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# DEVELOPMENT OF SPEED AND STRENGTH IN YOUNG FOOTBALL PLAYERS AGED 10-12 YEARS

**Mihai ŞANDRA***
University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087, Oradea, Romania, e-mail: mihaisandra98@yahoo.com

**Dragoş Vasile SĂVESCU**
University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087, Oradea, Romania, e-mail: savescudragos@yahoo.com

**Gheorghe Codruţ BULZ**
. University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087, Oradea, Romania, e-mail: bulz.codrut@gmail.com

**Marius Alin MARINĂU**
University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087, Oradea, Romania, e-mail: marius_marinau@yahoo.com

**Abstract:** The theoretical basis of training continues to grow, along with the expansion of scientific knowledge about how the human body is able to respond to various stimuli. Sports science and methods of training athletes are in constant development. This evolution is mainly based on expanding knowledge on how the human body adapts to different physical or psychological stressors.The present study aims to improve the efficiency of the specialized physical training process, depending on the targeted motor qualities, in our case speed and strength, is an increasingly accessed topic in search of obtaining a higher yield in a more efficient time.The study was conducted on a sample of 16 subjects, members of the U12 group.In the case of the applied program, we seek to achieve the proposed objectives, and by carrying out the planned, measured and interpreted physical training, we want to highlight the essential moments in the formation and development of the proposed program.

**Keywords:** training, motor skills, physical training, speed, strength, football.

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## INTRODUCTION

The purpose of the condition or physical form is resistance to fatigue, an indispensable aspect in any sports discipline. An athlete's recovery speed is directly proportional to their level of fitness. Physical training is considered to be a fundamental notion in the mastery of physical education and sport, regardless of the levels we are talking about (Aubert, 2002a; Papp et al., 2019; Erdely et al., 2020).

Training for peak fitness involves practice to develop all the fitness components required for the sport in question. The topicality of the subject and the importance of the problem addressed is the fact that the activity related to the football player's gear during the game depends to a large extent on the level of special physical training, which is at the foundation of the manifestation of

* Corresponding Author

his technical-tactical training (Sîrghi, 2016; Șandra et al., 2022). In this context, it is important that the athletes to be trained to tolerate both forms of fatigue, physical and mental (Bompa, 2013).

The changes occurring in the current football game refer to its orientation and structure as a whole on player lines (compartments and positions), as well as to the dynamism with which transitions from attack to defense and from defense to attack take place. Today, it is not possible to speak of the achievement of a scientific preparation of the game without a detailed, quantitative and qualitative knowledge of the dynamic constituent elements of its development in competitive conditions as different as possible, interpreting the game according to: the particularities of the players, the tactical concepts approached, the place of the game, the stake and the factors involved in the organization and running of the competition.

Each generation of sports training specialists seems to adhere to a certain slogan thataccurately describes the prevailing profile theories of the respective periods. Many coaches argue that form is made through games, although they should embrace the notion that form is made through practice. These coaches must be aware of the fact that in order to improve the technical and tactical procedures of an athlete, not only the game contributes to the increase in performance, but especially training contributes to their improvement (Bompa, 2013; Bulz et al., 2022).

All sports programs must address the physical, technical, tactical, psychological and theoretical aspects of training. These factors are essential to any training program, regardless of the athlete's age, individual potential, level of athletic development or stage of training. However, each factor is emphasized differently depending on the time of year, his biological age and the sport he is training for. Even though training factors are strongly interdependent, each of them develops in a specific manner. Physical training is the basis on which all other forms of training are developed. The stronger the foundation, the greater the potential for developing technical, tactical and psychological qualities (Bompa and Haff, 2009; Dragoș et al., 2022).

The training of athletes involves preparing the body, both from the point of view of increasing the morpho-functional indices, and as a psychological preparation to support continuous efforts and intensity. The training of athletes is preferable to be oriented, planned, systematic and long-term, with the objective of achieving performance (Gamble, 2012).

The physical preparation of football players has a special role in the entire training process, ultimately determining the athletes' performance in training and competitions. Actually, physical training is the basis for all other components of the training, even constituting the starting point for the entire training process. The physical training of football players is the indispensable premise of capitalizing on the technical-tactical expression capacity. High performances are achieved in football only by developed multilateral players, fast, strong and skilled, able to navigate well in the most complicated phases of the game (Balint, 2008).

In the last decades, a period in which continuous improvements were made in physical training, the development of the football game has reached a new conceptual stage of this sport, which refers to the fact that the game is organized and carried out based on well-defined ideas, of specialized and professional mentalities or attitudes. In today's football, a varied content of different sports training compartments (physical, technical-tactical, psychological) can be observed, including unpredictable actions, through which victory can be achieved, even in the last seconds (Bangsbo, 2006).

Just like physical training, speed has become a key factor in modern football, something revealed by the fact that most of the players have managed to achieve performances that in the past seemed impossible to achieve (Marinău, 2016). Compared to strength and endurance, which athletes, without extraordinary talent, can improve spectacularly if they train properly, speed is determined by heredity, requiring more native talent. Consequently, the mobilization of nervous processes, the rapid alternation between excitation and inhibition and the ability to regulate the

neuromuscular coordination system can result in an increased motor frequency (Szabo et al., 2021). In addition, the intensity and frequency of nerve impulses are determining factors in reaching a high speed. But still there is a period when exercises for the development of speed are more productive (Bompa, 2001).

The most favorable period in which it is possible to act in certain directions regarding the development of speed, specific to the period of development that is between 7-12 years (Teodoru, 2011). The pace of development decreases after this stage, and adaptation stimuli no longer cause appropriate answers. This hypothesis, tested experimentally, leads to the idea that the plan for development in this period of evolution must be drawn up with great care (Wilmore and Costill, 2002). Speed develops, being involved in reaction capacity and especially movement frequency, while speed acyclic and speed of action reach the maximum level a few years later. In the current state of scientific knowledge, we can speak of a key stage for the force in the speed regime (FRF, 2018).

When we discuss speed, we cannot ignore strength, motor qualities that directly influence the performance of the activity. Muscular strength is one of the most important qualities available to the human body, being required in most fields of activity, but very frequently in motor activity.

In general, there are two conceptions regarding the starting period of strength development, the first claims that strength can also develop before puberty, taking into account the morphological and physiological possibilities of prepubertals (e.g. the ratio between muscle mass and adipose tissue or body weight, level hormonal, neuromuscular coordination etc). Thus, different dynamic exercises can be used, and starting from the age of 12, intensities that do not exceed 1/3 of the body weight are used (Aubert, 2002b).

The second orientation refers to the situation in which the development of strength can be done (adequately) after overcoming the puberty period. At the beginning, you can gradually apply exercises that do not excessively demand the locomotor system, involving approximately 2/3 of the body weight, and later the level of intensity will reach the body weight and then exceed it (Bota, Cornelia, 2000).

Today, sports performance is determined by a number of factors and no one can say with certainty which of them has the greatest weight, so the study focuses on the idea of highlighting the positive effect it has in the development of the football game, especially in the case of juniors, in order to obtain higher indices of speed development, an optimal demand is needed, and most importantly, the physical demands must correspond to the particularities of age, level of physical training, degree of understanding, etc. Achieving performance, as well as the need to achieve it, is based not only on the phenomenon of emulation, but also on the individual's desire to improve, in the extensive training process (Prodan, 2016). In this idea, we proposed to conceive, we apply and evaluate a program for the development of motor qualities, speed and strength, in a U12 group.

## MATERIALS AND METHODS

The purpose of our research is to optimize the structure and content of the sports training of junior football players aged 10-12, based on the differentiated treatment of specific physical training in the pre-competitive period, carried out over three months. More precisely, the activity was structured in the form of three training cycles , each cycle lasting four weeks. Training took place on Mondays, Wednesdays and Fridays, and at the end of each week a friendly game took place. Prior to the start of the activity, the initial testing was carried out, and the whole process was completed with the final testing of the subjects.

In the framework of the research undertaken, the following methods were applied: analysis and generalization of specialized literature data; analysis of training process planning documents; pedagogical observation; testing method; the statistical-mathematical method of data processing and interpretation.

The present study was carried out on a sample of 16 juniors, the average age being 11.5 years. The means used to evaluate the activity carried out are presented in detail in table 1.

**Table 1.** The tests used in the present study and the objectives pursued.

| Nr. crt. | Test | Objective |
|---|---|---|
| 1. | Speed running 20 meters, starting from the feet (Speed 20m.) | By performing this test, we aim to evaluate the linear speed of starting and acceleration; |
| 2. | Sprint 4x10 meters, starting from the feet (Shuttle 4x10 m.) | Evaluation of speed with changes of direction, combining muscle strength, explosive strength, starting force, acceleration and deceleration; |
| 3. | Illinois Test (T. Illinois) | The Illinois test will help us evaluate agility, the ability to move with rapid changes of direction at different angles, combining muscle strength, starting strength, explosive strength, balance, acceleration and deceleration; |
| 4. | Standing long jump | The long jump capitalizes on the evaluation of the horizontal explosive force of the lower limbs, the lactic acid anaerobic power of the lower limbs; |
| 5. | Throwing the soccer ball with two hands above the head (Soccer ball throwing) | As part of this testing, we will monitor the evaluation of the explosive force of the upper limbs and the trunk; |
| 6. | Trunk flexion from lying on the back (Crunches challenge. 30/sec.) | In the last test, the objective is to evaluate the strength of the abdominal muscles. |

Throughout the duration of the study, the subjects carried out their activity based on the proposed program. This includes specific and non-specific means of the football game, means selected according to the objectives and the goal pursued. The means used in each training cycle can be found in table 2, along with aspects related to intensity, volume and breaks between repetitions. This program was created in such a way as to respect the particularities of the players' age, level of preparation and knowledge of the exercise mechanism.

For the Monday of each week, it was decided to plan homework for force and acceleration speed. Based on Verkhoshanski's (2006) assertion that a true sprint session must be preceded by plyometric exercises, the two themes of explosive lower body strength and acceleration speed were used in combination on Monday of each training cycle For the development of explosive force, the means used are: jumping on two feet, jumping over fences of different sizes, standing long jumps and long jumps with squatting, jumping step.

The Wednesdays during the training included elements regarding the development of strength in resistance regime, the method used was that of the strength circuit, consisting of different workshops. The volume of work but also the intensity increased with the transition from one training cycle to another. It was opted for the gradual increase from 5 to 6 and finally to 8 workshops, with the duration of the load starting from 15 sec, and the rear being 20 sec.

**Table 2.** Presentation of the content of the training cycles

| | | Acceleration speed | | | Explosive strength | | | Agility | | | Explosive strength | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cycle** | | **C I** | **C II** | **C III** | **C I** | **C II** | **C III** | **C I** | **C II** | **C III** | **C I** | **C II** | **C III** |
| **Intensity** | | 90-95% | 90-100% | 95-100% | 90-95% | 90-100% | 95-100% | 90-95% | 90-100% | 95-100% | 90-95% | 90-100% | 95-100% |
| **Duration** | **Minutes** | 5-8 min. | 5-8 min. | 5-8 min. | 10 min. | 10 min. | 7-8 min. | 10-12 min. | 10-12 min. | 10-12 min. | 8-10 min | 8-10 min | 8-10 min |
| | **Meters** | 80-90 m. | 100-120 m. | 110-120 m. | 13x | 15x | 17x | 40 metri | 40 m. | 60 m. | 60m. | 64 m. | 80m. |
| **Load duration** | | 4-5 sec. | 3-6 sec | 3-7 sec. | 2-7 sec. | 2-7 sec. | 2-7 sec. | 10-12 sec. | 10-15 sec. | 10-15 sec. | 15 sec. | 15-17 sec. | 15-17 sec. |
| **Rest duration** | | 45-90 sec. | 45-90 sec. | 45-90 sec. | 45-90 sec. | 45-90 sec. | 45-90 sec. | 30 sec. | 30 sec. | 30-45 sec. | 45 sec. | 1 min. | 1 min. |
| **Means** | | 4 x 7m. 2 x 20 m. 3 x 15m. | 4 x 12 m. 2 x 25 m. 2 x 15m. | 4 x 15 m. 2 x 30 m. 3 x 10m. | 4 x 10 S.J. 3 x 6 J.o.f. 3 x S.J. 3 x S.L.J. | 4 x 8 J.o.f. 4 x S.L.J. 2 x Sq.L.J 4 x S.J. | 3 x 8 J.o.f. 4 x 12 S.J. 5 x Sq.L.J 5 x S.L.J. | 2x (ladder +10m sla.) 2x (ladder +10m zig-zag) | 20m(5F+1B) 20m F. 4m.Left/Right. 4R. | 2x(ladder+ 8m sla.) 2x(ladder+ 10m zig-zag) 2 x 20(5F+1left+1right.) | 2x10Pushups 2x10R.Elastic Band. 2x10R. throwing the ball | 2 x 12pushups. 2x10R.throwing the ball | 2 x 10 pushups. 2x10R. throwing the ball. 2kg 2x10R. throwing the ball. 1kg |
| **Frecquency** | | 1 times a week | | | | | | | | | | | |

S.J. – Step Jump; J.o.f. – Jumping over the fence; S.L.J. – Standing long jump; Sq.L.J.– Long jump with squat; Sla –Slalom; F-Front; B-Back

The last day of a week of training contained aspects regarding the development of agility. The means used were represented by various variants of moving on a ladder, followed by accelerated running over different distances in zig-zag, slalom, running with a change in the direction of travel, forward and backward, left and right (5 front+1 back) and 180° turns with continued movement (both left and right).

For the development of the explosive force of the upper body, the means used were: exercises with the elastic band, push-ups, but also throwing the soccer ball and throwing the medicine ball of different weights.

## RESULTS AND DISCUSSIONS

The results obtained from the tests represent a control factor of the entire study and the efficiency of the means used to achieve the proposed objectives. For a more objective picture of the results obtained from the present study, we will compare both the initial results and the results final results obtained by the participants in all six tests considered.

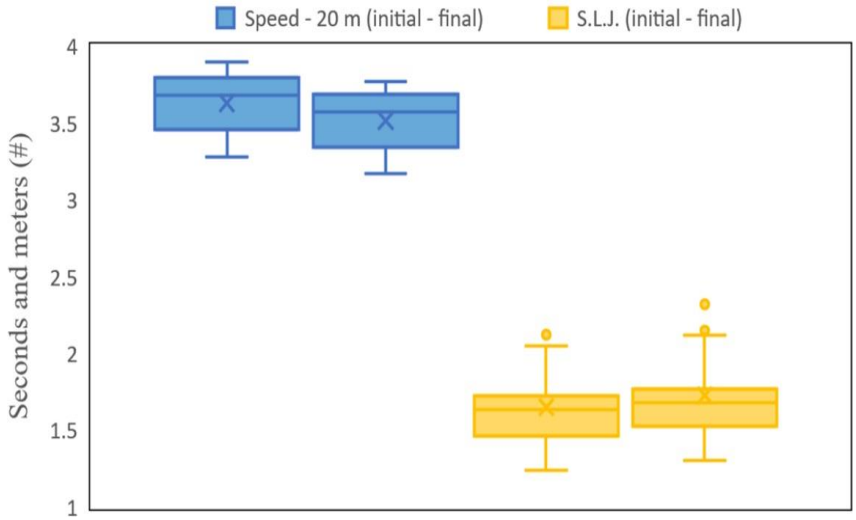


**Figure 1.** Graphic representation of the results obtained from the initial and final tests (Speed-20m., Standing long jump)

In the 20m sprint the group mean improved from 3.63 sec at initial testing to 3.51 secat final testing. This materializes through an average progress of 0.12 sec, and in percentages the progress is 3% (Fig.1). Based on the results obtained from the statistical-mathematical calculations, but also from the application of the effect size formula, it can be observed the fact that the most significant difference of the means is in the 20-meter speed run test, being located at the value of 1.03, representing the value of the effect size index.

The study of the coefficient of variability recorded for each sample provides us with data on the measure of relative dispersion. The lower the coefficient, the greater the homogeneity of the group. It is considered that a group is homogeneous when the coefficient is less than 10% (Maroti, 2008), and the best homogeneity of the group can be observed in speed tests, especially in the 20 m sprint, the coefficient being below 6% for both tests.

In the test S.L.J. (Fig.1), the performances of the group of soccer players were better in the second test, 1.73 m compared to 1.65 m in the initial test; the progress being estimated at approximately 0.08 m. A large value of the difference between the means can also be observed after obtaining the value of the effect size, the value index of 0.96 being the second most significant result after the one from the distance speed test of 20 m. In this test, the homogeneity of the group is more dispersed, but still the value obtained at the final test is 15.4%, 1.1 percent higher than the results obtained at the initial test, which indicates an improvement. Relative homogeneity is given in particular by the fact that the level of explosive force of the lower train at this age is influenced by the sudden and differentiated growth of the segments depending on the individual genetic characteristics of the children.

Comparison of averages recorded in the 4x10 m shuttle test shows a decrease in times from initial to final testing. Thus, the average values of the first testing were 11.43 sec, for the final testing to indicate an improvement of 0.7 sec (about 7%), the final values being 10.73 sec. For this sample, the result of the effect size can also be considered significant, having the value index located at 0.91 (Fig. 2). Following the statistical-mathematical calculations, it can be seen that the homogeneity of the group has the best values in the tests of running. The 4x10 m shuttle test has a value below 5% in both tests, which demonstrates a very good homogeneity of the entire group even after the training period.

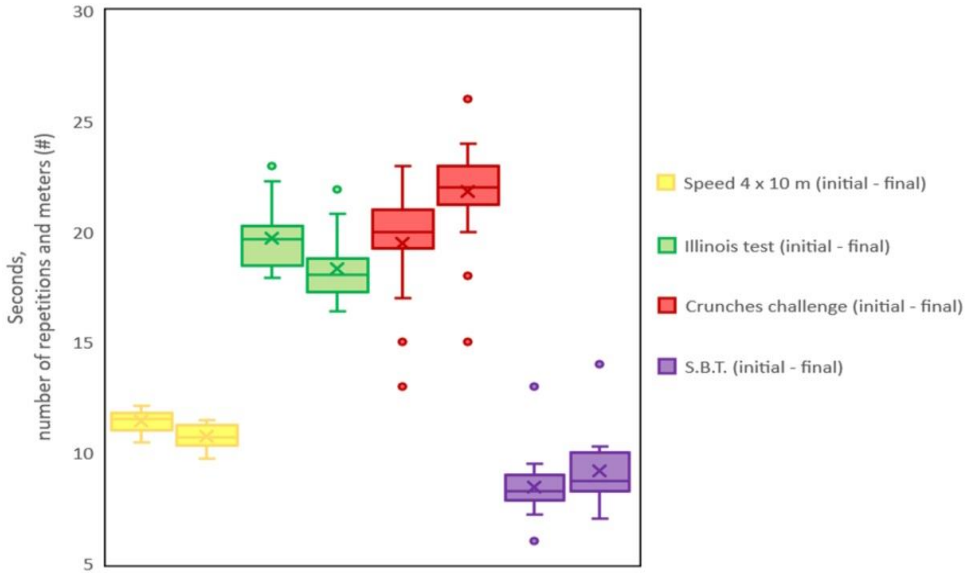


**Figure 2.** Graphic representation of the results obtained from the initial and final tests (Spped4x10m, Illinois, Crunches challenge, S.B.T.)

