THE EFFECTS OF PROPRIOCEPTIVE TRAINING ON THE SPEED OF ASSUMPTION OF GYMNASTIC ELEMENTS IN CHILDREN OF PRIMARY SCHOOL AGE

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Summary: The research studied the influence of experimental proprioceptive training on the speed of acquisition of selected gymnastic elements on beam in elementary school students. The results showed that the experimental treatment had a positive effect on the faster mastering of the technical elements of the gymnastic all-around on the beam. The t-test and Wilcoxon test confirmed a statistically significant difference between the experimental and control groups at a significance level of 0.01. The experimental treatment had a statistically significant effect on the speed of acquisition of gymnastic elements performed in dynamic balance, such as different types of turns. On the other hand, it did not have a statistically significant effect on the speed of adoption of static elements such as front balance and high forefoot, which proved to be easier to master. The research concludes that the experimental proprioceptive training constructed in this way can be offered as an effective training tool in working with children of elementary school age, and that it will have positive effects on the speed of acquisition of gymnastic elements and the motor ability of balance. A longer period of application of the treatment is recommended to achieve an even stronger effect.

Keywords: gymnastics, balance, proprioception, experimental treatment

INTRODUCTION

Motion is a fundamental property that permeates everything in the cosmos, including the movement of people, planets, plants, seas, animals, and more. People's movements and actions are the result of both internal (eg energy, motivation) and external (eg social environment, physical laws) factors (Warburton et al., 2006). The biological determination of movement represents a positive influence on the functioning of love and life, especially in the era of increased hypokinesia (physical inactivity) due to a sedentary lifestyle and other reasons. The development of sports in the broadest sense has progressed from elementary to the most complex, intricately constructed forms of movement. When we look back, we find simpler elements in games and exercises, such as sports gymnastics, where progress has reached the point of risk for the athletes themselves (Fulurija & Jovanović, 2019). Extraordinary achievements in athletics and swimming are often called "miracles of human possibility." In order to reach and maintain such heights, new methods, forms and means must be invented, which in turn drives further research and exploration of basic and specific movement skills, ultimately improving the sport as a whole. Research on different influences on motor status, whether cross-sectional or longitudinal, is important and welcome, especially studies focused on school-aged children. One of the motor skills that can be influenced in that period is balance. Of all the definitions of balance, the definition that says that "balance plays a significant role in achieving balance positions has vestibular, kinesthetic, tactile and optical analyzers, and the size of the support surface, the height of the body's center of gravity and the position of free parts are responsible for the complexity and difficulty of the balance position." bodies" (Gatrell et al., 2013). Or the definition from Ljubojević et al. (2012): "balance is the basic motor ability to maintain the body in a balanced stance (position), but also the motor ability to maintain a stable position (posture) of the body in various poses and movements". Regardless of the definition, in practice it has been established that balance is greatly influenced by the sense of sight, i.e. that balance manifests itself differently with open and closed eyes (Ogard, 2011). In addition to these, other factors have been determined that have a greater influence on the quality and ability of balance: genetic determination, condition of the vestibular apparatus, age, support surface, height of the body's center of gravity, number of motor habits, training, strength, coordination, flexibility, emotional state (Kayapnar , 2011). Looking in more detail, it can be seen that the physiological aspect of balance is present in several factors, i.e. neurophysiological processes and mechanisms (kinesthetic analyzers, vestibular apparatus, visual analyzers, tactile analyzers). Kinesthetic sensation, which enables awareness of body position and movement without visual cues, is an important aspect of proprioception (Wolf-Cvitak et al., 2002). Proprioceptors are sensors that inform the brain about one's own movements and gestures.They respond to changes in muscle stretch and tension, sending information to regulate the strength and timing of muscle contractions for coordinated movements (Taube et al., 2008).

