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IMPROVING PRECISE MOVEMENTS TEACHING TECHNIQUE IN PHYSICAL EDUCATION

The research is focused on examining the reliability of functioning and reserves of the control system of the movements with different coordination structure. The research sample consisted of 136 female students (age: 17-19). They were divided into 2 groups – control and experimental. The program aiming to increase the reliability and reserves of movement control system was implemented during Physical Education classes in the experimental group. The technique is based on physical exercises of complicated coordination with novelty elements executed with music background. The experimental program had a positive effect on the motor function of the experimental group students. The improvement of precise movements control in the EG was characterized by an increase of motor regulation quality, quick transition to the programmed mechanism of regulation under stable conditions of movements execution, as well as by an uprating of compensatory adjustment in order to maintain reliability of the motor function under the influence of confounding factors. The above mentioned indicates the increase in the reserve capabilities of the motion control system and serves as the criteria for these reserves.

Keywords: female students, management, precise movements, sensory deprivation, compensatory reactions, physical education.

Introduction

One of the key issues in systemic physiology and physical education is the problem of improving functional reserves (FR) of the human body in muscle activity. It covers various aspects of the integral activity of the human body (Bosenko et al., 2013; Mozzhukhin, 1988; Davidenko, 1990; Mishchenko, 1990; Radzievsky, 2002), among which the problem of the motion control system reserves is the least studied (Golubev, 1987; Davidenko, 1990; Dotsenko, 2004; Pryimakov, 2010).

Despite the fact that the general principles and mechanisms of motion control are reflected in the works of scientists (Bernstein, 1947; Gurfinkel, 1990; Donskoy, 1990; Ghez, 1985; Enoka, 1994), the issues of improving reliability and quality of motion control in extreme conditions of muscle activity by individuals of different age, sex, sport specialization, physical fitness (Golubev, 1987; Pryimakov, 2010; Becker, 2015), as well as for people with deviations in health (Dotsenko, 2011, Yukhimenko, 2007; Pryimakov, 2017) are still understudied.

A number of works (Bernstein, 1947; Donskoy, 1991; Dotsenko, 2004; Neumaier, 2003; Roth, 2009) demonstrate that the reserves of control systems for voluntary movements are related to the power of coordination mechanisms. However, the assessment of these re-

serves' "power", the sustainability of movements coordination structure maintaining mechanisms at the proper level under conditions of sports activities is not sufficiently examined.

The study of mechanisms for the implementation of motor programs in extreme conditions of muscle activity, increasing fatigue, the action of confounding factors and interference is relevant for the disclosure of motion control systems reserves, effective management of the training process, maintaining high performance, reliability of motor regulation, and resistance to fatigue.

Aim and Tasks

The paper aims to present the ways of improving the technique of teaching precise movements and increasing the reliability of their performance in terms of physical education.

The following tasks were addressed: 1) studying mechanisms and ways to improve the reliability of precise movements control; 2) investigating the level of reliability of movement control in students and the effectiveness of the developed methodology for its improvement in the process of physical education at universities.

Research Hypothesis

The hypothesis implies that the increase in the reliability of controlling movements of different coordination

structure in physical education and sports is associated with the accumulation of various equivalent (interchangeable) ways of the motor program implementation in the complicated conditions of muscle activity.

Research Methods

In this work, we used available, relatively simple research methods (including instrumental ones) (Sergienko, 2001, Raczek, 2003), using which we examined female students' (from 17 to 19 years old) reserves of movement control system under conditions of sensory limitations and interference. 136 female students (State University of Telecommunications and the National University of Railway Transport, not engaged in sports) were divided into a control group (CG) and an experimental (EG) group.

Students of the CG attended physical education classes in accordance with the state university program. To increase reserve capabilities of the motor system and improve compensatory reactions in the system of motion control, in the EG we also implemented a program for developing coordination abilities in PE classes (Dotsenko, 2004; Priymakov, 2010).