Comparison of averages recorded in the 4x10 m shuttle test shows a decrease in times from initial to final testing. Thus, the average values of the first testing were 11.43 sec, for the final testing to indicate an improvement of 0.7 sec (about 7%), the final values being 10.73 sec. For this sample, the result of the effect size can also be considered significant, having the value index located at 0.91 (Fig. 2). Following the statistical-mathematical calculations, it can be seen that the homogeneity of the group has the best values in the tests of running. The 4x10 m shuttle test has a value below 5% in both tests, which demonstrates a very good homogeneity of the entire group even after the training period.

Analyzing the data recorded in the Illinois test, we notice that the evolution of the group still tends towards progress, between the initial and final testing, being a significant increase of 1.38 sec (approximately 8%). Following the statistical-mathematical calculations made, the size of the effect has a large value of from a statistical point of view, which exceeds the threshold of 0.8, having an index of 0.94. This value represents a significant difference in the averages between the two tests.

The crunches challenge test, as in the case of previous tests, indicates an obvious progress of all participants. The group's progress amounts to about 9% between the two tests. Compared to the other samples, the value of the effect size is slightly lower, but remains statistically significant, the index being 0.85. (Fig. 2)

The upper limb strength test S.B.T. (Fig.2), shows a difference of 0.70 m between the average of the initial and final testing, which demonstrates an improvement in the group's performance from one test to another. The effect size value of the present testing was significant, the index reaching the value of 0.81. In this test, the homogeneity of the group is relative, due to the positions played by the players, goalkeepers and defenders being more exposed to this type of throw both in matches and in training. These aspects contributed to the reduction of homogeneity in this initial testing, a fact that is also highlighted by the improvement of homogeneity after the training period, where all players (regardless of positions) were subjected to the same type of training.

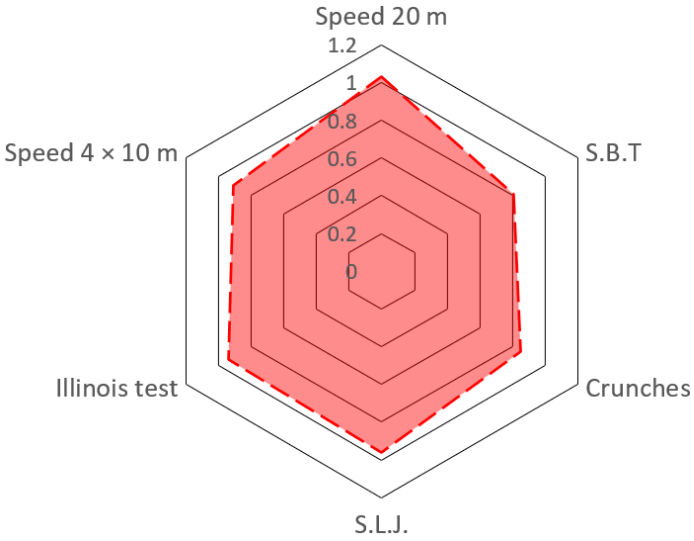


**Figure 3.** Graphical representation of effect size values for the six tests applied to the target group

The values presented in figure 3 represent the standardized difference between the averages and highlight whether or not this difference is statistically significant. This is a method to find out the degree of efficiency obtained after the training period. For the difference to be considered small, this value must be less than or equal to 0.2, for an average efficiency of the group this value must be between 0.2-0.8, and for a high efficiency from the point of view statistically, this value must be greater than or equal to 0.8(Fig.3).

## CONCLUSIONS

The current state of the football game and the directions for its further development, as seen from the analysis of the specialized literature, is characterized by an increasing influence on the level of training of players and teams, in terms of preparation their special physics.

Following the application of the training program in the present study, it was demonstrated that the experimental group registered a statistically significant superiority in the final tests for all motor tests applied, thus following the application of the program the performances during the game/training will be in growth.

The results obtained in this study can favorably influence aspects regarding the choice, the volume of work, the intensity of the effort, the complexity of the means chosen, in the preparation of football players and not only, but also constitute a starting point in the achievement of the proposed short-term objectives over a U12 group.

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# SPINSHOT THROW IN U18 JUNIOR BEACH HANDBALL: THE EFFECT OF GROUND FORCES

**Paul Ovidiu RADU***
Faculty of Physical Education and Sport Cluj-Napoca, Babeş-Bolyai University, Romania, Doctoral School
e-mail: radu.paul1993@yahoo.ro

**Adrian PĂTRAŞCU**
Faculty of Physical Education and Sport Cluj-Napoca, Babeş-Bolyai University, Romania,
e-mail: patrascuadrian102@gmail.com

**Iacob HANTIU**
Babeş-Bolyai University Cluj-Napoca, Faculty of Physical Education and Sport, Doctoral School
e-mail: iacobhantiu@gmail.com

**Abstract:** The game of beach handball is constantly expanding and its impact is increasing**.** The purpose of this study was to determine to what extent an intervention program can improve the value of ground forces in the spin shot goal throw. The study was composed of 13 sportswomen, aged between 16-18 years. The proposed intervention program took place over a period of 5 months (02.01.2020-06.01.2020) and was included in the annual training plan for female handball players. Throughout this period, the technical preparation of the throw at the goal from the pirouette (spin shot) was pursued through the use of a varied range of specific exercises. The AMTI NET force platform, model BP400600, was used to evaluate the forces generated on the ground, offering high accuracy. The platform offers both force analysis and algorithms to calculate variables such as: center of pressure, standard deviations, radial measurements, balance parameters. The results of this study showed us significant statistical differences for the parameters of performing the technical procedure without run up (HTS), FxImp (p= 0.05), Tq (p= 0.01), and as regards the performance of the complete technical procedure – with run up (JHT) we found statistically significant differences in the parameters TEx (p= 0.01), FzImp (p= 0.03), Tq (p= 0.01). Our study identified that the exercises used determined an increase in the values of the anterior-posterior impulse, the force torque, the execution time and the vertical impulse, the most important parameters for the achievement of the technical procedure of the throw to the goal from the spinshot in the beach handball game.
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**Key words:** ground forces, spinshot throw, beach handball, juniors

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## INTRODUCTION

Studies of major beach handball competitions have highlated the need to improve the efficiency of 2 points-goal throws. Among the technical medthods of throwing at the goal, the most frequently used are spinshots throws (Gehrer & Posada, 2010; Gruic et al., 2011; Zapardiel, 2018; Saavedra et al., 2019).

* Corresponding Author

The tehnique of throwing the ball in the game of beach handball is very important in achieving succes, but it does not depend only on muscle strength, but also on aspects regarding the coordination of the body segments and the skills that the athlete has (Gorostiaga, 2006; Granados et al., 2007; Saeterbakken et al., 2010).

Throwing at the goal is a technical element that is learned from the initiation period. It is perfected and strengthened in the subsquent stages of preparation. The goal throwing procedure often used in the beach handball game is the spinshot goal throwing. It is performed by jumping, but it is more complex (a twist in the air is added). It requires attention to learning, so that the athlete learns the movement corectly (van den Tillar & Ettema, 2004; 2006; Wagner et al., 2010).

In beach handball, during the spinshot goal throw, the unstable surface imposes a different movement to achieve the rotation of the torso and allow the transfer of momentum to the throwing arm, thus forcing the coaches to develop the forces necessary to achieve this procedure by the athletes. An important role is also how the athlete manages to use the reaction force of the support surface in increasing the force and efficiency of the throw.

## THE PURPOSE OF THE STUDY

The purpose of the study was to determin to what extent an intervention program can improve the value of ground forces in the spinshot goal throw.

## MATERIALS AND METHODS

*Subjects of the study*

Thirteen sports school handball players, aged between 16-18 years participated in this study. The athletes gave their formal consent to participate in this study, wich was also signed by their parents or guardians. School consent was also obtained.

*Program intervention of the study*

The proposed intervention program took place in the gym, over a period of 5 months, with three training sessions per week (Monday – Wednesady – Friday), each session lasting 90 minutes, and the program was included in the annual traning plan for female handball players. Throughout this period, the technical preparation of the throw at the goal from spinshot was pursued through the use of a varied range of specific exercises.

Assistive objects such as gymnastics trampolines and mattresses were used in this training program. The gymnastics trrampoline helped the athletes to get off the ground and perform the jump as high as possible, in order to achieve a complete twist in the air at the time of the goal throw. Gymnastics mattresses were used to imitate the unstable surface of sand, so that the athletes could perform spinshot at the goal in an environment as close as possible to the game of beach handball.

The exercises used in this training period were varied. Shots at goal from 90-degree, 180-degree and full turns were performed both from the spot and from the distance (walking and running), but also from different positions in front of the goal (left side or right side). Drills in which the attacking players are in numerical superiority such as 2 vs 1, 3 vs 2, were carried out at a goal at the beginning, with the completion of attacks from the sides of the field, with passive, semi-active and active defenders. At the end of the training program, school games were performed with different themes in which the athletes completed any attack with a throw at the goal with a spinshot from the jump.

*Measurments instruments used in this study*

The AMTI NETforce platform, model BP400600, was used to evaluate the forces generated on the ground, offering high accuracy. It is made of aluminum with a weight of 31.82 kg and dimensions of 400x600x82.55 mm. The platform offers both force analysis and algorithms to

calculate variables such as: center of pressure, standard deviations, radial measurements, balance parameters, etc.

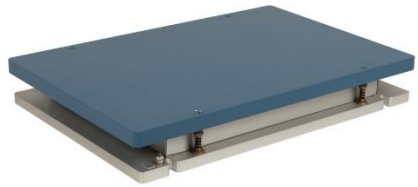

**Fig. 3** AMTI Netforce Platform (amti.biz, 2020)

Out of all the variables that the analysis program offers, we tracked the following: Vertical Impulse (FzImp), Anterior-Posterior Impulse (FxImp), Damping Force ($F_{amr}$), Pushing Power ($P_{imp}$), damping ($P_{amr}$), execution time (TEx), force torque (Tq), mechanical work when pushing ($L_{imp}$), mechanical work when damping ($L_{amr}$), these parameters being the most important factors in performing the technical procedure of throwing at the goal from spinshot. They refer to the following:

- The vertical impulse (FzImp) indicates the subjects' ability to change their state of motion during the procedure. This parameter highlights the moment between damping and thrust.
- The anterior-posterior impulse (FxImp) quantifies the change in the state of motion of the subjects towards the goal.
- The damping force ($F_{amr}$) has an indirect relation with the muscle force, since the push into the platform is carried out by the locomotor system
- Pushing power ($P_{imp}$), we find it at the moment of pushing within the technical procedure of throwing at the goal from spinshot, indicating the consumption of energy resources during execution.
- The damping power ($P_{amr}$) can differentiate the damping during the execution of the technical procedure of throwing at the goal from spinshot, so that a short execution time indicates a high energy consumption leading to the optimal preparation of the other phases of the procedure.
- The execution time (TEx) shows us the unit of time required to perform the technical procedure of throwing at the goal from the spinshot.
- The torque (Tq) on damping indicates the stability of the subjects at the moment of landing before performing the throwing procedure.
- The mechanical work of pushing ($L_{imp}$) illustrates the energy consumption at the moment of pushing during the performance of the technical procedure of throwing at the goal from spinshot.
- The mechanical work of damping ($L_{amr}$) indicates the energy consumption at the moment of damping the landing during the execution of the technical procedure of throwing at the goal from spinshot.

As part of the analysis protocol of the spinshot goal throw, two variations of the jump throw were measured:

- Jump 1 (HTS – Handball Twist Shot) – the subject had to simulate the procedure of throwing at the goal from a spin with hitting the platform and landing on the ground. The purpose was to isolate the momentum part of the actual spinshot.
- Jump 2 (JHT – Jump Handball Twist Shot) – the subject had to perform the full spinshot throw at the goal, with swing and the ball in hand, landing on the ground. The goal was to measure the complete execution of the spinshot goal throw.


**Fig. 4** Săritura 1 – HTS


**Fig. 5** Săritura 2 - JHT

*Data analysis and statistical processing*

Statistical analyses were performed using the SPSS Statistics program (version 17; SPSS, Inc., Chicago, Il) with a significance level of 5% (significance accepted when $p < .05$). The measurements of the research variables were performed according to the analyzed jump (HTS or JHT) and the measurement time: at the beginning of the intervention program (M1) and at its end (M2). Descriptive statistics calculations were performed – average and standard deviation. After analyzing the distribution of recorded scores, averages were compared using appropriate tests.

**RESULTS**

As a result of performing the Shapiro-Wilk data distribution test, it emerged that all analyzed parameters presented a $p > 0.05$, thus being able to conclude that the data have a normal distribution.

In order to compare the averages of the variables recorded in the M1 and M2 time of the research for Jump 1 HTS (Table 1), paired t-tests were performed, the analysis showing the following:

For the variables FxImp and Tq variables, the paired t-tests identified significant differences between the mean scores recorded in the two moments of the measurements – (FxImp M1: M = -9.93, DS = 10.09 and FxImp_M2: M = 14.23, DS = 3.37; $t_{(12)} = -2.16$, p = 0.05); respectively Tq_M1: M = -1696.57, DS = 153.88 and Tq _M2: M = 2770.50, DS= 367.05; $t_{(12)} = 2.91$, p = 0.01);

In the TEx and FzImp, no statistically significant differences were identified between the averages from the moments M1 and M2 – (TEx M1: M = 1.16, DS = 0.09 and TEx M2: M = 1.19, DS = 0.05; $t_{(12)} = -0.35$, p = 0.73); (FzImp_M1: M = 961.65, DS= 58.51 and FzImp_M2: M = 1003.66, DS = 33.56; $t_{(12)} = 0.57$, p = 0.58); Also, for the variables, $F_{amr}$, $L_{imp}$ $L_{amr,}$ $P_{imp}$, $P_{amr}$, , of HTS, no statistically significant differences were found.

**Table 1.** Paired t-test at HTS (N=13)

| Variable | Unit | Means | STDEV | t | df | Sig. (p) | Effect Size (d) |
|---|---|---|---|---|---|---|---|
| TEx_M1 | s | 1.16 | 0.09 | -0.35 | 12 | 0.73 | 0.20 / -.09 |
| TEx_M2 | s | 1.19 | 0.05 | | | | |
| FzImp_M1 | N*s | 961.65 | 58.51 | 0.57 | 12 | 0.58 | 0.33 / .16 |
| FzImp_M2 | N*s | 1003.66 | 33.56 | | | | |
| FxImp_M1 | N*s | 9.93 | 10.09 | -2.16 | 12 | 0.05 | 1.24 / -.60 |
| FxImp_M2 | N*s | 14.23 | 3.37 | | | | |
| Tq_M1 | $(10^{-2})$ * N*m | 1696.57 | 153.88 | 2.91 | 12 | 0.01 | 1.68 / .61 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tq_M2 | ($10^{-2}$) * N*m | 2770.50 | 367.05 | | | | |
| $F_{amr}$_M1 | N | 654.08 | 29.54 | 0.27 | 12 | 0.79 | 0.16 / .07 |
| $F_{amr}$_M2 | N | 664.84 | 23.05 | | | | |
| $P_{imp}$_M1 | W | 113.75 | 33.45 | 0.04 | 12 | 0.97 | 0.02 / .01 |
| $P_{imp}$_M2 | W | 116.05 | 40.53 | | | | |
| $P_{amr}$_M1 | W | 29078.67 | 1757.04 | 0.66 | 12 | 0.52 | 0.38 / .18 |
| $P_{amr}$_M2 | W | 31307.09 | 2585.58 | | | | |
| $L_{imp}$_M1 | J | 20.44 | 10.49 | 1.70 | 12 | 0.12 | 0.98 / .47 |
| $L_{imp}$_M2 | J | 2.10 | 0.80 | | | | |
| $L_{amr}$_M1 | J | 15302.83 | 1202.67 | 0.84 | 12 | 0.42 | 0.48 / .23 |
| $L_{amr}$_M2 | J | 16766.51 | 992.67 | | | | |

Note:
HTS= Handball Twist Shot; M1= initial measurements; M2=finale measurements; TEx= The execution time; Fzimp= The vertical impulse; Fximp= The anterior-posterior impulse; Tq= The torque; $F_{amr}$= The damping force; $P_{imp}$= Pushing power; $P_{amr}$= The damping power; $P_{imp=}$ mechanical work of pushing; $L_{amr}$As= mechanical work of damping

When comparing the averages of the variables recorded in moments M1 and M2 of the research for Jump 2 JHT – Jump Handball Twist Shot (Table 2) – Paired t-tests show us that:

For the variables TEx, FzImp, Tq, $L_{amr}$, $P_{amr}$, the paired t-tests identified significant differences between the mean scores recorded in the two moments of the measurements – (JHT_TEx_M1: M = 0.62, DS = 0.13 and JHT_TEx_M2: M = 1.15, SD = 0.10); $t_{(12)}$ = -2.88, p= 0.01); (JHT_$L_{amr}$_M1: M = 18139.65, DS = 1828.53 and JHT_$L_{amr}$_M2: M = 12206.62, DS = 688.27; $t_{(12)}$ = -2.70, p= 0.02); (JHT_Tq_M1: M = 855.54, SD = 492.76; and JHT_Tq_M2: M = 3205.39, SD = 367.36; $t_{(12)}$ = 3.35, p = 0.01); (JHT_$L_{amr}$_M1: M = 18139.65, DS = 1828.53) and JHT_$L_{amr}$_M2: M = 12206.62, DS = 688.27; $t_{(12)}$ = -2.70, p = 0.02); (JHT_Pamr_M1: M = -37156.11, DS = 3234.32 and JHT_$P_{amr}$_M2; M = 20944.87, DS = 1760.07; $t_{(12)}$ = -4.11, p = 0.00. In these variables the effect size is very large.

No statistically significant differences were observed between the means of: FxImp (JHT FxImp M1: M = 16.75, DS = 3.51 and JHT FxImp M2: M = 23.12, DS = 5.56; $t_{(12)}$ = 1.03, p = 0.32); $F_{amr}$ ((JHT $F_{amr}$ M1: M = 653.12, DS = 30.19 and JHT $F_{amr}$ M2: M =.661.32, DS = 23.70; $t_{(12)}$ = 0.21, p = .0.84); $P_{imp}$ variable (JHT $P_{imp}$ M1: M = 86.28, DS = 27.25 and JHT $P_{imp}$ M2 M = 39.78, DS = 9.09; $t_{(12)}$ = 1.85, p = .09). Also, no statistically significant differences were observed in the parameters $L_{imp}$, $_{of}$ JHT (JHT $L_{imp}$ M1: M = 6.75, DS = 5.67 and JHT $L_{imp}$ M2: M = 0.91, DS = 0.59; $t_{(12)}$ = 1.12, p = 0.28) (Table no. 2).