Proprioceptors are found in joints, skeletal muscles, tendons, and the inner ear. The proprioceptive system functions both on a conscious (enables proper functioning of the locomotor system) and on a subconscious level (maintains muscle tone, balance and joint stabilization). Various receptors, including muscle spindles, Pacinian bodies, and Ruffini endings, work together to determine limb position and speed of movement. Proprioception is a complex process that involves the transmission of information through afferent and efferent pathways of the nervous system (Laskowski, 2001). The most important fact in the process of developing and developing balance is that propriceptive processes can be perfected through exercise and training. Proprioceptive training has become an important part of preventive and developmental fitness programs and injury rehabilitation (Irrgang et al., 1994; Aman et al., 2015; Rivera et al., 2017). Certain studies have shown the effectiveness of proprioceptive training in improving balance (Blackburn et al., 2000; Kollmitzer et al., 2000; Eils & Rosenbaum, 2001; Malliou et al., 2004; Bordoloi & Sharma, 2012; Martínez-Amat et al., 2013; Karakaya et al., 2015; Alahmari et al., 2021), strengths (Blackburn et al., 2000; Bordoloi, et al., 2012; Winter et al., 2022) and other motor skills of athletes (Tropp & Askling, 1988; Ergen & Ulkar, 2007; Aman, et al., 2015) for both injured and uninjured people. This training aims to improve spinal protective reflexes and activation of stabilizer muscles that help prevent injuries (Robbins & Waked, 1998; Vengust et al., 2001).

In short, proprioception is a key sensory system that provides the brain with information about body position and movement, enabling coordinated, stable, and efficient motor control (Wong et al., 2012; Aman et al., 2015; Yılmaz et al., 2024). Targeted proprioceptive training has emerged as an important component of sports preparation and injury prevention programs. Activities on unstable surfaces and plyometric exercises are used to activate muscles that stimulate joint structures and produce reflex joint stabilization (Schiftan et al., 2015; Riva et al., 2016). Types of proprioceptive training can be divided into several groups: on balance boards; on airbags; on balls of different sizes, weights and materials; on cylindrical and semi-cylindrical surfaces; on trampolines and soft mats; on narrow walking surfaces (e.g. gymnastic beam), etc. The general methodical principles of proprioceptive training can be explained by the use of balance boards (Šalaj et al., 2007) and refer to the fact that regardless of the activity of these contents, they must not endanger the safety of the athlete, they should be challenging and interesting, during exercise it is necessary to engage as much as possible sensory systems (visual, auditory, tactile), it is desirable to combine elementary and specific forms of movement. The basis of functional progression refers to the choice of exercises: from slow to faster, from simple to complex, from known to unknown, from static to dynamic, from those with less pronounced force to those with high force, from exercises performed with one extremity to those performed with both limbs, in stable and unstable conditions, with eyes open and closed, without and with additional external loads, without and with manipulation of objects, without and with disturbance of balance, extended and contracted limbs (Kraemer & Ratamess, 2004).

Exercises for developing balance (including proprioceptive training) should be started in early school, even preschool age. There are numerous games and adapted exercises for children, such as climbing up and down the slope, dances, elements of rhythmic and sports gymnastics on the beam, floor and similar. The aim of this research is to determine the impact of a programmed experimental program of proprioceptive training on the speed of acquiring certain motor exercises, in this case selected elements on the beam.

METHODS

Sample of participants

The sample of participants consists of students of the primary school Dr. Aleš Bebler - Primož Hrvatini, fourth grade in the Republic of Slovenia. The students were chosen by the method of random selection. The experiment was conducted in a physical education room, which is equipped according to all European standards. The students who started participating in the program completed the research. The experimental group consisted of 20 students and 20 students of the control group. The students who were selected as a sample of participants had never practiced gymnastics.

