball, coordination ladder) was added in order to achieve the desired results.

Thus, the specific motor programme applied to the female athletes in the experimental group included different types of exercises that were largely dependent on the following components of coordination skills: ambidexterity, laterality, hand coordination and ball passing accuracy, general segmental body coordination, spatiotemporal perceptions, body coordination in performing various types of jumps, static and dynamic balance. Some types of exercises used in the intervention programme were: eye-hand, arm-foot and eye-foot coordination exercises, TE-TA circuits, throwing and catching objects, balance exercises, different types of jumps and changes of direction, but also reaction and rhythm exercises. The application of coordination exercises respected the didactic principles, especially the principle of accessibility that relies on three classic rules of the teaching practice, namely the transition from easy to difficult, from simple to complex, from known to unknown.

Some concrete examples of exercises used to develop coordination skills are presented below:

- eye-hand coordination: the athlete stands with both feet on the balance plate at a distance of half an arm’s length away from the wall where the motion sensors are positioned. The athlete must deactivate the motion sensor by hand (using the hand that is closest to the sensor); 3 x 30 sec/series, break: 10-15 sec;
- arm-foot coordination: the athlete stands an arm’s length away from the wall. The motion sensors are placed on the ground, between the wall and the athlete. The athlete throws the tennis ball against the wall with one hand and catches it with the other hand while touching the light sensor with their foot; 2-3 x, 30 sec/series, break: 10-15 sec;
- eye-foot coordination: five cones are placed in a circle. A motion sensor is attached to each cone. The athlete stands in the middle of the circle and must jump from both feet to both feet over the cone whose sensor lights up; 3 x 30 sec/series, break: 10-15 sec;
- TE-TA circuit: the exercise begins when the FITLIGHT sensor positioned at the start lights up. From the baseline, the athlete performs footwork at the training ladder while facing the direction of movement with an inward trend simultaneously with ball passing around the trunk (to the right) – one-count stopping – two-hand chest passing to the teammate who is in

centre field – sprinting to the basket – regaining – running shooting – recovering – dribbling to the second ladder – footwork facing the direction of movement with an inward trend concurrently with ball passing around the trunk (to the left) – two-count stopping – two-hand chest passing to the teammate who is in centre field – sprinting to the basket – regaining – jumping shooting (from the base of the three-second area, at an angle of 45 degrees). When the sensor placed near the training ladder lights up, the athlete must perform a squat;

- throwing and catching objects: the athlete stands with both feet on the balance plate at a distance of half an arm's length away from the wall where the motion sensors are positioned. The athlete throws the tennis ball against the wall with one hand and catches it with the same hand while touching the light sensor with the opposite hand; 4 x 30 sec/series, break: 10-15 sec;
- balance exercise: the athlete sits on the balance plate with both feet in the air. On either side of the athlete, at a distance of half an arm's length, a motion sensor is placed. The athlete must touch the sensor with the hand on that side; 3 x 30 sec/series, break: 10-15 sec;
- jumping exercise: standing with legs apart and hands behind the head in front of a row of 5-6 crates placed at equal intervals of 2-3 m: multiple jumps on both feet over the crates of the same height (30 cm); 3 x, break: 30 sec;
- reaction exercise: two balls of different colours are placed 4 m away from each other. The athlete is midway between the balls, and a sensor that lights up in different colours is placed 2 m in front of the participant. For each colour, the athlete has a different task to perform: RED = do a push-up; GREEN = move with added step to the right; YELLOW = touch the sensor; WHITE = move with added step to the left; 3 x 30 sec/series, break: 10-15 sec.

For both groups (experiment and control), the study included an initial test at the beginning of the competitive year and a final test upon completion of the proposed motor programme. To assess the development level of coordination skills, the following five tests were used: Tapping test, Rope jumping test, Alternate hand wall toss test, Square test and Kinaesthetic test.

The initial and final tests provided information on the performance of the research participants (experimental group and control group). This allowed noticing the progress of the experimental group after the implementation of the motor programme focused on improving coordination skills.