**Table 2.** Paired t-test at Jump Handball Twist Shot (N=13)

| Variable | Unit | Means | STDEV | t | Df | Sig. (p) | Effect Size (d) |
|---|---|---|---|---|---|---|---|
| TEx_M1 | s | 0.62 | 0.13 | -2.88 | 12 | 0.01 | 1.66 /.80 |
| TEx_M2 | s | 1.15 | 0.10 | | | | |
| FzImp_M1 | N*s | 515.53 | 122.45 | 2.52 | 12 | 0.03 | 1.45 / .70 |
| FzImp_M2 | N*s | 966.79 | 90.46 | | | | |
| FxImp_M1 | N*s | 16.75 | 3.51 | 1.03 | 12 | 0.32 | 0.59 / .37 |
| FxImp_M2 | N*s | 23.12 | 5.56 | | | | |
| Tq_M1 | $(10^{-2})$ * N*m | 855.54 | 492.76 | 3.35 | 12 | 0.01 | 1.93 / .93 |
| Tq_M2 | $(10^{-2})$ * N*m | 3205.39 | 367.36 | | | | |
| $F_{amr}$_M1 | N | 653.12 | 30.19 | 0.21 | 12 | 0.84 | 0.12 / .06 |
| $F_{amr}$_M2 | N | 661.32 | 23.70 | | | | |
| $P_{imp}$_M1 | W | 86.28 | 27.25 | 1.85 | 12 | 0.09 | 1.06 / .51 |
| $P_{imp}$_M2 | W | 39.78 | 9.09 | | | | |
| $P_{amr}$_M1 | W | 37156.11 | 3234.32 | -4.11 | 12 | 0.00 | 2.37 / 1.14 |
| $P_{amr}$_M2 | W | 20944.87 | 1760.07 | | | | |
| $L_{imp}$_M1 | J | 6.75 | 5.67 | 1.12 | 12 | 0.28 | 0.65 / .31 |
| $L_{imp}$_M2 | J | 0.91 | 0.59 | | | | |
| $L_{amr}$_M1 | J | 18139.65 | 1828.53 | -2.70 | 12 | 0.02 | 1.55 / .75 |
| $L_{amr}$_M2 | J | 12206.62 | 688.27 | | | | |

Note:
JHT= Jump Handball Twist Shot; M1= initial measurements; M2=finale measurements; TEx= The execution time; Fzimp= The vertical impulse; Fximp= The anterior-posterior impulse; Tq= The torque; $F_{amr}$= The damping force; $P_{imp}$= Pushing power; $P_{amr}$= The damping power; $P_{imp=}$ mechanical work of pushing; $L_{amr}$As= mechanical work of damping.

**DISCUSSION**

The results of this study showed us statistically significant differences for the parameters of the technical process without momentum (HTS), $Fx_{Imp}$ ($p = 0.05$), Tq ($p = 0.01$), and regarding the realization of the complete technical process - with momentum (JHT) we have found statistically significant differences in the parameters TEx ($p = 0.01$), $FzI_{mp}$ ($p = 0.03$), Tq ($p = 0.01$).

In this study, the development of the forces generated on the ground for the spinshot throw at the goal of handball players through exercises implemented in sports training was followed.

Considering that Gorostiaga (2006), Granados et al. (2007) and Saeterbakken et al. (2010) consider the execution time of technical procedures as an important aspect in achieving success in beach handball, in addition to muscle strength and coordination of body segments, it is necessary to interpret the results for this variable. Among the two types of jumps analyzed, HTS and JHT, a statistically significant difference was identified only in the second variant, which is closest to the form of the procedure used in beach handball. The increase in the average values of TEx between the initial and the final measurement can be interpreted by the possible influence of the exercises of correction and consolidation of the technical procedure.

Another interesting result to discuss is the evolution of the parameters FzImp and FxImp which showed differences between the two types of jumps measured. In the jump without momentum, the vertical impulse was not statistically significant, while in the case of performing the complete procedure, the forward impulse was not statistically significant. This state of affairs can be explained by the implicit difference in the execution of the procedure. Thus, the momentum generated in the case of JHT provides the necessary impulse to move the body of the subject after

the detachment from the ground, in the direction of the throw. In the opposite case, when the HTS was performed, the subjects needed a higher value of the horizontal impulse, thus also increasing the statistical significance.

At the same time, for both FzImp and FxImp, the values increased between the initial and the final measurement, thus indicating the influence of the training program in the development of these parameters. The exercises in which the gymnastics trampoline was used led to the balancing of the subjects at the time of jumping, but also to the development of their orientation in space at the time of performing the spin in the air.

The research subjects were female handball players, at the junior level, and are familiar with the classic handball throws (jump, standing or running throw). There are studies that have highlighted by which technical methods of throwing at the goal the players achieve the highest efficiency. According to them, the running goal kick has an efficiency of 98%, followed by the jump goal kick with 98% efficiency (Fradet et al., 2004; Wagner & Muller, 2008; Wagner et al., 2011).

Regarding the Tq parameter, it can be seen how for both types of jumps the values increased between the initial and the final measurement. Given the fact that the procedure itself contains both a strong rotation movement and a twisting movement of the trunk before performing the jump, it is important to analyze the values of this parameter. The higher the general force torque (Tq), the faster it is possible to pass from the loading phase (twisting+rotating) to the pushing and detaching phase. In the context of beach handball, performing a correct procedure but more fluently in movement, can ensure an accuracy of completion in the game situation with phases that follow quickly. At the same time, the very high values recorded in the case of JHT at the final measurement, may indicate that the intervention program had a positive effect on the subjects by providing additional muscle power that can become valuable in the context of performing this procedure on sand in competitive conditions.

The exercises to imitate the execution of spins and semi-spins without diving (turns of 90 degrees and 180 degrees) had an important role in making the procedure as fast and efficient as possible in its complete form, decreasing the values of the mechanical work on damping ($L_{amr}$), achieving a more efficient movement from the point of view of the damping technique at the initial moment of the jump.

Another interesting situation identified following the analysis of the obtained data is that of the $P_{imp}$ and $P_{amr}$ parameters, which showed decreases during the JHT jump. This phenomenon can be explained by the nature of the exercises incorporated in the training program that were aimed at improving the technique and less at the pure development of motor qualities. At the same time, we should not forget the possible effect of the improvement of neuromuscular control on the execution of the technique between the two measurements. An increase in neuromuscular control causes a decrease in the mechanical work required to perform a movement, and implicitly a decrease in the power developed during execution.

## CONCLUSIONS

In order to improve the execution of technical throw in the goal procedures, an appropriate training program can increase the parameters of ground forces in the game of beach handball. Our study identified that the exercises used determined an increase in the values of the anterior-posterior impulse, the force torque, the execution time and the vertical impulse, the most important parameters for the achievement of the technical procedure of the throw to the goal from spinshot in the beach handball.

**Conflicts of interests**

The authors declare that there is no conflict of interest.

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# THE INFLUENCE OF RECREATIONAL PHYSICAL ACTIVITIES ON ATTENTION AND STATIC BALANCE OF 6–9-YEAR-OLD GIRLS

**Otilia Teodora LIBER***
Babes-Bolyai University Cluj-Napoca, Faculty of Physical Education and Sport. Doctoral School.
e-mail: burz.teodora@yahoo.com

**Luminița Iolanda Edittha MLADONICZKY**
CJRAE Bihor, School Cunselor
e-mail: mladoedita@yahoo.com

**Iacob HANȚIU**
Babes-Bolyai University Cluj-Napoca, Faculty of Physical Education and Sport. Doctoral School.
e-mail: iacobhantiu@gmail.com

**Abstract:** Physical activities practiced for recreational purposes contribute to the development of essential skills that allow the efficient performance of daily tasks or sports activities. The aim of this study was to analyse the impact of recreational contemporary dance training on static balance and attention level of 6- to 9-year-old girls. The sample of the study was made of 26 girls, divided into two groups: 12 in the experimental group (EG) and 14 in the control group (CG). Subjects from the first group participated in recreational contemporary dance training for 1 hour, twice a week, for 6 months, and those from CG participated only in measurements. Static balance was assessed using the Wii Balance Board connected to See Sway software by analysing the distance (DCOP) and velocity (VCOP) and the deviation of center of pressure (COP) while maintaining balance in standing positions on both legs (SBL) and on one leg (SOL). The level of attention was measured using the Knock and Tap (K&T) test from the NEPSY neuropsychological test battery, making a quantitative interpretation of the direct score (DS) but also a qualitative one by transforming the direct scores into percentiles and classifying them on the 5 Attention Levels. Mean and standard deviation were calculated and compared using SPSS. The results showed that in EG, progress was recorded in both tests of balance maintenance, but statistically significant results were in the position of standing on one leg (DCOP: p =.017, VCOP: p =.018). At the control group were found the stagnation of the averages for balance on both legs and statistically insignificant progress on one leg (DCOP: p =.403, VCOP: p =.397). The level of attention showed increases in values in both groups, but they were statistically significant only in the experimental group, both for the direct score (p =.008) and for Level (p =.025). The conclusion of the study was that recreational contemporary dance training, practiced for 6 months twice a week, can positively influence the attention and postural control of 6 to 9year-old girls.

**Key words:** attentional control, balance, Wii Balance Board, See Saw, recreational contemporary dance, girls 6-9 years.

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* Corresponding author

**BACKGROUND**

Attention is one of the basic executive functions of humans, being essential in the qualitative processing of information (Cooley & Morris, 1990; Crețu, 2009). Although it is often studied by specialists from several fields, it is not presented by a unanimous definition Souza & Naves, 2021). Even more, Hommel et al. (2019) state that "no one knows what attention is". However, its role is known as vital to carry out tasks that require mental effort. According to Hasher et al. (2007), attention involves the ability to self-regulate in order to achieve a proposed goal through the capacity to focus on essential information and inhibit irrelevant ones. At the same time, according to Pashler et al. (2001), attention can be directed to internal or external stimuli depending on the requirement of the task. Provided that, the ability to control attention is vital in conducting daily activities as well as to obtain academic or sports achievements.

According to Wulf (2007), in order to learn a body movement, the attention must be directed towards the contraction of the required muscles together with coordination. When the skills are formed correctly, attention is used to achieve other goals that lead to performance improvement. Thus, in dance, attention it is constantly demanded, regardless of the level of the dancers. In the early stages is centred in the correct execution, in learning and memorizing the choreography and later can be directed to the expressive interpretation. Researchers Davis et al. (2011) and Diamond (2013) suggest that practicing physical activities can contribute to improving cognitive abilities in children, while being sedentary can alter these abilities. Therefore, it is believed that practicing recreational contemporary dance can have a positive impact on the development of attention in early aged children.

Balance plays an important role in the motor development of the human body. is an ongoing necessity to carry out various movements, making its advancement crucial for individuals to possess the necessary fitness for effectively accomplishing both everyday activities and sports-related endeavours (Cordun, 2009; Huxham et al., 2001). Also, Bressel et al. (2007) suggest that balance plays an important role in injury prevention. Often, athlete´s performance depends directly on the development of postural control (Hrysomallis, 2011). Dancers are most frequently called upon to perform pirouettes, as well as other specific movements that require them to balance on one leg (Bronner, 2012). In certain sports disciplines, balance assumes a technical aspect, wherein athletes are required to assume specific body positions and maintain them on a limited area support. These positions may include balancing on tiptoes, standing on one leg, or even balancing on the tip of one leg.

Children employ different strategies to maintain balance compared to adults, primarily because their neuromuscular system is not yet fully developed (Berard & Vallis, 2006; Ganley & Powers, 2005). Also, according to McNevin & Wulf (2002), the ability to focus attention directly influences balance.

**THE AIM OF THE STUDY**

The aim of this study was to analyse the influence of recreational contemporary dance training for 6 months on body balance and attention level in 6 to 9 year-old children.

**HYPOTESIS**

Considering the benefits that physical activities offer to people across all age groups, the following hypothesis was formulated for this research: Implementing an intervention program that incorporates recreational physical activity, specifically contemporary dance, will have a substantial impact on the attention and balance levels of girls aged 6-9 years.

## MATERIALS AND METHODS

*Sample:* At the start of the study, a total of 47 girls aged between 6 and 9 volunteered to participate. They were initially divided into two groups: the experimental group (EG) consisting of 22 members, and the control group (CG) with 25 members. The grouping was based on the participants' own choices to engage in training and measurements. In the experimental group, two subjects declined to participate in the study, and eight subjects were excluded due to frequent absences. In the control group, 11 subjects did not participate in the final measurements.

Ultimately, the study included 26 girls as subjects – 12 in the experimental group and 14 in the control group. To be eligible for participation, the subjects were required to not have a diagnosis of attention deficit disorder and had not previously engaged in extracurricular physical activities, except for the experimental group. The participants in the experimental group underwent an intervention program that involved recreational contemporary dance training for one hour, twice a week, over a span of six months (29.11.2021, to 3.06.2022).

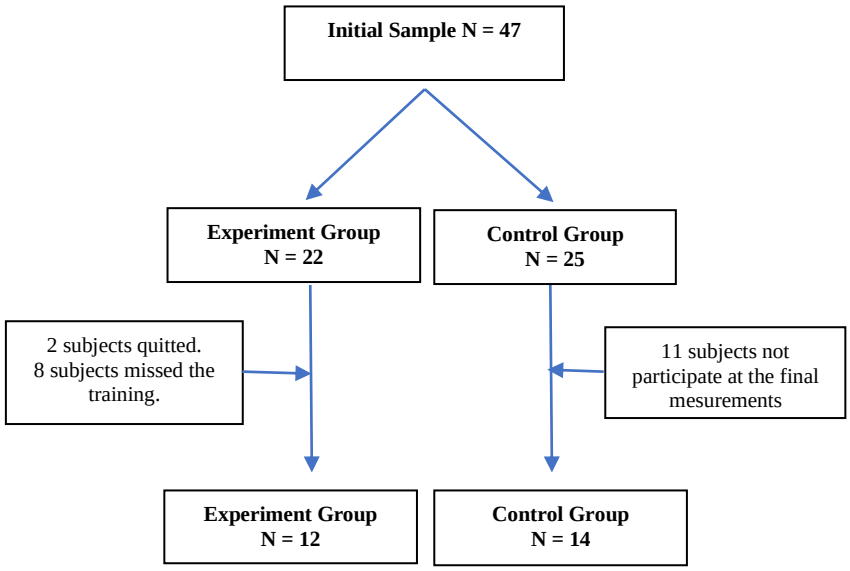


**Figure 1**. The research study flowchart

*Intervention programme*

Each lesson started with a synchronized body preparation routine accompanied by music, following the standard methodology of contemporary dance. This was continued by exercises aimed at enhancing flexibility in the lower limbs and back. In the first session of the week, the lesson progressed to static ballet exercises and artistic jumps, while the second session incorporated acrobatic elements from gymnastics. All exercises were tailored to match the subjects' training level. Towards the end of each lesson, the children were given the task of freely expressing themselves through body movements without any technical elements, accompanied by various musical rhythms. Subsequently, a slow rhythmic stretching routine was performed as a cool-down.

*Measurements*

To evaluate attention, the Kick and Tap (K&T) neuropsychological test from the NEPSY test battery was used in both groups before and after the intervention. The K&T test focuses on assessing self-regulation and inhibition by measuring the ability to adapt motor responses to conflicting verbal and visual instructions. It is a reliable test for children aged between 5 and 12 years in Romania (Korkman et al., 2007).

The K&T test consists of 30 items divided into two parts (Table 1). In the first part, the child learns and maintains instructions received, avoiding imitating the examiner's movements [e.g., hitting the table when the examiner taps, and tapping the table when the examiner hits; Figures 1 a) and b)]. The second part (items 16-30) involves self-regulation by inhibiting the previous tasks and learning a different cognitive set (e.g., performing a side punch when the examiner hits; remaining still when the examiner hits; punching when the examiner performs a side punch). Prior to each part of the test, examples of the movements are provided. The movements are performed with the preferred hand, while the other hand is relaxed with the palm open on the table (Korkman et al., 2007).

**Figure 2. a)** Kick **b)** Tap **c)** Side fist

**Table 1.** Items from the first and second part of the test „Kick and Tap".

| First part of the test | | | Second part of the test | | |
|---|---|---|---|---|---|
| Nr item | Examiner | Correct answer | Nr item | Examiner | Correct answer |
| 1 | Kick | Tap | 16 | Kick | Side fist |
| 2 | Kick | Tap | 17 | Side fist | Kick |
| 3 | Tap | Kick | 18 | Tap | Nothing |
| 4 | Kick | Tap | 19 | Kick | Side fist |
| 5 | Kick | Tap | 20 | Kick | Side fist |
| 6 | Tap | Kick | 21 | Tap | Nothing |
| 7 | Tap | Kick | 22 | Side fist | Kick |
| 8 | Kick | Tap | 23 | Kick | Side fist |
| 9 | Tap | Kick | 24 | Tap | Nothing |
| 10 | Tap | Kick | 25 | Tap | Nothing |
| 11 | Kick | Tap | 26 | Kick | Side fist |
| 12 | Tap | Kick | 27 | Side fist | Kick |
| 13 | Tap | Kick | 28 | Tap | Nothing |
| 14 | Tap | Kick | 29 | Side fist | Kick |
| 15 | Kick | Tap | 30 | Kick | Side fist |

In the assessment using the K&T test, each correct answer was given a score of 1, while incorrect answers received a score of 0. The total direct score was obtained by summing the points from both parts of the test, with a maximum possible score of 30. To interpret the data qualitatively, the total score of each subject was converted into specific percentiles based on their age. These percentiles were used to classify the subjects into five categories or levels of attention, as shown in Table 2. The statistical analysis was conducted for the following variables: the direct score (DS), the levels of attention (Level) determined by converting the total direct score into specific percentiles, and separately for each of the five levels of attention.

**Table 2.** Conversion of direct score to percentiles and rank them by age.

| Age | Direct Score | Percentile | Rank |
|---|---|---|---|
| 6-9 | 30 | ≥ 75 | Over the expected level |
| 6 | 26-29 | 26-75 | At the expected level |
| 7/8 | 27-29 | | |
| 9 | 28-29 | | |
| 6 | 17-25 | 11-25 | On the limit |
| 7 | 24-26 | | |
| 8 | 25-26 | | |
| 9 | 26-27 | | |
| 6 | 6-16 | 3-10 | Under the exected level |
| 7 | 16-23 | | |
| 8 | 19-24 | | |
| 9 | 19-25 | | |
| 6 | 0-5 | ≤2 | Far below the expected level |
| 7 | 0-15 | | |
| 8/9 | 0-18 | | |

Source: Korkman et al., 2007

For the measurement of static balance, the researchers utilized the Wii Balance Board (WBB) from Nintendo, which was connected to SeeSway software. The WBB is a portable balance plate that has been validated for assessing the displacement of the center of pressure (COP) and has demonstrated comparable efficiency to laboratory force plates (Clark et al., 2018). The parameters analysed were the distance of the projection of the center of pressure (DCOP) and the velocity of displacement of the center of pressure (VCOP). The measurements were taken while the participants-maintained balance for 30 seconds in the standing positions on both legs (SBL) and on one leg (SOL), with arms by the body and looking forward.