Variables

The sample of variables consists of one criterion variable - the speed of acquisition of elements and five predictor variables (static balance by walking, dynamic balance by turning on two legs, dynamic balance by turning on one leg, static balance by forefoot, dynamic balance by turning while walking). The criterion variable is represented by the number of repetitions to a technically correctly executed element. The maximum number of repetitions is 10, the minimum is 1, which gives the speed of acquisition of the elements on the beam, that is, from which attempt the test taker successfully performed the test. To test the first predictor variable, the test was used - "Front scale on the beam" element technique: which is performed from the initial position: upright foot position (with the leg that will go into the foot position), laterally in relation to the beam (along the length of the beam), suspension. The examinee starts the movement by first stretching the trailing leg, then slowly performs a forward bend and after reaching the horizontal position of the body, continues with stretching to the maximum ability of the student. The forward bend is guided by the movement of the chest, with the shoulder blades together and the head high in a slight shelter. Endurance is calculated from the moment when the body has calmed down, i.e. reached the position of the scales. This is followed by bowing (raising the torso) and lowering the leg to a forefoot or hindfoot position with one leg. The final position is the legged upright position - renunciation. Respondents can choose on which leg they will perform the element, i.e. which will be their working leg and which will be their free leg. To test the second predictor variable, the technique test of the element "Solar turn for 180^0 on the beam" was used: The subject performs the element from the initial position: standing upright and divergent (one leg is in front of the other leg) handstand. The movement continues through a single-legged ascent and at the same time a swing with the arms into a lunge position, followed by a 180^0 turn to the side in the direction of the rear leg and the back in the direction of the turn. After the completed rotation by 180^0, he ascends (descends to the entire foot of both legs) and disassociates again. All the time, the weight of the subject's body should be equally distributed on both legs. The final position is the same as the initial position. To examine the third predictor variable, a test was used - "Turn on one leg for 180^0 on the beam" element technique: The subject performs the element from the starting position: front-leg stance. By reflecting from one leg, the weight of the body is transferred to the other leg (on which the rotation will be performed, that leg is called the working leg) in the ascent and at the same time he performs a swing with the arm until the front hand is bent. During the rotation, the free leg is fixed by the foreleg crouched against the ankle joint of the working leg and simultaneously rotates on the working leg by 180^0. At the end of the turn, he lowers the working leg to the entire foot, and keeps the free leg in a forefoot position, renunciation (final position). To examine the fourth predictor variable, a test was used - "High forefoot on beam" element technique. The examinee performs the element from the starting position, stance: forefoot with one leg, renunciation.By transferring the weight of the body to the foreleg, the examinee should strongly swing the other (working) leg next to the beam to a high foreleg and connected to the foreleg stance. The movement continues with the transfer of the body weight to the foreleg and a strong swing of the other leg to a high foreleg, and connected to the foreleg position (starting position). To examine the fifth predictor variable, the test - Element technique "Turn with step on the beam" was used. The examinee performs the element from the starting position: front leg stance once, renunciation. By transferring the weight of the body to the other leg and rotating around the same leg by 180^0, the examinee goes through the leg position and then continues the movement through a turn to the same side - by transferring the weight to the front leg and performs a 180^0 turn again to the leg position (initial position).

Experimental program

The experimental program was independently programmed in such a way that three proprioceptive exercises were applied in each training session (table 1). Each exercise was repeated at least 10 times, with a break between proprioceptive exercises of three minutes. In this way, the subjects effectively exercised for twenty minutes at each training session, which on a weekly basis amounts to an hour.

Table 1. Content of the experimental program

1.A WEEK	
1.Training	Squat with both legs on a balance ball, Three steps to the side laterally with a stop and stabilization, Raise on toes on a trampoline.
2.Training	Endurance (plank) on a balance ball, Lateral walking with an elastic band, One-legged squat on an unstable surface.
3.Training	Glute bridge on a balance ball, One-legged standing with eyes closed, One-legged side hops.
2.A WEEK	
4.Training	High jump with stabilization on one leg, Back lunge with knee lift on an unstable surface, Trunk rotation on balance ball with medicine ball.
5.Training	One-legged stand on the balance board, Squat with jump on the trampoline, Jumps forward and back with stabilization.
6.Training	Endurance in a lateral position on a balance ball, Stepping forward on an unstable surface, Standing on one leg while circling the head left - right.
3.A WEEK	
7.Training	Squat with both legs on a balance ball, Three steps to the side laterally with stop and stabilization, ,Lifting on toes on a trampoline.
8.Training	Endurance (plank) on a balance ball, Lateral walking with an elastic band, One-legged squat on an unstable surface.
9.Training	Glute bridge on a balance ball, One-legged standing with eyes closed, One-legged side hops.
4.A WEEK	
10.Training	High jump with stabilization on one leg, Back lunge with knee lift on an unstable surface, Trunk rotation on balance ball with medicine ball.
11.Training	One-legged stand on the balance board, Squat with jumping on the trampoline, Jumps forward and backward with stabilization.
12.Training	Endurance in a lateral position on a balance ball, Stepping forward on an

	unstable surface, Standing on one leg while circling the head left - right.
5.A WEEK	
13.Training	Squat with both legs on a balance ball, Three steps to the side laterally with a stop and stabilization, Raise on toes on a trampoline.
14.Training	Endurance (plank) on a balance ball, Lateral walking with an elastic band, One-legged squat on an unstable surface.
15.Training	Glute bridge on a balance ball, One-legged standing with eyes closed, One-legged side hops.
6.A WEEK	
16.Training	High jump with stabilization on one leg, Back lunge with knee lift on an unstable surface, Trunk rotation on balance ball with medicine ball.
17.Training	One-legged stand on the balance board, Squat with jumping on the trampoline, Jumps forward and backward with stabilization.
18.Training	Endurance in a lateral position on a balance ball, Stepping forward on an unstable surface, Standing on one leg while turning the head left - right.