Results

The data were statistically processed with IBM SPSS software, version 23. The statistical analysis involved calculating the indicators of central tendency and mean differences between the experimental and control groups in pre-test and post-test. The effect size was also calculated using the Cohen's d coefficient. (Table 3 and Table 4)

Table 3. *Descriptive statistics and mean differences between the initial and final tests for the coordination skills of the experimental group*

Tests for coordination skills	Initial test				Final test				Mean difference	$t_{(35)}$
	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*		
Tapping test	17.50	21.20	**19.37**	1.12	13.50	18.40	**15.56**	1.56	3.08	15.73***
Rope jumping test	108.00	144.00	**125.50**	10.67	145.00	164.00	**153.66**	6.12	-28.16	-12.26***
Wall toss test	17.00	23.00	**19.58**	1.88	27.00	35.00	**31.08**	2.60	-11.50	-17.81***
Square test	6.70	10.20	**8.74**	1.08	4.02	6.40	**4.70**	.65	-4.04	16.75***
Kinaesthetic test	2.00	5.00	**3.33**	.98	7.00	9.00	**7.58**	.66	-4.25	-13.95***

Experimental group: N = 36; M = mean; SD = standard deviation
*** $p \le .01$, ** $p \le .05$

Table 4. *Statistical analysis of the differences between the experimental and control groups in the tests for coordination skills – Final testing*

Tests for coordination skills	Experimental group		Control group		Mean difference	t (67)	Cohen's d (effect size)
	M	*SD*	*M*	*SD*			
Tapping test – T2	15.56	1.56	18.85	.69	**-3.28**	**-6.62*****	**2.02**
Rope jumping test – T2	153.66	6.12	125.83	13.74	**27.83**	**6.40*****	**2.01**
Wall toss test – T2	31.08	2.60	19.58	1.67	**11.50**	**12.84*****	**4.42**
Square test – T2	4.70	.65	9.02	1.02	**-4.32**	**-12.36*****	**5.05**
Kinaesthetic test – T2	7.58	.66	3.83	.93	**3.75**	**11.28*****	**4.65**

Experimental group: N = 36, Control group: N = 32; T2 = final test; M = mean; SD = standard deviation
*** $p \le .01$, ** $p \le .05$

In the first test for the assessment of coordination skills, Tapping test, female players in the experimental group obtained an average of 15.56 executions compared to female players in the control group, whose average was lower by approximately 3 executions (Figure 2). The differences are statistically significant.

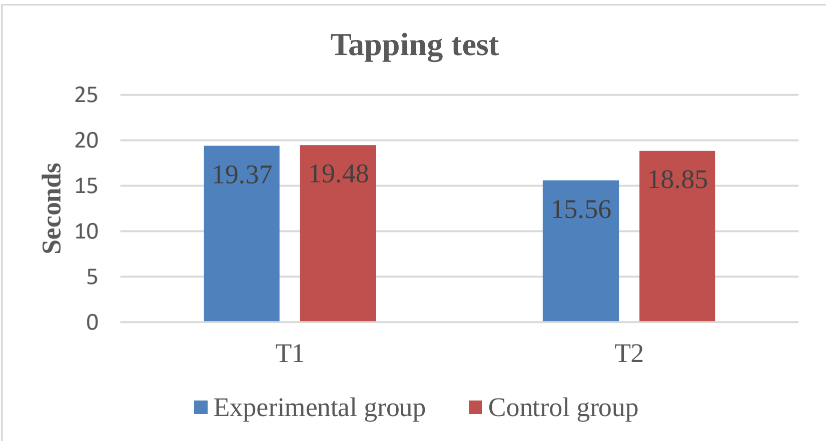

Figure 2. Differences between the experimental group and the control group in the Tapping test (T1 = initial test, T2 = final test)

In the second test for the assessment of coordination skills, Rope jumping test, female players in the experimental group obtained an average of 153.66 executions compared to female players in the control group, whose average was lower by approximately 27 executions (Figure 3). The differences are statistically significant.