## RESULTS

After collecting the initial measurements, a t-test for independent samples was conducted to compare the values obtained in the experimental group (EG) with those in the control group (CG). The results indicated that there were no statistically significant differences in the means of the direct scores from the attention assessment test between the two groups at the beginning of the study [$t(24) = 1.21$, $p = .240$]. Additionally, the differences in the means of the balance parameters for both standing on both legs (SBL) [DCOP: $t(11.34) = 2.03$, $p = .067$; VCOP: $t(11.35) = 2.02$, $p = .067$] and standing on one leg (SOL) [DCOP: $t(24) = 1.01$, $p = .324$; VCOP: $t(24) = 1$, $p = .328$]

were not significant. These findings suggest that the two groups were homogeneous in terms of the analysed parameters.

Following the completion of the intervention program, final measurements were taken in both groups, and the averages were compared. The data from the initial and final measurements allowed for the calculation of the number of subjects, means, and standard deviations for each level of attention based on the conversion of the direct scores into specific percentiles, as presented in Table 3. The majority of subjects in both the experimental group (EG) and control group (CG) were classified at levels 2, 3, and 4. The evolution of the two groups was similar, with higher mean direct scores observed in the final measurements for both groups, except for levels 1 and 5.

In the experimental group (EG), no subjects were classified at the lowest level of attention, while the control group (CG) had one subject in both the initial and final measurements, with an initial mean of 17 and a final mean of 13. At level 5, the experimental group had a mean of 30 in both the initial and final measurements, with one subject before the intervention and two subjects at the end of it. The control group did not have any subjects in this category, not only at the initial measurement but also at the final measurement.

**Table 3**. Number, means, and standard deviations of pre- and post-test total direct scores by attention levels on EG (N = 12) and CG (N = 14)

| Level | Group | N Pre | N Post | Mean Pre | Mean Post | SD Pre | SD Post |
|---|---|---|---|---|---|---|---|
| 1 - Far below the expected level | EG | 0[a] | 0[a] | | | | |
| | CG | 1 | 1 | 17.00 | 13.00 | | |
| 2 - Under the expected level | EG | 2 | 0[a] | 23.00 | | 0.00 | |
| | CG | 4 | 3 | 22.25 | 23.33 | 2.22 | 2.89 |
| 3 - On the limit | EG | 5 | 2 | 24.40 | 25.00 | 0.89 | 0.00 |
| | CG | 5 | 3 | 25.00 | 25.67 | 0.71 | 1.53 |
| 4 - At the expected level | EG | 4 | 8 | 27.25 | 27.88 | 0.50 | 0.83 |
| | CG | 4 | 7 | 27.25 | 27.43 | 0.50 | 0.79 |
| 5 - Over the expected level | EG | 1 | 2 | 30.00 | 30.00 | | 0.00 |
| | CG | 0[a] | 0[a] | | | | |

A paired t-test was performed to compare the initial and final means of DS and Level of Attention parameters for EG and CG (Table 4). Statistically significant differences were found in DS (p =.008) and Level of Attention (p =.025) and large effect sizes in EG, while no statistically significant differences were found in CG (DS: p =.396; Attention Level: p =.414). However, the means also increased slightly in the CG, although the difference was not significant.

**Table 4**. Comparison of pre- and post-test means on the attention parameters DS and Attention Level

| Group | Pair | Variable | Mean | SD | t | df | Sig (2 - tailed) | Size effect (d) |
|---|---|---|---|---|---|---|---|---|
| EG | Pair 1 | DS pre | 25.58 | 2.23 | 3.22 | 11 | .008 | .939 |
| | | DS post | 27.75 | 1.66 | | | | |
| | Pair 2 | Level pre | 3.33 | 0.89 | 2.60 | 11 | .025 | .750 |
| | | Level post | 4.00 | 0.60 | | | | |
| CG | Pair 1 | DS pre | 24.29 | 3.10 | 0.88 | 13 | .396 | |
| | | DS post | 25.14 | 4.11 | | | | |
| | Pair 2 | Level pre | 2.86 | 0.95 | 0.84 | 13 | .414 | |
| | | Level post | 3.14 | 1.03 | | | | |

The paired t-test was performed to compare the mean values from the first and second measurements for the parameters analysed in the SBL test in the two groups. According to the results, no statistically significant differences were identified for the analysed parameters in any group (Table 5). These results suggest that the applied program did not influence balance in maintaining the standing position on both legs.

**Table 5.** Comparison of pre- and post-test means of the DCOP and VCOP variables for the SBL sample.

| Group | Pair | Variable | UM | Mean | SD | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| EG | Pair 1 | DCOP pre<br>DCOP post | cm | 72.92<br>42.31 | 58.15<br>7.75 | -1.92 | 11 | .081 |
| | Pair 2 | VCOP pre<br>VCOP post | cm/s | 2.43<br>1.40 | 1.92<br>0.26 | -1.95 | 11 | .078 |
| CG | Pair 1 | DCOP pre<br>DCOP post | cm | 38.66<br>38.66 | 7.76<br>9.28 | 0 | 13 | 1.000 |
| | Pair 2 | VCOP pre<br>VCOP post | cm/s | 1.29<br>1.29 | 0.26<br>0.32 | 0.08 | 13 | .939 |

For the parameters of the SOL, a paired t-test was performed to compare the averages recorded before and after the intervention. According to the data in Table 6, at GE, statistically significant differences were identified both in the variable DCOP [t (11) = -2.8, p =.017] and in VCOP [t (11) = -2.79, p =.018], the size of the effect being large (d =.81 for both variables). At GC, the differences were not statistically significant for any of the parameters. These results suggest that the program applied to the experimental group had a positive impact on maintaining balance while standing on one leg.

**Table 6.** Comparison of pre- and post-test means at DCOP and VCOP in the SOL sample.

| Group | Pair | Variable | UM | Mean | SD | t | df | Sig. (2-tailed) | Size effect (d) |
|---|---|---|---|---|---|---|---|---|---|
| EG | Pair 1 | DCOP pre<br>DCOP post | cm | 224.18<br>146.51 | 105.87<br>32.76 | -2.8 | 11 | .017 | -0.81 |
| | Pair 2 | VCOP pre<br>VCOP post | cm/s | 7.47<br>4.89 | 3.52<br>1.08 | -2.79 | 11 | .018 | -0.81 |
| CG | Pair 1 | DCOP pre<br>DCOP post | cm | 176.49<br>146.44 | 131.27<br>46.69 | -0.86 | 13 | .403 | |
| | Pair 2 | VCOP pre<br>VCOP post | cm/s | 5.89<br>4.88 | 4.37<br>1.56 | -0.88 | 13 | .397 | |

## DISCUSSIONS

The findings of your study align with existing literature on attention and executive functions in children. Attention is indeed considered one of the basic executive functions, and its development is closely linked to the maturation of the prefrontal cortex in children (Shaheen, 2014). While both groups may have experienced some natural improvement in attention due to this developmental process, the greater progress observed in the experimental group suggests that the intervention program, specifically contemporary dance practice, had a positive impact on attentional control.

The positive association between extracurricular physical activities and higher levels of attention during childhood has been reported in previous studies (Davis et al., 2011; Diamond, 2013). Your study's results support this notion, indicating that recreational contemporary dance can positively influence attention in 6- to 9-year-old girls.

The analysis of attention levels based on the converted direct scores revealed that most subjects in both the experimental group and control group were classified in the middle categories (2, 3, and 4) of attention. This suggests that attention levels were already relatively good for most participants at the beginning of the study. However, there were noticeable changes in attention levels among some individuals during the intervention.

In the sub- and borderline attention categories, the number of subjects decreased while the means increased, indicating that some participants moved to higher attention levels following the intervention. In the above-expected category, the mean increased, and the number of subjects in this category also grew. This suggests that some participants showed significant progress, achieving higher levels of attention.

At the extreme levels, specifically in the category "well below expected" attention, there was stagnation in the number of subjects and a regression of the mean in the control group. However, it is important to consider that attention is influenced by various factors, such as individual interest in the task and motivation (Lupșa & Bratu, 2005). Therefore, it is challenging to generalize that the lack of practicing extracurricular physical activities was the sole cause of this result. Nonetheless, it is worth noting that the experimental group did not have any subjects at the lowest level of attention but showed improvements in the opposite extreme (level 5) with two subjects at the final measurement. The analysis of attention levels and the paired t-test results indicate that attention significantly increased in both groups, but the experimental group showed greater progress following the intervention program compared to the control group. The statistically significant greater increases in the K&T direct score in EG ($p = .008$) compared to CG ($p = .396$) support the finding of improved attention in the experimental group. Additionally, the experimental group achieved a statistically significant higher average level of attention ($p = .025$) following the training, in contrast to the control group ($p = .414$).

Regarding the effect of the intervention program on balance, the results from analyzing the displacement of the center of pressure indicate that the program influenced balance primarily when maintaining a standing position on one leg. In this condition, the experimental group demonstrated a decrease in the average COP displacement and velocity, suggesting improved balance control. On the other hand, the control group showed stagnant results, with the distance and velocity of COP movement remaining the same in the sample maintaining balance on both legs (SBL). These findings suggest that the applied program had a significant impact on balance in the SOL sample but had limited effects in the SBL sample.

The greater impact on maintaining SOL balance in the experimental group may be attributed to the frequent requirement of unipedal stance in dance lessons, which may have helped the subjects become more accustomed to this task. Specific exercises targeting balance development, as observed in dance, have been shown to enhance performance in discipline-specific movements rather than daily activities (Hugel et al., 1999; Giboin et al., 2015). However, your study also revealed improvements in postural control in the common SBL test, which is not characteristic of dancing. This suggests that practicing recreational contemporary dance can contribute to the development of static balance in girls aged 6–9, beyond the specific movements of the dance discipline.

## CONCLUSIONS

The recorded results support the notion that contemporary dance training has a positive impact on postural control, particularly in maintaining balance on one leg. This is consistent with the nature of dance lessons, where unipedal stances are frequently practiced. The intervention program effectively enhanced postural control in this specific aspect of balance. Regarding attention, the results demonstrate that both groups experienced improvements in attentional control, but the experimental group showed greater progress. This finding aligns with previous research suggesting that attention and cognitive skills generally improve with age in children, but extracurricular physical activities can further enhance their development. In conclusion, engaging in recreational contemporary dance training for a duration of 6 months, twice a week, with each session lasting an hour, can have a positive impact not only on postural control but also on attentional control in girls aged 6-9.

### Limitations

We believe that the main limitations of the research are related to the small number of subjects and trainings that were attended during the research period.

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# EFFORT CAPACITY AND MOVEMENT SPEED DEVELOPMENT USING AQUATIC EXERCISE IN TENNIS PLAYERS

**Florin MIRON***
Babeş-Bolyai University Cluj Napoca, FEFS, Doctoral School e-mail: flori77ra@yahoo.com

**Dan MONEA**
Babeş-Bolyai University Cluj Napoca, FEFS, Doctoral School, e-mail dan.monea@ubbcluj.ro

**Horea ŞTEFĂNESCU**
Babeş-Bolyai University Cluj Napoca, FEFS, Doctoral School , e-mail horea_stefanescu@yahoo.com

**Abstract:** The objective of this study is to highlight the effect of physical exercises specific to the game of tennis, carried out in the aquatic environment to optimize the effort capacity and motor qualities in children and juniors. As all good players know, it doesn't matter how good the player can hit the ball if he cannot get to it. Correct movement skills are vitally important for success on the tennis court. Tennis requires quick movement in all directions. Performance speed: This refers to the time it takes from initiation until the completion of an action/stroke. In the example, this speed refers to the time it takes you to move to the ball, get set up to hit the ball, and to recover for the next shot. The impact of such an intervention program in the aquatic environment is a multilateral one, having benefits on optimizing performance capacity, maintaining an optimal state of health and opening new horizons for children practicing the game of tennis. Twenty 10-12-year-old tennis players were involved in the training program, who took an initial and a final evaluation, with the aim of identifying the advantages of the means used. Exercises for the development of movement speed and acceleration should be planned and performed during the general training periods and during the development periods for children and juniors.A novelty element of this experimental research is represented by the implementation in the training program of tennis players in the aquatic environment and exercises from other sports branches such as swimming, gymnastics and athletics. The intervention program is a bold attempt to weave and combine exercises from different sports, in a non-specific and totally different environment, in order to improve performances and results, looking at the perspective, without necessarily aiming at great current performances , in the short term, which could bring disappointments, create certain barriers or even lead to the abandonment of sports activities.

**Key words: effort capacity, speed, tennis, aquatic environment**

* * * * * *

* Corresponding Author

**INTRODUCTION**

The theoretical-practical knowledge in relation to the game of tennis proves that this sport has evolved significantly in terms of the effort and speed of the technical-tactical actions it involves, and therefore I consider it imperative to improve and develop the effort capacity and movement speed.

The player may have to sprint forward to reach a drop shot, back up for an overhead, or move from side to side to reach wide forehands and backhands

The player doesn't overlook the importance of working on his movement on the court although it is essential to work on grooving the player's.

Efficient movement of tennis players on the tennis court doesn't only depend on speed and agility, but also quickness.

Initial acceleration can also be associated with the first 10 m of a sprint, while agility is seen as the capacity of easiness in changing directions, and quickness in starting and stopping (

On average, a sprint distance performed during a point is between 4 to 7 m, and an average of 4 to 7 changes of direction.

Based on these statistics and facts, tennis players need to have remarkable dynamism in multidirectional movements during matches and explosive, short movements over the court (Elliott, 2006).

Speed or velocity defined by) as it describes the rate at which a player moves from one location to another. state that it is the capability to cover a distance quickly.

During running through water, oxygen consumption is 3 times higher at a speed of 50m/min, this value can be achieved at a considerably lower speed than running on land (Brinks et al., 2009).

Competitive tennis athletes need a mixture of anaerobic skills, such as speed, agility and power, combined with high aerobic capabilities (Kovacs et al., 2007).

Heart rate is an essential aspect for a trainer, as it provides information about the intensity of physical effort in relation to the capabilities of each individual (Cumming 2017).

The judicious intercession of conventional means with the "unconventional" adapted (in which practical executions are doubled by the permanent cerebral demand, where the intervention of some new stimuli requires the ability of attention forcing the player to overachiever thus inducing adaptations of performance capacity) must be an essential requirement of current preparation and an essential concern of the specialist in the motor field.

From a biological point of view, physical and especially sports effort is an appropriate biological (exciting) stimulus that forces the body to respond through electrical, mechanical, thermal manifestations (Monea, 2010).

In the specialized literature, there are scientific articles that demonstrate the fact that an aquatic gymnastics program that includes aerobic exercises, running, specific jumps and different distances covered by swimming procedures, significantly improves blood oxygen intake, heart rate and muscle strength , so these programs are also recommended for people who want to get in the best possible physical condition (Ivanova, 2019; Pieniązek et al., 2021).

**MATERIAL AND METHODS PURPOSE OF RESEARCH**

Monitoring training programs in the aquatic environment in order to identify the most relevant aspects that can contribute to the optimization of effort capacity and their subsequent implementation in long-term planning in the tennis game.

The selection of some means and the development of an unconventional methodical line (carried out in the aquatic environment) dedicated to optimizing the physiological profile, respectively increasing the effort capacity imposed by current tennis.

The comparative analysis of the recorded values, their interpretation and the statement of conclusions that reveal the efficiency (inefficiency) of the integration of the previously mentioned means in the sports training of children and juniors in the game of tennis

**HYPOTHESES OF THE RESEARCH**

The starting point in the proposed practical-methodical approach has as its starting point the following remark: if the situations in which the athlete is transposed in the preparation process are diversified and the executions have an appropriate dosage (volume, intensity, complexity) the motor accumulations obtained through the specific exercise can be effectively transferred to current court tennis (positive transfer).

Considering that the optimization of sports training in current field tennis is conditioned by the level of effort capacity, we will organize (carry out) an experimental study that will confirm/invalidate the hypothesis according to which the integration in training of tennis-specific motor structures adapted (held) in the aquatic environment will had the effect of optimizing the effort capacity of 10-12 year old tennis players and will induce increases in physiological parameters as expected.

**PROCEDURES AND METHODS OF RESEARCH**

Bibliographic study, organizing-conducting the experimental study, graphical analysis, statistical relevance (arithmetic mean, median, standard deviation, coefficient of variation, amplitude);

*Procedure*

This research used the Cosmed K5 spirometer, wich is a portable device used to assess lung function during exercise. This is a useful method to assess lung capacity, tidal volume and airflow under exercise to assess respiratory function and fitness in athletes. This spirometer provides data such as tidal volume, vital capacity, maximum expiratory flow rate, inspired and expired oxygen and many other parameters that can be used to monitor and optimize training. The K5 also allows the evaluation of a number of cardiovascular parameters such as heart rate, blood pressure and oxygen saturation, thus enabling the overall assessment of sports and fitness performance. The device was used to monitor vital capacity.

Freelap is a high-performance timing system designed to measure and analyze runners' times during training and competition. This system uses wireless technology and precise timing sensors that fit easily into a belt or wristband to measure the runner's time with an accuracy of 1/1000 of a second. Freelap can be used to measure running times, acceleration, top speed, pace and many other important metrics to analyze and improve runner performance. The system is easy to use and can be configured in different ways to meet the specific needs of each coach or athlete. Freelap is considered one of the most accurate and reliable timing systems on the market and is commonly used by high performance coaches and athletes around the world.

*Applied test*

The VAMEVAL test being the means of evaluation for this physiological parameter.

The field test consists in two chalenges of a progressive run between two lines drawn at a distance of 20 meters from each other. The pace of the run is dictated by a CD-player that emits audible beeps, the player must cover the distance between the two lines in the interval between the beeps. The player will aim to move at a running speed so that they reach the line and turn at the beep.

Physical running tests: 6x20m, 5m, 10m and shuffle test.

***Participants and experiment development***

The subjects of the experiment in number 20 organized in the two conventional experimental groups (experimental and control) are engaged in performance activity with numerous participations in tennis competitions.

The duration of the experimental approach was 12 months. The experimental and control groups were monitored throughout this interval (taking data to allow the interpretation of the adaptation to the specific effort, respectively to allow the validation of the effectiveness of the proposed training means. Data were taken that reveal the specific evolution of the following physiological parameters: frequency respiration at rest and during exertion.

While the control group performed a standard training programme according to the conventional training plan, the experimental group took part in adapted training stages (where the actuators are adapted to the aquatic environment), traineeships inserted in conventional annual plan. The means and methods applied under the adapted, unconventional program refer synthetically to: displacement in water, water games (volleyball, polo, badminton, exercises imitative forehand and backhand strokes using mis stringless racquets). All these means and methods are carried out in swimming pools, where athletes have evolved into water with increased progressive depth (knee level, coxofemurale joints, elbow, scapular-humerale joints).