Statistical data processing

For the purpose of data processing, the statistical program MATLAB was used, within which descriptive statistics were processed, which obtained basic statistical parameters such as the mean value, standard deviation, skewness and kurtosis, which tested the normality of the distribution, etc., and the parametric statistical method, T - test and non-parametric statistical method - Wilcoxon test to determine the difference between the experimental and control groups.

RESULTS

Table 2. The number of repetitions performed to a satisfactory performance technique

EX.GR	1.PV	2. PV	3. PV	4. PV	5. PV	CON.GR	1. PV	2. PV	3. PV	4. PV	5. PV
1	3	2	4	1	2		2	1	1	2	1
2	1	3	3	1	4		1	3	3	1	4
3	4	2	6	2	3		1	4	4	3	4
4	2	3	1	3	1		3	3	4	3	3
5	3	2	4	2	4		2	5	5	3	4
6	3	4	3	3	3		3	6	5	4	5
7	1	2	4	4	3		2	4	5	3	3
8	2	1	2	3	2		3	5	5	4	5
9	2	1	4	1	2		2	3	4	2	5
10	1	2	2	2	2		4	3	3	1	5
11	3	2	4	1	2		2	1	1	2	1
12	1	3	3	1	4		1	3	3	1	4
13	4	2	6	2	3		1	4	4	3	4
14	2	3	1	3	1		3	3	4	3	3
15	3	2	4	2	4		2	5	5	3	4
16	3	4	3	3	3		3	6	5	4	5
17	1	2	4	4	3		2	4	5	3	3
18	2	1	2	3	2		3	5	5	4	5
19	2	1	4	1	2		2	3	4	2	5
20	1	2	2	2	2		4	3	3	1	5

EKS.GR.-experimental group, KON. GR.- Control group, 1 PV - first predictor variable, 2 PV second predictor variable, 3 PV third predictor variable, 4 PV - fourth predictor variable, 5 PV - fifth predictor variable.

Table 2 shows the test subjects of the experimental and control groups with the number of repetitions to the correctly performed element on the beam. Subjects of the experimental group managed to master the element "Front scales on the beam" with the first attempt, six of them, with two attempts of six subjects, with three attempts of six subjects and with four attempts of two subjects. The subjects of the control group were able to perform the same element correctly from the first attempt: four of them, with two attempts, eight of them, six of them with three attempts, and only two with 4 repetitions. "Turn 180^0 on the beam" in the experimental group with only one attempt was performed correctly by four subjects, in the second attempt by ten of them, in the third attempt by four of them and in the fourth attempt by only two subjects of the experimental group. The same element control group respondents from the first attempt only two respondents, from the second none, from the third eight respondents, from the fourth attempt four respondents, from the fifth attempt four and from the sixth two. The element "180^0 turn on one leg on the beam in the experimental group was performed by two subjects from the first attempt, from the second four, from the third four, from the fourth eight and from the fifth none, and from the sixth two. The same element was performed correctly by two of the subjects of the control group from the first attempt, from the second attempt none, from the third four, from the fourth six, from the fifth seven. The element "High forefoot on the beam" in the experimental group was performed by six of them on the first attempt, six on the second, six on the third, and two on the fourth. Four of the subjects of the control group successfully performed the element from the first attempt, three from the second, eight from the third and three from the fourth. The element "Turn with step on the beam" was successful from the first attempt in the experimental group by two subjects, from the second attempt seven, from the third six and from the fourth attempt four. In the control group, the same element was performed by two subjects on the first attempt, none on the second, four on the third, five on the fourth, and eight on the fifth attempt. From these two tables, it can be seen that the subjects of the control group needed a greater number of attempts for certain elements such as turns.