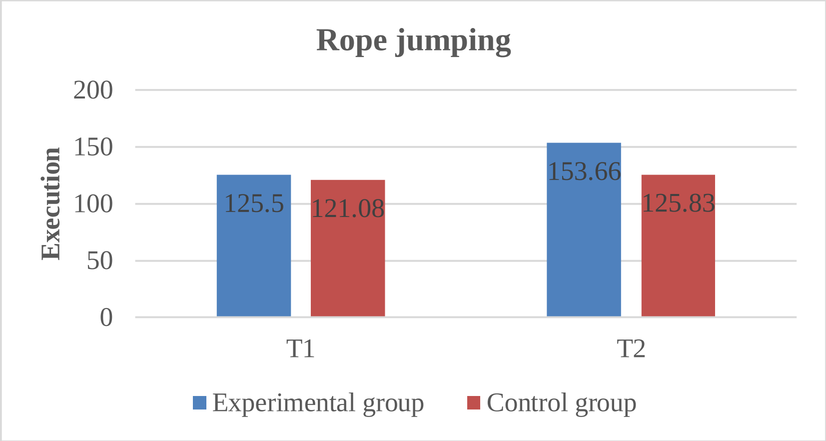

Figure 3. Differences between the experimental group and the control group in the Rope jumping test (T1 = initial test, T2 = final test)

In the third test for the assessment of coordination skills, Alternate hand wall toss test, female players in the experimental group obtained an average of 31.08 executions compared to female players in the control group, whose average was lower by approximately 11 executions (Figure 4). The differences are statistically significant.

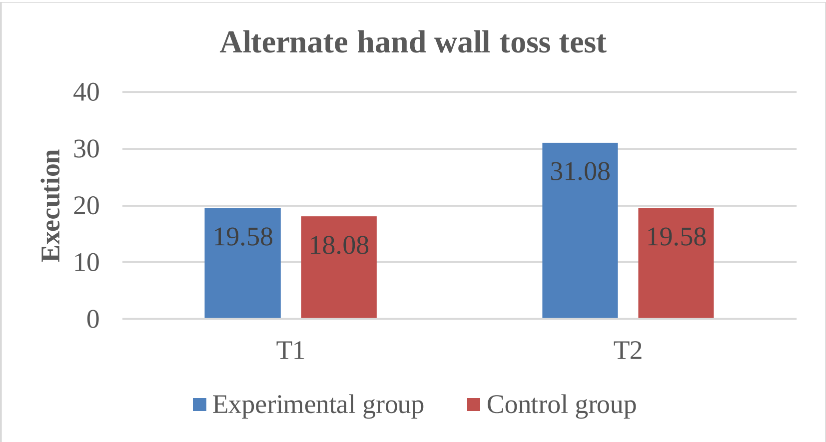

Figure 4. Differences between the experimental group and the control group in the Alternate hand wall toss test (T1 = initial test, T2 = final test)

In the fourth test for the assessment of coordination skills, Square test, female players in the experimental group obtained an average of 4.7 seconds compared to female players in the control group, whose average was lower by approximately 4 seconds (Figure 5). The differences are statistically significant.

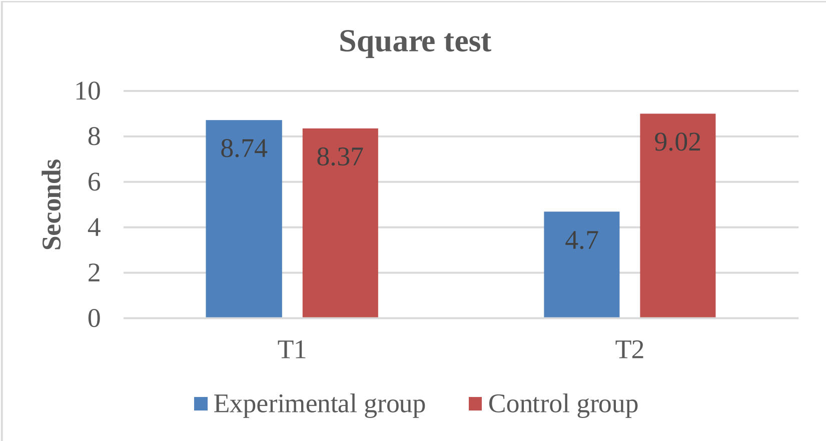

Figure 5. Differences between the experimental group and the control group in the Square test (T1 = initial test, T2 = final test)

In the last test for the assessment of coordination skills, Kinesthetic test, female players in the experimental group obtained an average of 7.58 executions compared to female players in the control group, whose average was lower by approximately 3 executions (Figure 6). The differences are statistically significant.