The introduction in the training program of swimming exercises (free style) over a distance of 100-125m can have a significant contribution to the improvement of physiological parameters of junior tennis players.

The short-term cold water program increases the output of striated muscles, so fatigue sets in later (Knechtle et al., 2020). Increases cardiopulmonary endurance - swimming trains and strengthens the cardiovascular system, increasing the ability of the heart and lungs to deliver oxygen to the muscles and remove carbon dioxide (Muniz-Pardos et al., 2022). The tennis players of the experimental group who took part in the research carried out physical exercises in the aquatic environment with an average of 7.5 hours during one month. Thanks to a systematic physical effort, dosed and adapted to the particularities and needs of each individual, the nervous system, which coordinates the entire activity, undergoes a series of positive changes (Görner, 2020; Turdaliyevich & Pulatovna, 2020; Yapici-Öksüzoğlu, 2020)

## RESULTS AND DISCUSSIONS

In the experimental study carried out, aimed at optimizing the effort capacity and physiological parameters, the results with reference to the respiratory frequency at rest indicate a statistically significant difference, therefore the hypothesis is confirmed.

In the experimental study carried out, aiming at the optimization of the physiological parameters, the results with reference to the respiratory frequency during the effort indicate a statistically insignificant difference, consequently the hypothesis is rejected.

In conclusion, the hypothesis according to which the integration in sports training of some motor structures specific to tennis carried out in the aquatic environment can have a positive effect on the effort capacity of 10-11-year-old tennis players and can induce increases in physiological parameters, the results of the experiments are partially confirmed and require more research on this. However, preliminary data show that water training may be beneficial for developing exercise capacity and improving the performance of athletes in the game of tennis.

In conclusion, the hypothesis according to which the integration in sports training of some motor structures specific to tennis carried out in the aquatic environment can have a positive effect on the effort capacity of 10-11-year-old tennis players and can induce increases in physiological parameters, the results of the experiments are partially confirmed and require more research on this. However, preliminary data show that water training may be beneficial for developing exercise capacity and improving the performance of athletes in the game of tennis.

**Table 1**. Respiratory rate at rest

| Statistical indicators | Experiment | Control | Statistical indicators | Experiment-Control | |
|---|---|---|---|---|---|
| **Average** | 16.10 | 17.60 | **Average difference** | | -1.50 |
| **Median** | 16.00 | 18.00 | **Average difference (%)** | | 9.32% |
| **Abaterea std.** | 0.99 | 1.58 | **The non-parametric test Mann-Whitney** | Z | p |
| **Minimum** | 15 | 15 | | -0.549 | 0.030 |
| **Maximum** | 18 | 20 | **Effect size** | | 0.48 |
| **Amplitude** | 3 | 5 | | | |
| **Coef. variability** | 6.2% | 9.0% | | | |

The respiratory frequency at rest is lower in the experimental group, on average, by 1.50 resp/min (9.32%). The dispersion of the results shows a homogeneous structure in the case of both groups. The effect size is large. The results obtained by the athletes of the two groups are significantly different, according to the Mann-Whitney test, the significance threshold p=0.030 < 0.05, for Z = -2.166**.**

Synthesis

| Mean difference | Effect size | The difference between the groups is | Null hypothesis |
|---|---|---|---|
| -1.50 (9.32% ) | high | statistically significant | Is rejected |

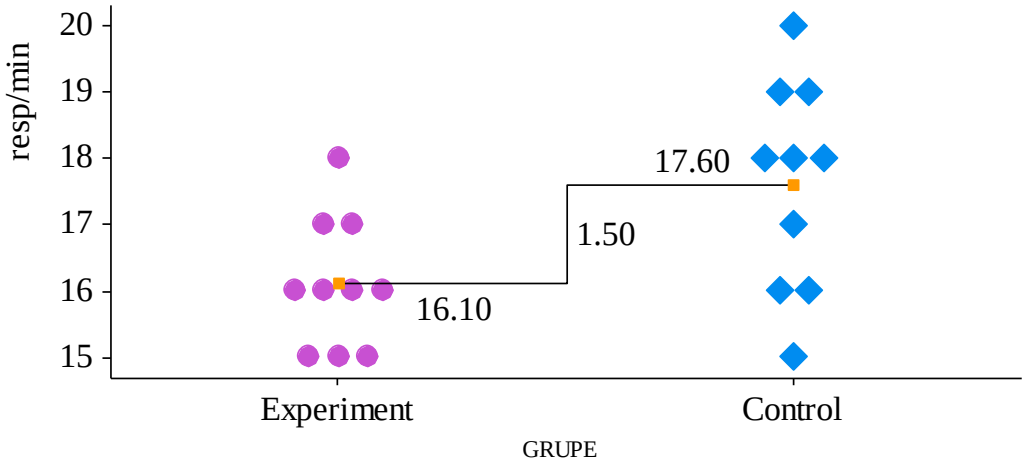


**Figure 1**. Respiratory rate at rest

**Table 2.** Respiratory rate during exertion

| Statistical indicators | Experiment | Control | Statistical indicators | Experiment-Control | |
|---|---|---|---|---|---|
| **Average** | 31.80 | 32.10 | **Average difference** | | -0.30 |
| **Median** | 32.00 | 32.00 | **Average difference (%)** | | 0.94% |
| **Abaterea std.** | 1.23 | 1.37 | **The non-parametric test Mann-Whitney** | **Z** | p |
| **Minimum** | 30 | 29 | | -**0.549** | 0.583 |
| **Maximum** | 33 | 34 | **Effect size** | | 0.12 |
| **Amplitude** | 3 | 5 | | | |
| **Coef. variability** | 3.9% | 4.3% | | | |

The respiratory frequency during effort is lower in the experimental group, on average, by 0.30 resp/min (0.94%). In the case of both groups, the dispersion of the results is homogeneous. The effect size is small. The results of the Mann-Whitney test indicate a statistically insignificant difference between the two groups, the significance threshold p=0.583 > 0.05, for Z = -0.549. In fig. the averages, their difference and the individual results obtained by the athletes are presented in graphic form.

Synthesis

| Mean difference | Effect size | The difference between the groups is | Null hypothesis |
|---|---|---|---|
| -0.30 (0.94% ) | low | statistically insignificant | Is accepted |

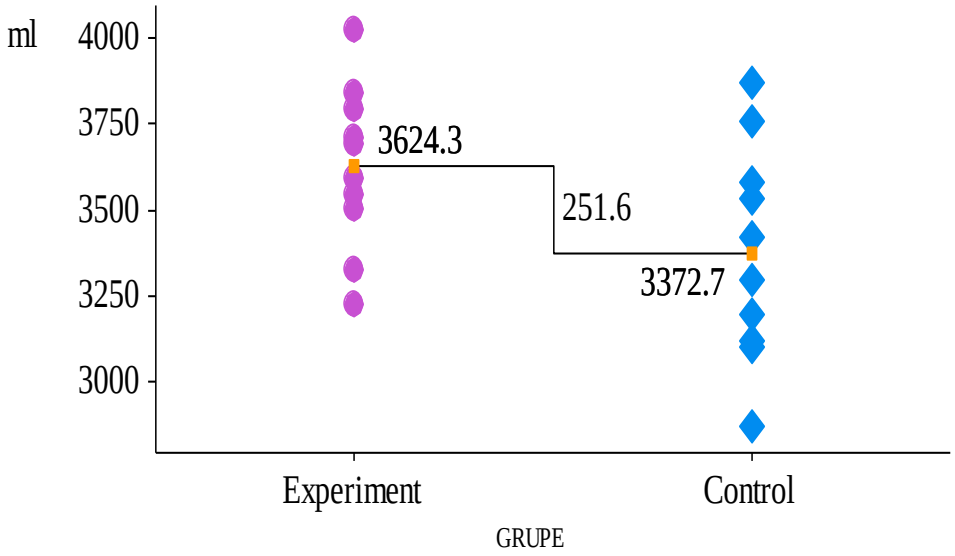


**Figure 2.** Respiratory rate during exertion

**RUNNING 6 x 20 m**

**Table 3**. The values of the motor quality test speed "running 6 x 20 m"

| Statistical indicators | T.I. | T.F. | Statistical indicators | T.F.-T.I. | |
|---|---|---|---|---|---|
| **Mediate** | 4.62 | 4.49 | **Average difference** | | -0.13 |
| **Median** | 4.67 | 4.51 | **Progress** | | 2.8% |
| **std deviation** | 0.19 | 0.17 | **95% C.I.** | (-0.17 ; -0.08) | |
| **Minimum** | 4.3 | 4.2 | **Standard deviation** | | 0.06 |
| **Maximum** | 4.9 | 4.7 | **The non-parametric test Wilcoxon** | Z | p |
| **Amplitude** | 1 | 1 | | -2.803 | 0.005 |
| **Coef. variability** | 4.1% | 3.7% | **Effect size** | | 0.63 |

The average time in the 6x20 m run decreased at the final testing of the experimental group by 0.13 sec. The progress achieved in the development of movement speed and agility in order to optimize the tennis game is 2.8%. The difference of means is in the range (-0.17; -0.08), in 95% of cases. The results are homogeneously dispersed in the case of both tests. The size of the effect is large to very large and statistically significant, p=0.005<0.05, for Z = -2.80.

Sintesys

| Diff. averages | Effect size | The difference between the groups is | Null hypothesis |
|---|---|---|---|
| -0.06 (1.36% ) | Very small | statistically significant | accepted |

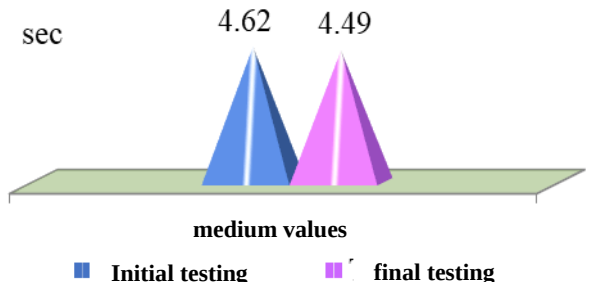


**Fig.3** Synthesis of the results of the assessment of motor quality speed "running 6 x 20 m"

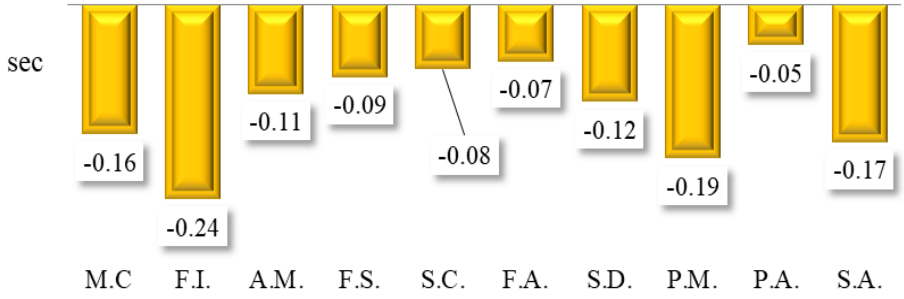


**Fig.4** Representation of individual progress of motor quality speed

**SHUFFLE TEST**

**Table 4.**The values of the evaluation in the shuffle test

| Statistical indicators | T.I. | T.F. | Statistical indicators | T.F.-T.I. | |
|---|---|---|---|---|---|
| **Mediate** | 8.62 | 8.11 | **Average difference** | | -0.51 |
| **Median** | 8.68 | 8.00 | **Progress** | | 6.0% |
| **std deviation** | 0.32 | 0.39 | **95% C.I.** | (-0.72 ; -0.30) | |
| **Minimum** | 8.0 | 7.5 | **Standard deviation** | | 0.29 |
| **Maximum** | 9.0 | 8.8 | **The non-parametric test Wilcoxon** | Z | p |
| **Amplitude** | 1 | 1 | | -2.705 | 0.007 |
| **Coef. variability** | 3.7% | 4.8% | **Effect size** | | 0.60 |

In the shuffle test test, the time is shorter in the experimental group, on average, by 0.45 sec (5.56%). In the case of both groups, the dispersion of the results is homogeneous. The effect size is large. The results obtained by the athletes of the two groups are significantly different, according to the Mann-Whitney test, the significance threshold p=0.026 < 0.05, for Z = -2.232. In the figure, the averages, their difference and the individual results obtained by the athletes are presented in graphic form.

*Sintesys*

| Diff. averages | Effect size | The difference between the groups is | Null hypothesis |
|---|---|---|---|
| -0.45 (5.56% ) | high | statistically significant | Is rejected |

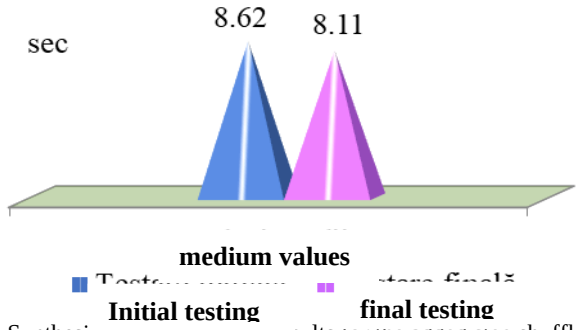


**Fig.5** Synthesis of the evaluation results for the added step shuffle test

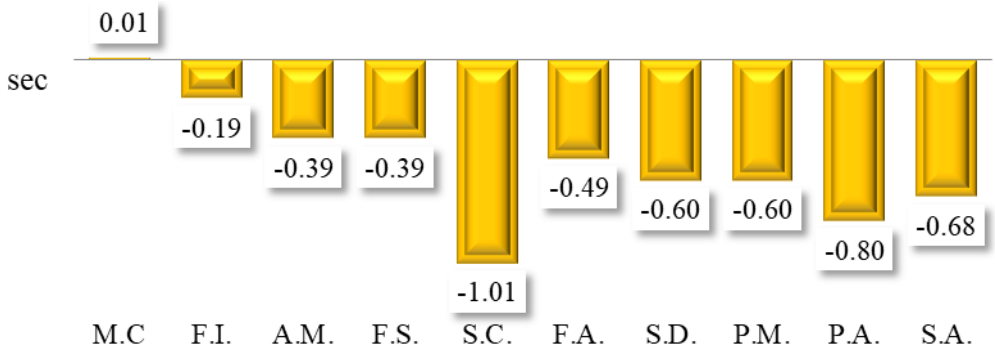


**Fig.6** Representation of individual progress of motor quality speed

**DISCUSSIONS**

Aquatic training programs involving running, strength and endurance exercises have a positive impact on the sports performance of children and junior tennis players under competitive and adverse conditions.

Following some studies in 2002, Bethany Diamond, master trainer for Nautilus Institute, at the Sports Medicine Center in Seattle, Washington state concluded the following:

The muscular force necessary to overcome water resistance to achieve speed in water translates into swifter movement on land. Speed training on land is achieved by sprints. For example, suicide drills (running to cones spaced incrementally farther apart and returning to the starting line after touching each) develop both speed and quickness. However, although effective, such land drills have an inherent risk of injury to the ankles and knees. Water's buoyant support negates much of that risk.

Agility drills in water improve a player's ability to change direction and regain balance quickly. When a client moves through water, a current moving in the same direction is created. When cued to change direction, the athlete is forced to move against this strong current, which can be difficult to overcome. Such rapid directional changes in the water challenge and develop balance and foot speed.

According to a study carried out by Shei (2014), by practicing physical exercises and swimming in the aquatic environment, the functional capacity of the respiratory system (total lung capacity, expiratory reserve volume and inspiratory reserve volume) improves, as well as that of maximal oxygen absorption and consumption during exertion.

In 2002, in the study regarding the effect of aquatic and non aquatic training on speed and agility among male volleyball players M.Gokul Raj & M. Senthil Kumar evaluated twenty adults (ten male and ten female) by running at two levels of immersion (hip and chest) and two speed conditions (slow and fast). Data were collected using an underwater force platform. The following variables were analyzed: vertical force peak (*Fy*), loading rate (*LR*) and anterior force peak (*Fx anterior*). Three-factor mixed ANOVA was used to analyze data.

The results of the study had shown there was a significant difference between aquatic training, non-aquatic training and control group on speed and agility. Further the results of the study showed that there was a significant increase on speed and agility after twelve weeks of aquatic training and non-aquatic training. However the improvement was in favour of experimental groups. There was a significant difference was occurred between aquatic training, non-aquatic training and control group after eight weeks of specific training programme. Aquatic training programme have better improvement in speed and agility compared with other groups.

Regarding the physiological parameters Igarashi & Nogami (2018) after conducting a study stated that exercise on land, aquatic exercise should have a beneficial effect by lowering blood pressure. In addition, aquatic exercise should lower the blood pressure of subjects with hypertension, and other forms of aquatic exercise besides swimming should also lower blood pressure.

Another study conducted by Yardley et al. attests to the fact that physical exercise in the aquatic environment contributes to maintaining a stable blood pressure - by improving circulation and cardiovascular health. (Yardley et al., 2012).

Following an experiment carried out in the aquatic environment, Mooventhan & Nivethitha (2014) concluded that Aerobic exercise is specific to these physical activities, programmed systematically, continuously and gradually, with intensity and volume adapted to the objectives pursued, significantly improves cardiovascular resistance.

Kwok et al (2022) concluded that running in the aquatic environment and variation in water temperature have a positive influence on maximal oxygen volume and physiological parameters but at the same time recommend more studies on this aspect.

**CONCLUSIONS**

The body's ability to adapt to effort is improved due to the versatility of the exercises applied in difficult conditions.

The hypothesis according to which the integration in the sports training of certain motor structures specific to tennis carried out in the aquatic environment can have a positive effect on the effort capacity and speed movement, even the results of the experiments are still uncertain.

The coordinative and physical capacities of the aquatic environment (repetitions characterized by superior concentration parameters – request of Nas and skeletal muscle) produce positive accumulations on the tenismanilor's capacity of effort.

It is observed an improvement in the practical way of addressing unpredictable situations in training and in competition;

Even the progress of the experimental group was noticable higher than the control group, the obtained **results partialy validates the research hypothesis.** Nevertheless we recomand the implementation of such program wich has beneficial effects that are found in the performances of 10-12-year-olds.

The small number of subjects negatively influences the research results.

The first limitation of our study derives from the small sample of participants

This aspect is related to the difficulties in identifying children who will accept belonging to an experiment involving physical exercise in a non-specific environment, as well as their willingness to engage in intervention programs, despite the fact that they can produce positive changes on sports training.

We recommend the use of these programs and in early stages as the engine profile of children involved in the sports performance of the formation during this period, and the uniquely diversified, adapted means (which manage to capture the interest) must be integrated into the conventional sports training programme.