Table 3. Descriptive statistics for subjects from the experimental and control groups

EX. GR.	**20**	**20**	**20**	**20**	**20**	**CON.GR.**	**20**	**20**	**20**	**20**	**20**
Mean	2,2	2,2	3,3	2,2	2,6		2,3	3,7	3,9	2,6	3,9
Median	2	2	3,5	2	2,5		2	3,5	4	3	4
Min	1	1	1	1	1		1	1	1	1	1
Max	4	4	6	4	4		4	6	5	4	5
Std	1,0	0,9	1,4	1,0	0,9		0,9	1,4	1,3	1,0	1,3
Skew	0,2	0,5	0,2	0,2	0,1		0,2	-0,2	-1,2	-0,3	-1,2
Kurt	-1,0	0,0	0,0	-1,0	-0,8		-0,6	0,0	1,0	-1,0	1,0

EKS.GR.- experimental group, CON.GR.-control group, MIN-minimum, MAX-maximum, STD-standard deviation, SKEW-skunis, KURT-kurtosis.

By looking at the results of Table 3, it can be said that both distributions are normal, without being skewed to one side. Only in the variable 180^0 turn on one leg and turn with a step in the experimental group, the results show a little more spiciness, and in the control group a little more flattening.

Table 4. T-test results

n1	20
n2	20
t	-5,2691
sd	0,5905
α	0,05
p	1,09E-05

Table 5. Wilcoxon test results

n1	20
n2	20
z	-3,9035
Rank sum	162
α	0,05
p	9,48E-05

T-test and Wilcoxon test were used to determine the differences between groups, which is shown in Tables 4 and 5. The T-test value -5.2691 shows the difference between the average of the two groups in relation to the variation in the data. A negative T-test value indicates that the average value of the experimental group is lower than the average value of the control group. The standard deviation of 0.5905 is a measure of the variability in the data between the two groups. The level of significance (a) is 0.05, which means that it can be claimed with 95% certainty that the data is exactly that. In the last row of the table, the level of significance is shown in exponential format, and the value 1.09 E-05 means 0.0000109, which is significantly less than 0.05. The p value is far less than the alpha level of 0.05 which means that the difference between the mean of the experimental and control groups is statistically significant. In this regard, we can claim that the experimental program in the experimental group had a statistically significant impact on the performance of gymnastic elements on the beam.

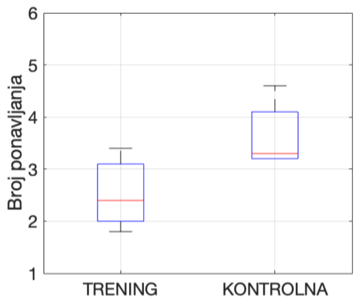
The results of the Wilcoxon test are used to test for differences between two independent groups (in this case experimental and control) when the normality of the data distribution cannot be assumed. A Z value of -3.9035 indicates how different the ranks of one group are from the ranks of the other group in standard deviations. A negative sign indicates that the ranks of one group (experimental) have lower values than the other (control). The total sum of the ranks is 162, and the significance level is 0.05, which again indicates the existence of a statistically significant difference between the ranks in the two groups. The value of pu in exponential format is 0.0000948, which is significantly less than 0.01. From all of the above, it can be concluded that both tests for testing the significance of differences between independent samples showed the existence of a statistically significant difference between the experimental and control groups at the significance level of 0.01.

Table 6. Independent samples t-test for each exercise individually

	t	**sd**	**α**	**p**
1.variable -PVG	-0,7454	0,9487	0,05	0,4619
2.variable-O180	-5,5205	1,0247	0,05	5,36E-06
3.variable-O180J	-2,6656	1,1937	0,05	0,0123
4.variable-VP	-1,1448	0,9265	0,05	0,2613
5.variable-TURN SP	-5,653	0,8756	0,05	3,69E-06

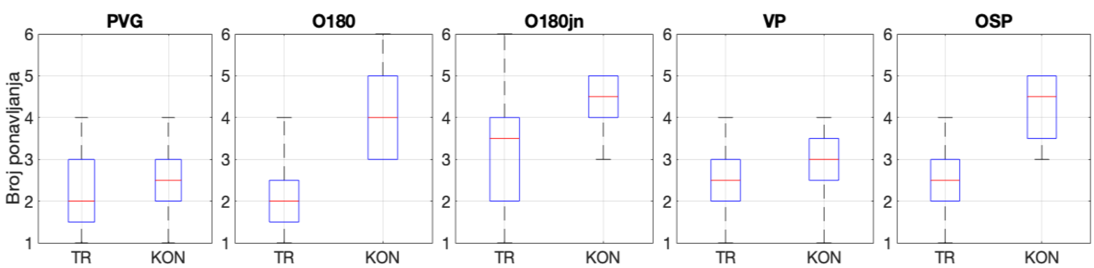
Table 6 shows the T-test for each individual variable, and the results show that there is a statistically significant difference at the 0.05 level for all variables, while the exponential value p indicates that the second, third and fifth variables are highly statistically significantly different between the experimental and control group.