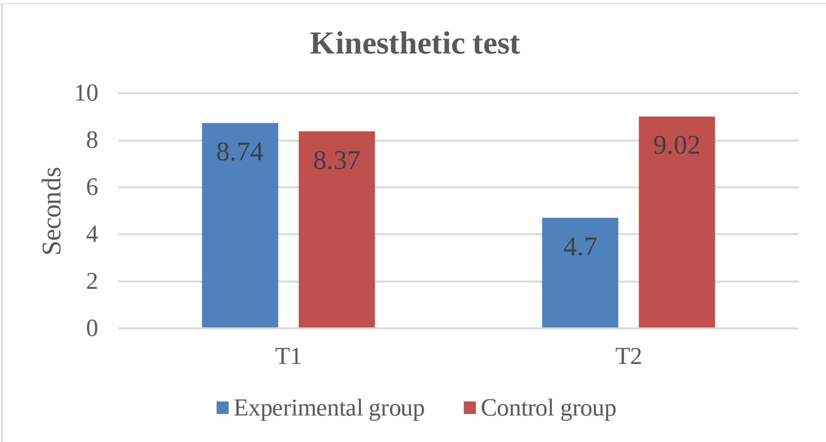

Figure 6. Differences between the experimental group and the control group in the Kinesthetic test (T1 = initial test, T2 = final test)

As can be seen in Figure 7, the largest difference is found in the Kinesthetic test. Following the participation in the intervention programme, an average improvement of 127.62% was obtained in terms of performance. The smallest difference is found in the Tapping test where the percentage difference between the initial test and the final test is 19.66%. Therefore, it can be said that the proposed intervention programme leads to an improvement in performance of about 20% for this test.

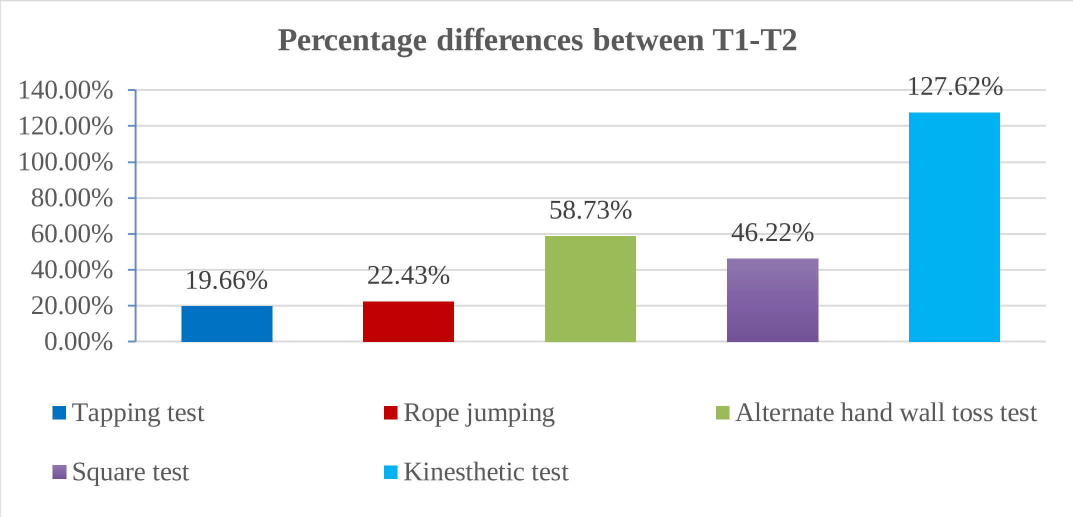

Figure 7. Performance improvement in the tests for the assessment of coordination skills following the intervention programme – Experimental group

We also calculated an absolute average value of the percentage increase in the experimental team's performance for all tests assessing coordination skills and we obtained the value 54.93%. This value indicates that the implemented intervention programme has improved by 54.93% the average performance of the experimental team in the tests for the assessment of coordination skills, which confirms the research hypothesis.