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# MUSCLE STRENGTH ACCUMULATION AND ITS TRANSFER TO TENNIS GAME IN CHILDREN AND JUNIORS USING AN AQUATIC TRAINING PROGRAM

**Florin MIRON***
Babeș-Bolyai University Cluj Napoca, FEFS, Doctoral School , e-mail: flori77ra@yahoo.com

**Dan MONEA**
Babeș-Bolyai University Cluj Napoca, FEFS, Doctoral School e-mail dan.monea@ubbcluj.ro

**Horea ȘTEFĂNESCU**
Babeș-Bolyai University Cluj Napoca, FEFS, Doctoral School, e-mail horea_stefanescu@yahoo.com

**Abstract:** The primary objective of this study is to highlight the effect of physical exercises specific to the game of tennis, carried out in the aquatic environment for the optimization of motor qualities, strength and speed of execution and the optimization of performance capacity. In the experimental study, 20 tennis players aged 10-12 years were involved, who took an initial and a final assessment, with the aim of identifying the advantages of the means used in the aquatic environment, on the strength of the main muscle groups involved in this sport.

Medicine ball training has a long history in strength training programs for athletes, and tennis requires high explosive muscle strength in the upper limbs of its athletes. However, during medicine ball training, attention should be paid to the gradual way. First, we should take medicine ball training with primary difficulty, and then gradually move to medicine ball training with intermediate and advanced difficulty. At the same time, attention must be paid to the safety of athletes in the dangerous practice of throwing medicine balls. Medicine ball training should be done under the guidance of professional trainers throughout the training. Although the main purpose of medicine ball training is to increase explosive arm strength of tennis players, it can have a great impact on developing the strength and power of the whole body.

The medicine ball training should be carried out during the training process, especially the coordination training of the upper and lower limbs, which can effectively improve the coordination of the whole body. Tennis requires high speed and strength. It is an explosive sport of strength. At the same time, upper limb explosive force is also the foundation of tennis players' professional quality. If there is no good upper limb explosive force, it will restrict the improvement of tennis players'skill level. In tennis, like many sports, strength training is essential for a great performance. The strength and power development, can lead to a high capacity of movement speed, great ball pace during tennis shots and not at last it will prevent the tennis players from injuries.

**Key words:** tennis, medicine ball, muscle strength, aquatic environment

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* Corresponding Author

## INTRODUCTION

Considering the advancements in Strength and Conditioning (S&C) training principles and technology over the past few decades (i.e. racquet design), the nature of the game has been shown to gradually gravitate towards a power and speed-dominant play style, with athletes consistently serving upwards of 200+ km/h.

The ability to hit the ball with power in order to optimize the speed efficiency factor in the game of tennis is conditioned by the muscular strength of the upper body, the muscles of the back of the abdomen and the arms.

Consequently, a training program in the aquatic environment, using exercises for the development of these muscle groups, represents an important means that could be implemented in the training plan of tennis players.

Antony & Ameerali, 2017 stated that training using medicine balls is an effective and safe way to increase the training load and the occurrence of adaptation to the functional systems of the player's body.

Physical exercise in the aquatic environment develops most muscle groups, trains and tones almost all muscle groups, which leads to an increase in muscle strength and endurance (Żukowska & Szark-Eckardt, 2017).

Water sports and swimming strengthen the ligaments and help prevent injuries caused by excessive stress placed on them during training on hard surfaces. (Muniz-Pardos et al., 2022).

A significant benefit of physical exercises carried out in water is given by the fact that, in the aquatic environment, the body "loses" weight according to Archimedes' principle, corresponding to the volume of water displaced. This aspect facilitates the execution of movements and allows more efficient recovery of deficient muscle groups, due to more favorable conditions in terms of mechanical stress (Cumming, 2017).

The short-term cold water program increases the output of striated muscles, so fatigue sets in later (Knechtle et al., 2020). If the duration of the program in cold water increases, they can lead to an increase in muscle tone, externalized clonic contractions appear in the form of involuntary tremors (Knechtle et al., 2020).

Practicing swimming brings numerous benefits in terms of correcting posture, due to the particularities specific to the aquatic environment, such as the positioning of the body and the bodily demands required for movement in the water. These elements can support the balanced development of the locomotor system, cardiorespiratory functions and metabolism (Zuzana et al., 2022).

In the aquatic environment, the joints are freed from the weight (Archimedes' principle), so that the muscular effort can be diminished or amplified depending on the exercises performed (Tate et al., 2020; Taşkıran, 2020).

## MATERIAL AND METHODS PURPOSE OF RESEARCH

The selection of some means and the development of an unconventional methodical line (carried out in the aquatic environment) dedicated to optimizing the profile of tennis players in order to develop the quality of mortic force, respectively to increase the speed of execution of specific technical procedures in the current game of tennis.

Monitoring training programs in the aquatic environment, in order to identify the most important and relevant aspects that can contribute to the development and optimization of biomotor qualities and their subsequent implementation in long-term planning in the tennis game.

**HYPOTHESES OF THE RESEARCH**

The means of training in the aquatic environment, using physical exercises from gymnastics, fitness, with the medicine ball and last but not least exercises specific to the game of tennis (with racket) could have positive effects on the development of strength and power, at the level of the entire muscular system (with emphasis on the upper body) and optimization of efficiency factors, especially ball speed in basic strokes (serve, forehand and two-handed backhand).

**PROCEDURES AND METHODS OF RESEARCH**

Bibliographic study, organizing-conducting the experimental study, graphical analysis, statistical relevance (arithmetic mean, median, standard deviation, coefficient of variation, amplitude);

*Procedure*

In the experimental research, 3 kg medicine balls were used for the evaluation of muscle strength in the trunk, back and abdomen, and equipment specific to the game of tennis.

Tests for efficiency factor, ball speed for basic techniques, serve, forehand and two-handed backhand were conducted in the environment specific to the game of tennis, Supido radar speedometer that registers speed between 5-200 km/h rackets, balls and spin shot ball machine.

*Applied test*

Assessment of motor quality, strength for the upper limbs was evaluated by means of the following tests:

- throwing the medicine ball from above the head (service)
- throwing the medicine ball from the side (forehand )
- throwing the medicine ball from the side (backhand)

Evaluation of the ball speed efficiency factor in the game of tennis for the basic technical procedures of the serve, the forehand and the two-handed backhand.

*Participants and experiment development*

The tennis players involved in the experimental research were 20 in number, organized in the two conventional experimental groups (experimental and control), engaged in the performance activity by participating in field tennis competitions.

The duration of the experimental approach was 12 months. The experimental and control groups were monitored throughout this interval (taking data to allow the interpretation of the adaptation to the specific effort, respectively to allow the validation of the effectiveness of the proposed training means.

Data were taken that reveal the specific evolution of the following parameters: strength and speed of execution and the optimization of performance capacity.

While the control group performed a standard training program according to the conventional training plan, the experimental group took part in adapted courses (where the actuation systems are adapted to the aquatic environment), courses inserted into the conventional annual plan.

The means applied within the adapted, non-conventional program refer synthetically to: moving in water, water games (volleyball, polo, torso twists with and without a medicine ball, imitative exercises for the right shot and the lapel shot using rackets with and without connection). All these means are carried out in swimming pools, where the athletes evolved in water with progressively increased depth (the level of the coxofemoral joint, the elbow, the scapulo-humeral joint).

The introduction into the training program of swimming exercises (free style) over a distance of 100-125m in each training lesson can have a contribution to the development of strength in the upper limbs and last but not least to the capacity for effort.

**RESULTS AND DISCUSSIONS**

The results of the current study confirm the hypothesis that physical exercises specific to the game of tennis, carried out in the aquatic environment, develop the motor qualities, strength and power in the muscles of the upper body and speed of execution of the basic technical procedures of the serv, forehand shot and two handed backhand.

The results of many studies dealing with medicine ball training have shown a significant and notable improvement in physical capabilities related to explosive muscular strength, strength characterized by speed, strength endurance and flexibility, in addition to the fact that speed, agility and technical skills for various sports such as studies (Kobak et al., 2019).

*Discussions*

Several studies recommend medicine ball throws (MB) and resistance training (RT) methods to increase ball velocity in tennis (Fernandez-Fernandez, et al. 2013) or overhead throw sports (Escamilla RF, 2012).

The explosive strength of the tennis players' upper limbs can be effectively improved through the Medicine Ball training. The tennis players' overall speed also benefited, reflecting the improvement of the tennis players' specific performance.

Following a study after using aquatic training programs, (Mateescu. 2010) which aimed to develop and experiment some training programs through schemes of aquatic and dry land combined contractions, concluded that, due to unstable water environment and its resistance, aquatic exercises involve all muscle groups in an attempt to maintain the vertical position of the body, and the execution speed is fast and explosive, all of which are a effective way to develop strength.

Research findings by Terraza-Rebollo M, Baiget E in 2021 on the acute and delayed effects of strength training on ball speed and accuracy in young competitive tennis players indicate that MB and RT, avoiding repetition to failure and at maximum intended execution, have no acute and delayed deleterious effects on stroke tennis performance. Therefore, it could be suggested that these two strength training methods using these protocols could be useful to train maximal and explosive strength without decreasing ball speed and accuracy and could be used before a technique session. tactics on the field or off-season, and in-season.

The results of the current study came in line with the studies of each of (Kobak et al, 2019; Beckham et al, 2019; Pramod & Divya 2019);which showed that there is a positive effect of physical training programs on the muscle strength (explosive force, and the force characterized by speed),speed, and endurance of strength, and from here the researchers stated that programming the training by using traditional methods without working with modern methods cannot reach the player to the highest level of achievement.

**Table 1**. Test values "two-handed medicine ball throw at serve"

| **Statistical indicators** | T.I | T.F. | **Statistical indicators** | T.F.- | T.I. |
|---|---|---|---|---|---|
| **Average** | 3.91 | 4.38 | **Average of differences** | | 0.47 |
| **Median** | 3.92 | 4.41 | **Progress** | | 12.1% |
| **Abaterea std.** | 0.09 | 0.14 | **95% C.I.** | | (0.41 ; 0.53) |
| **Minimum** | 3.8 | 4.1 | **Standard deviation** | | 0.09 |
| **Maximum** | 4.1 | 4.6 | **The non-parametric Wilcoxon test** | Z | p |
| **Amplitude** | 0 | 0 | | -2.807 | 0.005 |
| **Coef. variability** | 2.3% | 3.1% | **Statistical indicators** | | 0.63 |

Following a study, Pramod & Divya, 2019, states that training using medicine balls is a good way to develop muscle strength, which is an essential component of all movements and technical skills.

In the test of throwing the medicine ball with two hands at the service, the length of the throw increased at the final testing of the experimental group, on average, by 0.47 m. The progress achieved, regarding the force and speed of the ball at the service, is 12.1%. With a confidence of 95% the difference of the means is in the range (0.41 ; 0.53). The dispersion of the results shows a homogeneous structure for each test. The size of the effect is large to very large and statistically significant, p=0.005<0.05, for Z = -2.81.

Synthesis

| Diff. Average | Progress | Effect size | The difference is: | The null hypothesis |
|---|---|---|---|---|
| 0.47 | 12.1% | high to very high | statistically significant | is rejected |

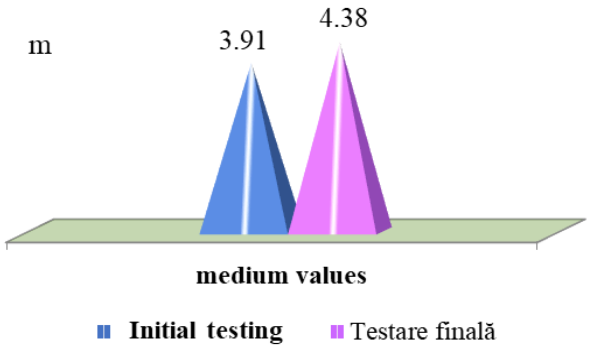


**Figure 1**. . Synthesis of the evaluation results "throwing the medicine ball with two hands at serve"

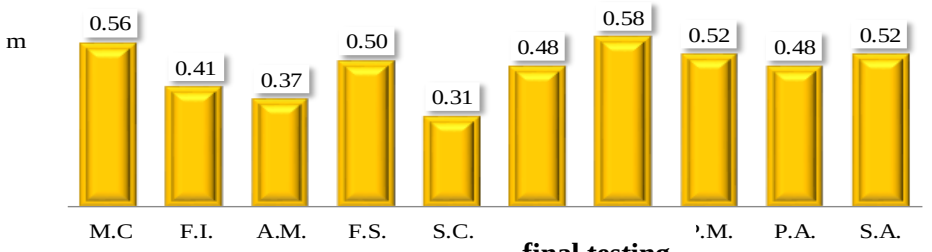


**Figure 2**. . Graphical representation of individual progress i ine ball throwing at Serve

**Table 2.** Values of the "two-handed backhand medicine ball throw" test values

| **Statistical indicators** | 4.92 | 5.52 | **Statistical indicators** | T.F.- | T.I. |
|---|---|---|---|---|---|
| **Average** | 4.91 | 5.48 | **Average of differences** | | 0.61 |
| **Median** | 0.12 | 0.17 | **Progress** | | 12.4% |
| **Abaterea std.** | 4.7 | 5.3 | **95% C.I.** | | (0.54 ; 0.68) |
| **Minimum** | 5.1 | 5.9 | **Standard deviation** | | 0.10 |
| **Maximum** | 0 | 1 | **The non-parametric Wilcoxon test** | Z | p |
| **Amplitude** | 2.5% | 3.1% | | -2.805 | 0.005 |
| **Coef. variability** | 4.92 | 5.52 | **Statistical indicators** | | 0.63 |

Throw length increased at the final testing of the experimental group by an average of 0.61 m when throwing the medicine ball with two hands on the backhand. The progress achieved, regarding the force and speed of the ball on the backhand shot, is 12.4%. The 95% confidence interval for the difference in means is (0.54 ; 0.68). The dispersion of the results shows a homogeneous structure for each test. The difference between the means is large to very large and statistically significant, p=0.005<0.05, for Z = -2.81.

.Synthesis

| Diff. Average | Progress | Effect size | The difference is: | The null hypothesis |
|---|---|---|---|---|
| 0.61 | 12.4% | high to very high | statistically significant | is rejected |

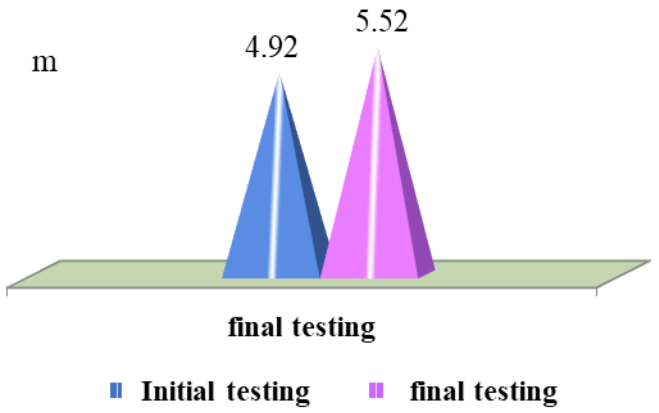


**Figure 2.** Synthesis of the results of the "two-handed backhand medicine ball throw" evaluation results

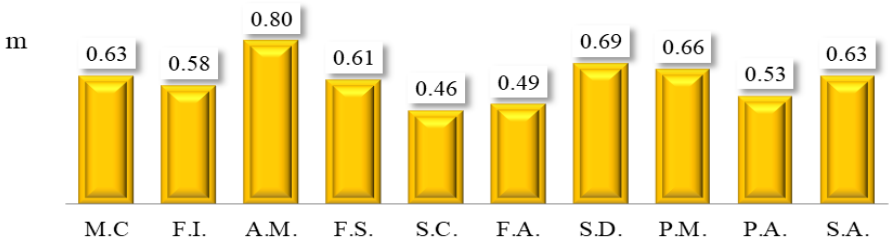

**Figure 4** Graphic representation of individual progress "two-handed backhand medicine ball throw"

**RUNNING 6 x 20 m**

**Table 3.** Values of the "two-handed medicine ball throw on the forehand" test

| **Statistical indicators** | T.I | T.F. | **Statistical indicators** | T.F.- | T.I. |
|---|---|---|---|---|---|
| **Average** | 3.91 | 4.38 | **Average of differences** | | 0.47 |
| **Median** | 3.92 | 4.41 | **Progress** | | 12.1% |
| **Abaterea std.** | 0.09 | 0.14 | **95% C.I.** | | (0.41 ; 0.53) |
| **Minimum** | 3.8 | 4.1 | **Standard deviation** | | 0.09 |
| **Maximum** | 4.1 | 4.6 | **The non-parametric Wilcoxon test** | Z | p |
| **Amplitude** | 0 | 0 | | -2.807 | 0.005 |
| **Coef. variability** | 2.3% | 3.1% | **Statistical indicators** | | 0.63 |

The average time in the 6x20 m run decreased at the final testing of the experimental group by 0.13 sec. The progress achieved in the development of movement speed and agility in order to optimize the tennis game is 2.8%. The difference of means is in the range (-0.17; -0.08), in 95% of cases. The results are homogeneously dispersed in the case of both tests. The size of the effect is large to very large and statistically significant, p=0.005<0.05, for Z = -2.80.

Sintesys

| Diff. Average | Progress | Effect size | The difference is: | The null hypothesis |
|---|---|---|---|---|
| 0.65 | 13.1% | high to very high | statistically significant | is rejected |

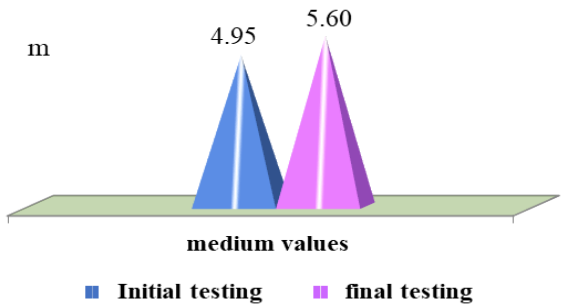


**Fig.5** Synthesis of the results of the evaluation "throwing the medicine ball with two hands on the right"

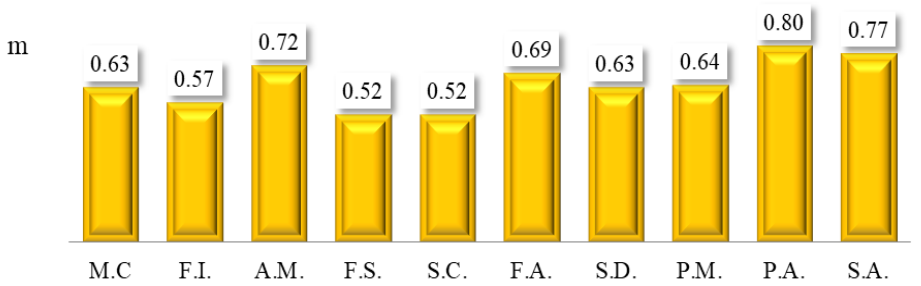


**Fig.6** Graphical representation of individual progress "two-handed medicine ball throw on the right"

**Table 4**. Efficiency factor test values "speed of serv. 1"

| **Statistical indicators** | T.I | T.F. | **Statistical indicators** | T.F.- | T.I. |
|---|---|---|---|---|---|
| **Average** | 70.80 | 82.35 | **Average of differences** | | 11.55 |
| **Median** | 70.25 | 81.75 | **Progress** | | 16.3% |
| **Abaterea std.** | 3.30 | 2.68 | **95% C.I.** | | (10.23 ; 12.87) |
| **Minimum** | 67.50 | 79.50 | **Standard deviation** | | 1.85 |
| **Maximum** | 79.00 | 89.00 | **The non-parametric Wilcoxon test** | Z | p |
| **Amplitude** | 11.50 | 9.50 | | -2.809 | 0.005 |
| **Coef. variability** | 4.7% | 3.3% | **Statistical indicators** | | 0.63 |

Service 1 speed increased at the final testing of the experimental group, on average, by 11.55 m/s. The progress made regarding the development of the ability to hit with precision in the desired areas is 16.3%. With a confidence of 95% the difference of means is in the range (10.23 ;12.87). The dispersion of the results recorded in both tests is homogeneous. The size of the effect is large to very large and statistically significant, p=0.005<0.05, for Z = -2.81.