Chart 1. Graphic representation of the experimental and control groups in relation to the speed of adoption of the entire set of predictor variables



On graph 1, it is noticeable that there is a difference between the experimental group and the control group in relation to the number of repetitions, because the subjects of the experimental group successfully performed the technical gymnastic element from a smaller number of attempts than the control group.

Chart 2. Graphical representation of the experimental and control groups in relation to the rate of adoption for each variable separately



As in the first graph, it is clearly visible in the second that certain variables from the set of predictor variables in both the experimental and control groups had results that did not differ greatly in the number of attempts to correctly perform the element. Such is the case with the first and fourth variables. With the third variable, the difference is visible, but not as much as with the second and fifth variables. All of this points to the fact that both methods, the parametric T-test and the non-parametric Wilcoxon test, determined a statistically significant difference in the set of predictor variables compared to the criteria in the experimental group.

DISCUSSION

The research, which was conducted in the real conditions of a city school, with students of the fourth grade of elementary school age, who had never been involved in sports gymnastics, and aimed to determine whether there is a positive influence of the constructed experimental program of proprioception on the speed of acquisition of gymnastic elements in specific conditions on a reduced support surface, in this case on a beam. In this way, it was possible to indirectly draw conclusions about the influence of proprioceptive experimental treatment on balance, however, this was not the primary goal of this research. The subjects were divided into two groups, by random selection (experimental and control), where the experimental group, in addition to regular physical education classes for six weeks, participated three times during the working week for twenty minutes in a training that influenced proprioception. The control group had only physical education classes. At the end of the experimental treatment, the students were given together to see and perform certain gymnastic elements for the first time, and the number of attempts to perform a technically correct gymnastic element was recorded. After the subjects of both groups were tested, it was determined that between the experimental and control groups there is a statistically significant difference in favor of the experimental group in the speed of adopting the elements of gymnastics on the beam, which balance is achieved in static or dynamic conditions. It was also determined that in certain variables there is a statistically significant difference in the speed of execution of the elements of the subjects of the experimental group compared to the control group. Thus, it was determined that in all dynamic tests (elements of all three turns on the beam - on both legs, on one leg and with a stepover), the treatment showed a stronger influence on them than static gymnastic elements (front balance and high forefoot on the beam). Although the experimental treatment lasted only six weeks, i.e. a total of six hours of effective work divided into 18 trainings, it still had a significant impact on the criterion variable - the speed of learning gymnastic elements. In this regard, it can be stated that even such short-term but intensive programs are applicable in physical education classes, as well as in sections of free activities of elementary school children. If we add to that the beneficial effect of proprioceptive stimuli on injury prevention and faster recovery of convalescents, experimental programs are an important content in classes. The obtained results are in accordance with the results obtained in the research conducted by Malliou et al. (2004), Emery et al. (2005), Romero-Franco et al. (2012), Martínez-Amat et al. (2013), Dobrijević et al. (2016), Pinzón-Romero et al. (2019), Ferlinc et al. (2019).

CONCLUSION

From the conducted research and the obtained results, it can be concluded that the experimental treatment had a positive effect on the faster mastering of the technical elements of the gymnastic all-around on the beam. It can also be concluded that the experimental treatment constructed in this way can be offered as an effective training tool in working with children of elementary school age, and that it will have a positive impact on the speed of acquisition of the mentioned gymnastic elements, as well as on the motor ability and balance. Of course, a longer period of application of this treatment can be recommended, which will certainly have an even stronger, more significant impact. In accordance with the above, the results showed that the experimental proprioceptive training program had a statistically significant effect on the speed of adoption of the selected set of predictor variables (selected gymnastic elements). Also, the experimental treatment had a statistically significant effect on the speed of acquisition of gymnastic elements on the beam performed in dynamic balance, that is, turns. On the other hand, the experimental treatment did not have a statistically significant effect on the speed of adoption of elements of the front scale and high forefoot. It can be concluded that the static gymnastic elements, such as the front balance and high forefoot, are easier to master and that the students learn them faster than the dynamic gymnastic elements, such as the different types of turns used in this experiment. Finally, we should mention as no less important the fact that all respondents from the experimental as well as the control group expressed their desire to do similar programs again. The innovative program interested them and enriched their motor stereotypes of movement in a specific way.

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