Discussion

The present study aimed to test the effectiveness of a specific motor training programme for the improvement of coordination skills in female basketball players aged 13-15 years. We chose this age group to test the effectiveness of the proposed programme because it is the appropriate period for the acquisition of skills necessary to build the technical background of a basketball player. According to several authors, dribbling is the most important technical skill that should be highlighted in the game of basketball. Through dribbling, peripheral vision, the "sense of the ball" and the perception of distance from the opponent are developed, all of them combined with the intellectual abilities of a basketball player (Boychuk, 2015; Demcenco, 2017).

The results of this study show that coordination skills can be significantly improved during a 6-month period through a systematic training programme that includes eye-hand, arm-foot and eye-foot coordination exercises, various TE-TA and slalom circuits, throwing and catching objects, static and dynamic balance exercises, different types of jumps and changes of direction but also reaction and rhythm exercises. The improvement of coordination skills was significant for all the components measured through the tests applied: speed and coordination of the upper limbs, body coordination, eye-hand coordination, spatial orientation, kinaesthetic differentiation ability. Of these components, the easiest to train through the proposed programme was the kinaesthetic differentiation ability.

The relevance of these results is supported by many authors. Thus, Boichuk et al. (2018) consider that special attention should be paid to sport-specific skills because the technical training of basketball players depends on the development level of these coordination skills. Boichuk et al. (2017) claim that technical and tactical skills do not depend on a single coordination ability but on a combination of all the components of coordination ability. The research conducted by Kozina et al. (2018) highlights that the high level of development of coordination skills is decisive for improving the technique of the game and leads to its qualitative increase. At the same time, it enables the athlete to quickly adapt to changes during match play and make the best technical and tactical decisions.

Coordination skills are also needed in recreational activities such as Adventure Park, which consist in completing routes of progressive difficulty, which are signalled by specific colours (yellow, green, red, blue and black). These types of activities require abilities related to balance, kinaesthetic differentiation, spatiotemporal orientation, reaction and coordination of body segment movements (Bădău & Bădău, 2018).

In the preparation of badminton players (Srinivasan & Saikumar, 2012), handball players (Nesen et al., 2018) and volleyball players (Kozina et al., 2018), the use of the training ladder has led to improved coordination skills at lower limb level.

The results of this study are relevant in at least two basic directions in basketball: specific technical training and secondary selection.

Some limitations in conducting this study make us interpret the results with caution. First of all, the current training sessions of the female athletes from both groups were carried out by the study participants' coaches at that time. The experimental motor programme was developed by the main researcher, who is also licensed as a basketball coach. In the pre-test, there were no significant differences between the two groups. During the 6 months of the intervention, there may have been changes in the current training that were not kept under control but may have impacted the development of coordination skills. Second, coordination ability was assessed by specific tests that distinctly measured its components. It would be interesting to design a way of assessing the development of coordination skills in relation to actual performance during the game of basketball, either in a longitudinal study or in a predictive study.

Conclusion

The findings of this study show that the application of a specific motor programme integrated in the training sessions leads to significantly better results in terms of development of coordination skills. These results also attest to the significant role played by the use of modern auxiliary equipment (such as motion detection sensors) in the training and development of coordination skills.

Therefore, we can say that the motor programme focused on the development of coordination skills should be included in the sports training process for the age group 13-15 years, where the priority should not be to get results but to get skills and abilities and develop qualities that will offer players solutions for any game situation.

We hope that the results of this research will help physical education teachers and basketball coaches who teach for the age group 13-15 years.

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