Synthesis

| Diff. Average | Progress | Effect size | The difference is: | The null hypothesis |
|---|---|---|---|---|
| 11.55 | 16.3% | high to very high | statistically significant | is rejected |

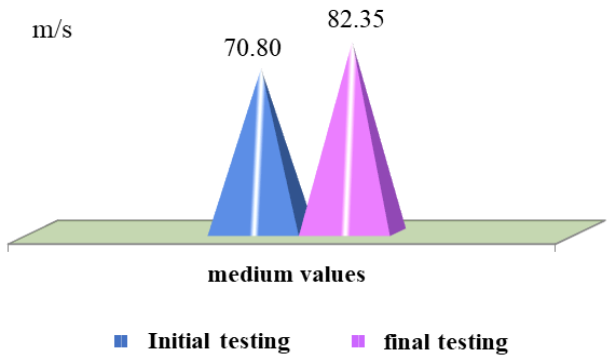


**Fig. 7.** Summary of the results of the evaluation of the efficiency factor "speed of shoot 1"

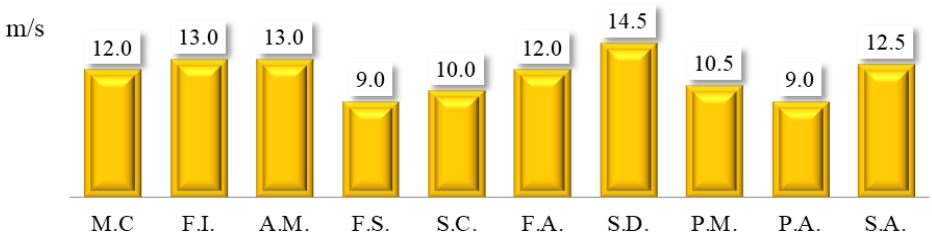


**Fig. 8**. Graphic representation of the individual progress of the speed efficiency factor

**Table 5**. Values of the efficiency factor test "speed of the forehand"

| **Statistical indicators** | T.I | T.F. | **Statistical indicators** | T.F.- | T.I. |
|---|---|---|---|---|---|
| **Average** | 61.80 | 77.95 | **Average of differences** | | 16.15 |
| **Median** | 61.00 | 78.00 | **Progress** | | 26.1% |
| **Abaterea std.** | 3.45 | 3.32 | **95% C.I.** | | (15.24 ; 17.06) |
| **Minimum** | 58 | 74 | **Standard deviation** | | 1.27 |
| **Maximum** | 70 | 86 | **The non-parametric Wilcoxon test** | Z | p |
| **Amplitude** | 12 | 12 | | -2.814 | 0.005 |
| **Coef. variability** | 5.6% | 4.3% | **Statistical indicators** | | 0.63 |

On the forehand, the speed increased in the final testing of the experimental group, on average, by 16.15 m/s. The progress achieved in developing the ability to hit with precision in the desired areas is 26.1%. With a confidence of 95% the difference of the means is in the interval (15.24 ; 17.06). The dispersion of the results is homogeneous in the case of both tests. The size of the effect is large to very large and statistically significant, p=0.005<0.05, for Z = -2.81

Synthesis

| Diff. Average | Progress | Effect size | The difference is: | The null hypothesis |
|---|---|---|---|---|
| 16.15 | 26.1% | high to very high | statistically significant | is rejected |

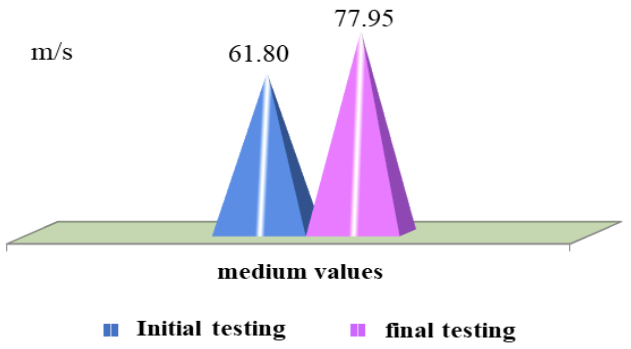


**Fig. 9.** Synthesis of the results of the evaluation of the efficiency factor of the speed of the right shoot

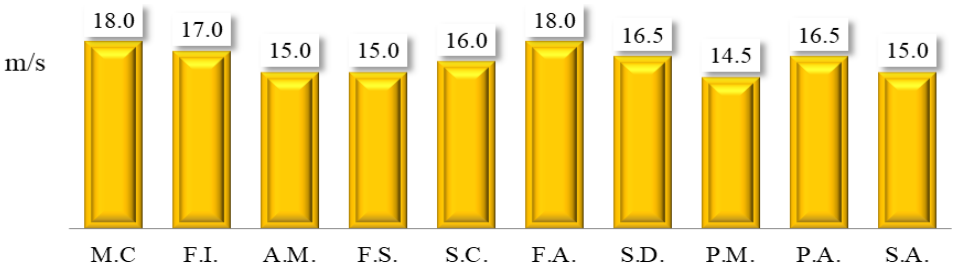


**Fig. 10.** Graphic representation of the individual progress of the speed efficiency factor

**Table 6**. Values of the efficiency factor test "speed of the backhand"

| **Statistical indicators** | T.I | T.F. | **Statistical indicators** | T.F.- | T.I. |
|---|---|---|---|---|---|
| **Average** | 58.10 | 76.55 | **Average of differences** | | 18.45 |
| **Median** | 57.50 | 76.50 | **Progress** | | 31.8% |
| **Abaterea std.** | 2.34 | 4.13 | **95% C.I.** | | (15.39 ; 21.51) |
| **Minimum** | 55 | 71 | **Standard deviation** | | 4.28 |
| **Maximum** | 63 | 84 | **The non-parametric Wilcoxon test** | Z | p |
| **Amplitude** | 8 | 14 | | -2.807 | 0.005 |
| **Coef. variability** | 4.0% | 5.4% | **Statistical indicators** | | 0.63 |

The speed of the backhand stroke increased in the final testing of the experimental group, on average, by 18.45 m/s. The progress made is 31.8%. With a confidence of 95% the difference of means is in the range (15.39 ; 21.51). The dispersion of the results recorded in both tests is homogeneous. The difference between the means is large to very large and statistically significant, p=0.005<0.05, for Z = -2.81.

Synthesis

| Diff. Average | Progress | Effect size | The difference is: | The null hypothesis |
|---|---|---|---|---|
| 18.45 | 31.8% | high to very high | statistically significant | is rejected |

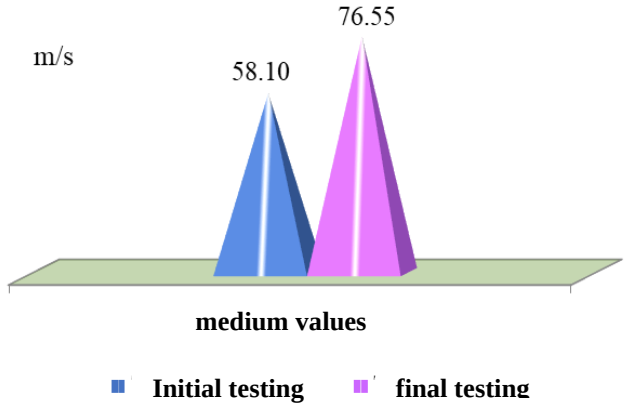


**Fig. 11.** Synthesis of the results of the evaluation of the backhand speed efficiency factor

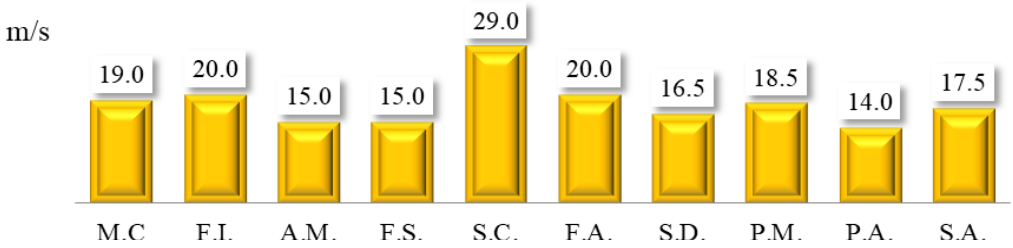


**Fig. 12.** Graphic representation of the individual progress of the speed efficiency factor

**DISCUSSIONS**

Several studies recommend medicine ball throwing (MB) and resistance training (RT) methods to increase ball speed in tennis (Fernandez-Fernandez, Ellenbecker , Sanz-Rivas , Ulbricht , Ferrauti). or overhead throwing sports (Escamilla RF, Ionno M, Scott de Mahy M, Fleisig GS, Wilk KE, Yamashiro K. 2012 & Van Den Tillaar. 2004).

The explosive strength of the upper limbs of tennis players can be effectively improved by training with the shown edicine ball. The overall speed of the tennis players also benefited, reflecting the improvement in the specific performance of the tennis players.

Following a study, following the use of aquatic training programs, (Mateescu. 2010) which aimed to develop and experiment with training programs through combined contraction schemes in water and on land, concluded that, due to the aquatic environment unstable and its resistance, water exercises involve all muscles. groups in an attempt to maintain the vertical position of the body, and the speed of execution is fast and explosive, all of which are an effective way to develop strength.

Research findings by Terraza-Rebollo M, Baiget E in 20121 on the acute and delayed effects of strength training on ball speed and accuracy in young competitive tennis players indicate that MB and RT, avoiding repetition to failure and at maximum intended execution, have no acute and delayed deleterious effects on stroke tennis performance. Therefore, it could be suggested that these two strength training methods using these protocols could be useful to train maximal and explosive strength without decreasing ball speed and accuracy and could be used before a technical session- tactics on the field or off-season, and in-season.

The results of the current study were consistent with studies by (Kobak et al., 2019; Beckham et al., 2019; Pramod et al., 2019; Falgenbaum et al., 2018; Soloman, 2018; Trajkovic et al., 2017 ; Marques; et al, 2013; Szymanski et al, 2007 Ignjatovic et al, 2012 et al, 2011) who showed that there is a positive effect of physical training programs on muscle strength (explosive strength and strength characterized by speed) , speed and strength endurance, and hence the researchers stated that programming training using traditional methods without working with modern methods cannot reach the player at the highest level of achievement.

Following a study, Pramod & Divya, 2019 states that training using medicine balls is a good way to develop muscle strength, which is an essential component of all movements and technical skills.

**CONCLUSIONS**

The body's ability to adapt to the effort is improved thanks to the versatility of the exercises applied in difficult conditions, in the aquatic environment.

Regarding the hypothesis according to which the integration in the sports training of some motor structures specific to tennis carried out in the aquatic environment can have a positive effect on the development of strength and power and the optimization of efficiency factors, especially the speed of the ball in the basic shots (serv, forehand and two-handed backhand the results of the experiments are still uncertain.

In our study we can observe that the progress of the experimental group was noticeably higher than that of the control group, the results obtained validate the research hypothesis.

Consecuetly we recommend the implementation of such a program that has beneficial effects that can be found in the performance of 10-12-year-old children.

The limitation of our study derives from the small sample of participants.

This aspect is related to the difficulties of identifying children who will accept membership in such experiments involving physical exercise for a long period of time, in a non-specific

environment, as well as their willingness to engage in intervention programs, despite the fact that they can produce positive changes in sports training.

Consequently, we recommend the implementation of means of training in the aquatic environment using physical exercises with the body's own weight and with medicine balls to optimize the performance capacity of children and juniors in the game of tennis.

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# STUDY REGARDING THE EFFECTS OF EXERCISE VARIATION IN MUSCLE THICKNESS TO IMPROVE MUSCLE STRENGTH

**Ionuț CRĂCIUN**
University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087, Oradea, e-mail: ionutucraciun@yahoo.com

**Mirela ȘTEF**[1,2*]
[1]University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087,
[2]Research Centre on Human Performance, University of Oradea, e-mail: mstef@uoradea.ro

**Marius Alin MARINĂU**[1,2]
[1]University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087,
[2]Research Centre on Human Performance, University of Oradea, Romania, e-mail: marius_marinau@yahoo.com

**Paul Florian DRAGOȘ**[1,2]
[1]University of Oradea, Department of Physical Education, Sport and Physical Therapy, 1st University street, 410087,
[2]Research Centre on Human Performance, University of Oradea, Romania, e-mail: dpaul@uoradea.ro

**Abstract:** The term "muscle confusion" has been used to describe the effects of constantly varying exercise selection as a means to provide a novel stimulus that enhances muscular adaptations. By most definitions, frequency of training pertains to the number of exercise sessions performed in a given period and is generally expressed on a weekly basis. However, another important aspect of frequency is the number of times a specific muscle group is trained over the course of a given week. Despite speculation on the topic, the optimal training frequency for a muscle group has yet to be determined. The subjects of our research are thirty healthy and physically active males from Salonta city from Romania volunteered joined for this study, with at least 2 years of experience with resistance training, 15 subjects are part of the experimental group (GExp) and 15 of the subjects are part of the control group (GCtrl). The main goal of this study was to investigate the impact of random exercise selection and range of repetitions on MT, body composition and strength, Thus, having said that, those who used the muscle confussion method experienced more consistent changes in body composition and centimeters gained on the perimetry side compared to the control group.

**Key words:** exercise variation, muscle confusion, resistance training, muscle, fitness

* * * * * *

## INTRODUCTION

It is known that the human body is a complex and intelligent machine that adapts to external stimuli in order to survive, it constantly creates adaptations to cope with different tasks in daily life or in sports training (Lopez et al. 2018; Xu et al. 2023). That is why it is recommended to use new stimuli so that the body periodically adapts to external stimuli and produces results in

* Corresponding Author

accordance with the demands of sports training or everyday professional life and activity (Baz-Valle et al. 2019; Rauch et al. 2020).

The term "muscle confusion" has been used to describe the effects of constantly varying exercise selection as a means to provide a novel stimulus that enhances muscular adaptations (Fonseca et al. 2014a; Rauch et al. 2020; Schoenfeld et al. 2016). The American College of Sports Medicine (2009) and the National Strength and Conditioning Association have advocated that changing/including exercises between microcycles can also enhance strength gains. This recommendation is based on cross-sectional surface electromyography and functional MRI data indicating that different exercises aiming to activate the same muscle group (e.g., squat and leg press exercises) may promote distinct motor unit recruitment. We may say that changing/including exercises for the same muscle group within a training routine would optimize motor unit activation of the target muscle group, thus, maximizing gains in skeletal muscle strength and CSA over a given training period (Fonseca et al. 2014b)

Resistance training (RT), muscle contraction against external weight, potently increases muscle strength and mass (hypertrophy), improves physical performance, provides a myriad of metabolic-health benefits and combats chronic disease risk (Currier et al. 2023; Phillips and Winett 2010). Proper manipulation of (RT) variables is considered essential to optimize postexercise muscular adaptations. Is well-established that (RT) as an effective method to increase muscle mass, strength and overall health in different populations (Folland and Williams 2007; Rauch et al. 2020). It has been proposed that proper manipulation of RT variables may help to optimize muscular adaptations. Practitioners can manipulate a variety of RT variables to elicit desired muscular adaptations. These include both quantitative variables, such as training volume, frequency, rest intervals or cadence and qualitative variables, such as exercise selection. As a general rule, those involved in RT programs with hypertrophy as a primary goal train each muscle group relatively infrequently but perform a high volume of work per muscle group in a session (Hackett et al. 2013; Schoenfeld et al. 2016). This is accomplished using a split-body routine (SPLIT), where multiple exercises are performed for a specific muscle group in a training bout. Compared with full-body routines, it is believed that a split routine allows total weekly training volume per muscle group to be maintained with fewer sets performed per training session and greater recovery afforded between sessions (Currier et al. 2023; Dan Alexandru Szabo 2020; Gotshalk et al. 1997; Risfandi Setyawan 2021). In addition, working a muscle with a greater training volume in the same session helps to increase intramuscular metabolic stress which in turn may enhance the hypertrophic response to the exercise bout (Kraemer and Ratamess 2004; Wernbom et al. 2007).

Although strength training (ST) has been widely recommended as an effective method to increase muscle strength and mass. Regarding the structure of an ST program, a positive relationship between training volume and gains in muscle strength and hypertrophy has been suggested supporting the concept that training volume should be increased throughout an ST program to maximize its functional and phenotypical adaptations (Fonseca et al. 2014b; Sperandei et al. 2016)

By most definitions, frequency of training pertains to the number of exercise sessions performed in a given period and is generally expressed on a weekly basis. However, another important aspect of frequency is the number of times a specific muscle group is trained over the course of a given week. Despite speculation on the topic, the optimal training frequency for a muscle group has yet to be determined (Currier et al. 2023; Gjestvang et al. 2023; Wernbom et al. 2007)

Arnold Schwarzenegger, a name with resonance in the world of fitness and bodybuilding, who throughout his career has accumulated 4 titles of "Mr.Universe", 8 titles of "Mr. Olympia" the most important and prestigious bodybuilding competition, holding some important titles in

powerlifting competitions as well, refers to the "muscle confusion" method through the famous line "shocks the muscle", a line that still resonates in the minds of young practitioners and supporters of this movements called fitness. Based on this dogma, Arnold achieved impressive results throughout his career, he managed to bring a new concept regarding the physical appearance that a bodybuilder should have (edited by Michael Butter 2011).

Dorian Yates, 7-time champion in the "Mr. Olimpia", 7 times winner of the "IFBB-Grand Prix" competition and 2 times champion of the "IFBB Night Of The Champions" competitions, a man who revolutionized the professional bodybuilding of that time with his incredible looks, made his competitors to seem small next to it. Dorian Yates, like Arnold, used the "muscle confusion" method in his training to avoid ceiling and build that impressive muscle mass. Even today, his training is structured based on this principle and in several conferences he refers to this method by saying.

The purpose of this study was, to compare the effects of a traditional training program (fixed exercises and repetition ranges) to a training program where exercises and repetition ranges were randomized on a session-by-session basis on markers of muscular adaptations (muscle confusion or exercise variation), to investigate the effects of different combinations of training intensities and exercises selection. We hypothesized that the exercise variation (random selection) would increase in muscle mass and strength.

**MATERIAL AND METHODS**

Thirty healthy and physically active males from Salonta city from Romania volunteered joined for this study, with at least 2 years of experience with resistance training. We splitit the sample in two groups, one experiment groupe (GExp) of 15 subjects (age = 18 ± 1.4 years; body-mass = 74 ± 5.1kg; body-height = 177 ± 5.3 cm; BMI = 23 ± 0.14) and 15 subjects in control groupe (GCtrl) (age = 19 ± 1.3 years; body-mass = 74 ± 10 kg; body-height = 179 ± 1,2 cm; BMI = 22 ± 0.25). Subjects were experienced with RT and were asked to refrain from any additional physical training during the experimental period. They have confirmed that they do not use anabolic steroids or any other illegal agents known to increase muscle size. Written informed consent was obtained from each participant after a thorough explanation of the testing protocol, the possible risks involved, and the right to terminate participation at will.

Training program, subjects were randomly divided into two groups, an experimental group (GExp) and a control group (GCtrl). Subjects from the GCtrl group carried out an 12-week resistance training or strength training, program consisting of 4 sets of 8 exercises performed 4 times per week. On Monday and Thursday, participants performed an upper-body workout, while on Tuesday and Friday they performed a lower-body workout, for a total of 48 RT and ST sessions. Upper body exercises in GCtrl group included latpull down, bench-press, pendlay row, shoulder press, dumbbell fly and dumbbell pull-over, while the lower body exercises included back squat, deadlift, leg press, hip thrust, leg extension and leg curl. Training load was linearly periodized by reducing the number of repetitions per set every 2 weeks, from 12RM to 6RM. See Table 1 for more details.

Subsects from GExp group they did as well a RT program with the same duration and sessions per week as GCtrl, but with exercises randomly chosen each session from a c database of 70 tipe of exercises.

All subjects took part in at least 95% of the training sessions.

Anthropometric measurements, height (cm), with help of a tallyometer or a tape measure, a scale graduated in cm can be glued to the wall and, at least, with subdivisions of 0.5 cm, body weight (kg), it is recorded in kg and sub-units of kg (from hundredths to hundredths of grams). Body Mass Index (BMI) was calculated as follows: total body mass (in kg) / stature (in $m^2$)

Body composition using InnerScan Body Composition Monitor, Tokyo, Japan, this device is safe, fast, portable, non-invasive and monitors segmented body composition analysis, differentiating between fat and muscle. Tanita's accuracy, innovation and durability are backed by extensive clinical research and an independent medical advisory board. Here we were shown both the adipose tissue in percentages and in kg, the muscle mass of these in percentages and kg, the hydration they had in the body, the bone mass, visceral fat , the degree of obesity, but also the metabolic age at which the subjects were functioning and where everything had an optimal value. We measured the circumference using a centimeter tape in (cm), neck circumference, chest circumference, abdominal circumference, suprailiac circumference, arm and forearm circumference, thigh and calf circumference, we mesurd 5 times.

Tests for measuring force: beanch press 10 RM test, dead lift 10 RM test, squat 10 RM test, Pull up max rep test, dips max rep test. On the day of the tests, the subjects had no other sports activities, apart from the daily routine

Statistical analyses, data are presented as mean with standard deviations (SD). An independent samples T-test was carried out on pre-intervention muscle thickness data to check for potential differences between groups. Cohen's d effect size (ES) with 95% CIs were calculated to analyze the magnitude of the potential pre-post intervention differences, both within and between groups. The following criteria were employed for interpreting the magnitude of the ES: trivial (<0.2), small (0.2–0.6), moderate (0.6–1.0) and large (>1.0). All calculations were performed using JASP 0.9.2 for Mac (University of Amsterdam, Netherlands). The level of significance was set as $p < 0.05$.

## RESULTS

Characteristics of the subjects, we cannot observe major differences between the initial and final testing in age and Hight (table 1), the subjects gained weight from 74 ± 5.1 to 77 ± 4.9 in GExp and 74 ±10.0 to 75 ± 8.8 GCtrl, BMI also increased in both groups from 23 ± 0.14to 23 ± 0.14 in GExp and 22 ± 0.25 to 23 ± 0.22 GCtrl,

**Table 1**. Characteristics of the subjects

| | **GExp** | | **GCtrl** | |
|---|---|---|---|---|
| | IT ± SD | FT ± SD | IT ± SD | FT ± SD |
| **Age** (**year**) | 18 ± 1.4 | 18 ± 5.4 | 19 ± 1.3 | 19 ±4.1 |
| **Hight** (cm) | 177 ± 5.3 | 178 ± 1.2 | 179 ±1.2 | 180 ±1.2 |
| **B**ody-mass (kg) | 74 ± 5.1 | 77 ± 4.9 | 74 ±10.0 | 75 ±8.8 |
| **BMI** | 23 ± 0.14 | 24 ± 0.14 | 22 ± 0.25 | 23 ± 0.22 |
| **IT** = initial test, **FT** = final test**, BMI =** Body Mass Inde**x** | | | | |

Body composition, in the initial testing, the experimental group obtains in the initial testing an average of 18 ± 4.02 % of adipose tissue in the final testing we obtain an average of 17 ± 4.9 % adipose tissue, GCtrl obtains an average of 12 ± 3.73 % of adipose tissue and in the final testing obtains an average of 12 ± 3.73 % of adipose tissue, masscle mass the GExp obtains an average of 61 ± 5.8 kilograms of muscle mass during the initial testing and in the final testing we obtain an average of 65 ± 6.2 kilograms of muscle mass, GCtrl obtains an average of 41 ± 10.74 kilograms of muscle mass, and during the final testing it obtains an average of 45 ± 10. 47 kilograms of muscle mass, bone mass GExp obtains an average of 3265 ± 249 kilograms of bone mass at the initial tests, and in the final tests we obtain an average of 3267 ± 249 kilograms of bone mass,

GCtrl in initial tests obtains an average of 3075 ± 340 kilograms of, and in the final tests it obtains an average of 3077 ± 341 kilograms of mass, for visceral fat, the device we used shows us this indicator in 5 levels, level 1 being without any risk, our subjects having nickel 1 both at the initial and final testing, we must take into account that our subjects are subjects fitness practitioners

**Table 2.** Body composition

| | **GExp** | | **GCtrl** | |
|---|---|---|---|---|
| | IT ± SD | FT ± SD | IT ± SD | FT ± SD |
| adipose tissue (%) | 18 ± 4.02 | 17 ± 4.9 | 12 ± 3.73 | 12 ± 3.73 |
| muscle mass (kg) | 61 ± 5.8 | 65 ± 6.2 | 41 ± 10.74 | 45 ± 10. 47 |
| bone mass (kg) | 3265 ± 249 | 3267 ± 249 | 3075 ± 340 | 3077 ± 341 |
| Visceral fat (lvl) | 1 ± 0 | 1 ± 0 | 1 ± 0 | 1 ± 0 |
| **IT** = initial test, **FT** = final test**,** | | | | |

Tests, the experimental group records in the IT an average of beanch press (kg) 63 ± 7.1, and in FT 76 ± 6.1 kilograms, Ctrl group it obtains in IT an average of 55 ± 10.2 kilograms, in FT 65 ± 9.763 kilograms, dead lift (kg) Exp group obtains an average of 58 ± 13 kilograms at IT, and 77 ± 15 kilograms in FT, Ctrl group obtains in IT 50 ± 14.9 kilograms, FT 63 ± 12.7 kilograms, squat (rep) Exp group obtains an average of 8 ± 3 repetitions, and 16 ± 5.7 repetitions in FT, Ctrl group obtains in IT 6 ± 3.4 repetitions and at FT 12 ± 3.3 repetitions, pull up max (rep) Exp group obtains 10 ± 2.8 repetitions, and 23 ± 6.9 repetitions at FT, Ctrl group obtains in IT 10 ± 6.1 repetitions, FT 16 ± 5.6 repetitions, dips max (kg) Exp group obtains an avarage of 56 ± 13.4 kilograms, and 83 ± 20.1 kilograms in FT, Ctrl group obtains IT 56 ± 20.1 kilograms, in FT 16 ± 5.6 kilograms (table 3).

**Table 3**. The avarage of physical test

| | **GExp** | | **GCtrl** | |
|---|---|---|---|---|
| **Tests** | IT ± SD | FT ± SD | IT ± SD | FT ± SD |
| beanch press **(kg)** | 63 ± 7.1 | 76 ± 6.1 | 55 ± 10.2 | 65 ± 9.7 |
| dead lift **(kg)** | 58 ± 13 | 77 ± 15 | 50 ± 14.9 | 63 ± 12.7 |
| **S**quat **(rep)** | 8 ± 3 | 16 ± 5.7 | 6 ± 3.4 | 12 ± 3.3 |
| Pull up max **(rep)** | 10 ± 2.8 | 23 ± 6.9 | 10 ± 6.1 | 16 ± 5.6 |
| dips max **(kg)** | 56 ± 13.4 | 83 ± 20.1 | 56 ± 20.1 | 72 ± 23.3 |
| **IT** = initial test, **FT** = final test | | | | |

Effect size (ES) the experimental group obtains a high ES value, namely 1.9 for the beanch press test with the chest barbell, and the control group obtains an average value, namely 0.7. For the barbell squat test, the experimental group obtains a large ES namely 0.14 and the control group obtains a large effect namely 0.8. For the traction test at the fixed bar g. Experiment

obtains a high ES namely 1.8 as well as in the case of the control group but the value is 1.7. For the test of parallel push-ups g.

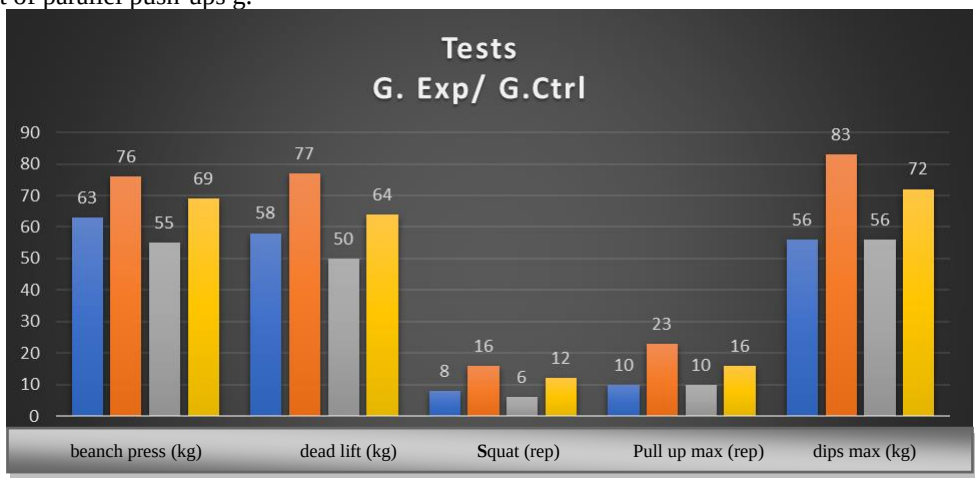


**Figure 1**. The avarage of physical test

The experiment obtains a high EF of 2.6 and the control group also obtains a high EF with the value of 1 and for the test of straightening with the standing barbell g. The experiment obtains a high EF of 1 and the control group obtains a certain average EF, 0.6. (fig. 2)

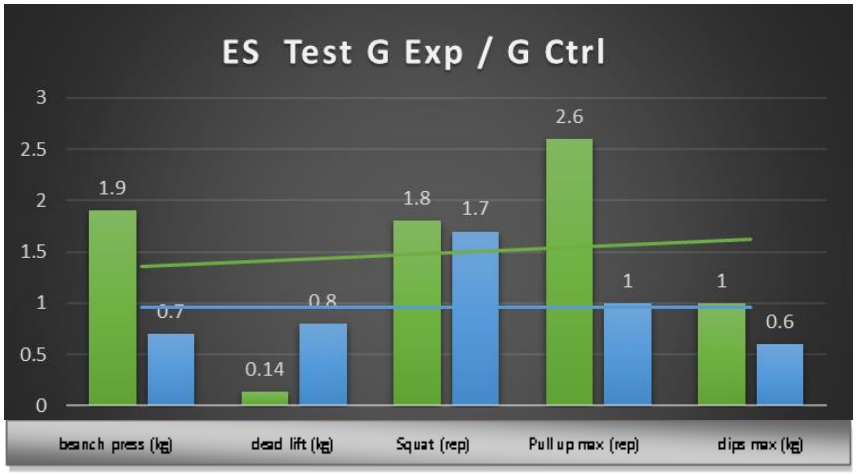


**Figure 2.** Effect size in physical tests

Effect size (ES) on segment circumference measurements in the case of the experimental group we obtain an ES of 0.6 and the control group obtains a value of 0 for the neck perimeter, for the chest perimeter in the experimental group we obtain an ES value of 1.5 and for the control group a value of 0.2, the abdominal circumference has an ES value of 0.2 and in the case of the control group we have the value 0, the iliac circumference has an ES value of 0.2 for the experimental group and for the control group the value is 0. The arm circumference has a value of 1.5 for the experimental group and 0.3 for the control group, the forearm perimeter has an ES value of 1.5 for the experimental group and for the control group the value of 0.5. The thigh

circumference for the experimental group has an ES value of 0.7 and for the control group the value of 0.2, the calf circumference has an ES value of 0.9 and the value for the control group is 0.

In case of experimental groups, the ES value is medium for neck circumference, high for chest circumference, low for abdominal circumference, low for iliac circumference, high for arm and forearm circumference, medium for thigh circumference and high for calf circumference.

In the control group, ES value is small for neck circumference, small for chest circumference, small for abdominal circumference, small for iliac circumference, medium for arm circumference, medium for forearm circumference, small for thigh circumference and small for calf circumference (Fig. 3).

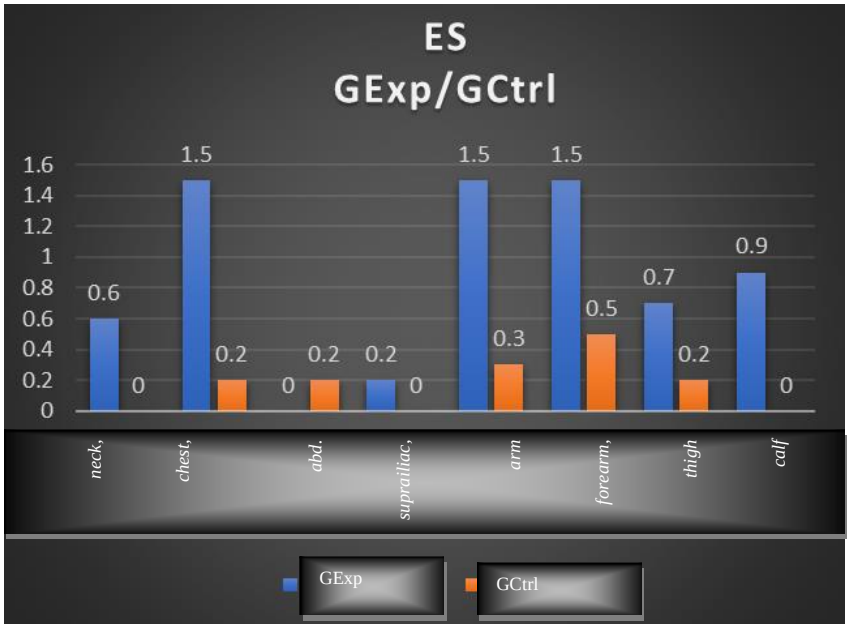


**Figure 4**. Effect size, circumference measurements

**CONCLUSIONS AND DISCUTIONS**

The main goal of this study was to investigate the impact of random exercise selection and range of repetitions on MT, body composition and strength.

We can see a progress after our study, the seame resolts we can observ in 2 sutdies of Fonesca from 2014 through this study, researchers investigated the correlation between exercise modification and increases in strength and muscle mass by measuring the transverse diameter of the thigh muscles and using the 1 MR test. Depending on how they used exercise, they divided the 49 subjects into 5 groups: constant intensity and constant exercise (CICE), constant intensity and varied exercise (CIVE), varied intensity and constant exercise (VICE), varied intensity and varied exercise (VIVE) and control group (C). Following the final results of the study, the cross-sectional area of the whole quadriceps muscle (CSA) increased significantly in all experimental groups from the initial testing to the final testing, in both the right and left leg: CICE: 11.6 and 12.0% ($p < 0.0001$); CIVE: 11.6 and 12.2% ($p < 0.0001$); VICE: 9.5 and 9.3% ($p < 0.0001$) and VIVE: 9.9 and 11.6% respectively ($p < 0.0001$). Comparisons between groups demonstrated that all experimental groups increased quadriceps cross section compared to group C ($p \leq 0.02$). There were no +differences in muscle CSA for group C after training ($p > 0.05$).(Fonseca et al. 2014b)

Also Eneko Baz-Valle in 2019 shows both conditions promoted large, statistically significant increases in the bench press and back-squat 1 repetition maximum without differences between groups. Muscle thickness (MT) measures for the individual quadriceps showed large, statistically significant increases in of the vastus lateralis and rectus femoris for both conditions, with no observed between-group differences. Although no between-group in MT were noted for the vastus intermedius, only the CON displayed significant increases from baseline. Participants in EXP showed a significant, moderate improvement in the intrinsic motivation to training, while participants in the CON group presented non-significant decreases in this variable..(Baz-Valle et al. 2019)

Rauch et al., 2020 who compared performing a predetermined list of exercises to self-selecting exercises based on individual preferences. Findings showed no between-group differences in LBM (as measured by DXA), although only the group that self-selected exercises showed significant increases from pre- to post-study. These results somewhat deviate from those in our study.

Our study had a few limitations that should be acknowledged. Finally we can compare the test measurements of the two groups in terms of effect size (ES), the experimental group has in terms of perimetry, 6 perimeters that have a biger effect size compared to the control group has effect sizes " medium' or 'small'.

For the force measurement tests the experimental group obtains 4 biger effect sizes and the control group obtains 5 biger effect sizes.

Looking at the perimetry graphs, the experimental group manages to outperform the control group in terms of centimeter gain and centimeter loss for iliac and abdominal circumferences.

As for body composition, the experimental group obtains higher scores and changes than the experimental group.

Thus, having said that, those who used the muscle confussion method experienced more consistent changes in body composition and centimeters gained on the perimetry side compared to the control group, instead on the strength side, even if the difference is only 1 effect size we can say that those who did not change their training had a higher ES than those who changed their training plans.

One thing observed during the study is that those who changed the workouts experienced a more pronounced "pumping" sensation which generated more enthusiasm and interest during the workouts compared to those who stayed with the same workout and supported at some point that training is boring and tedious.

We can said that, the training method can be considered to be effective in terms of gaining muscle mass and losing fat, and even for the development of several manifestations of strength motor quality.

Finally we can say that the hypothesis of the present study is confirmed.

We can say that, the rotation of exercises was performed randomly, without attention to individual needs and abilities. Individualized programming in which exercise selection is carefully manipulated to account for biomechanical, physiological, and anthropometric factors may further enhance muscle adaptations.

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