It was based on physical exercises of increased coordination complexity with elements of novelty. Exercises with a large number of motor changes were used (Priymakov et al., 2010; Moosmann, 2008; Neumaier, 2009). The complexity of physical exercises increased due to changes in their spatial, temporal and dynamic parameters (Dotsenko, 2004, Fairclough, 2006), the functional deprivation of sensory systems, the combination of motor skills, etc. The motor intensity of classes was increased: in EG up to 83.37%, in the CG - 76.4%.

Statistica 13.1 (Borovikov, 2006) was used for statis-

tical processing of the experimental material. The standard statistical criteria (M, σ , m, V, Lim, Student's t-test) were calculated, Bravais-Pearson correlation coefficient and regression analyzes were carried out as well.

Research Results

The analysis of the research results showed that the implementation of the designed physical education program resulted in the improvement of the quality of precision movements control, compensatory reactions and the reliability of motor regulation under complicated conditions, both in the CG and in the EG.

Below the features of the motor control when walking a line, performing hand movements to check accuracy, keeping balance in the Flamingo test, ballistic accuracy movements (fixed target throwing) before and after the experiment, are presented.

Tight-Rope Walking

Features of cyclic locomotor motion control on a given trajectory for accuracy were examined in tight-rope walking to a given landmark (at a distance of 3 meters). The subject performed several options for walking: under conditions of visual control (VC), auditory control (AC), based on locomotor memory immediately after vestibular stimulation (LMAVS), only on the basis of locomotor memory (LM) - with the activation of the proprioceptive feedback channel.

The analysis of the extent of errors performed in all variants of walking, without taking into account the specifics of the sensory control of locomotion, showed that the pedagogical experiment resulted in the improvement of the quality of the motor control in all the directions analyzed: forwards, backwards, to the left and to the right, both in the CG and in the EG (Figure 1).

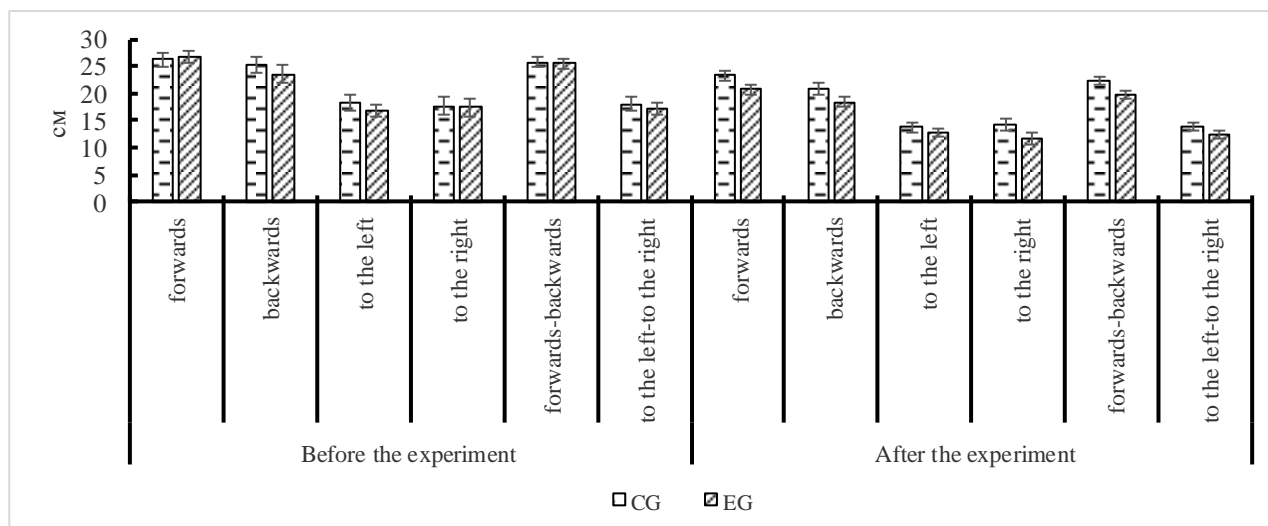


Fig. 1. Deviations in the Endpoint when Tight-Rope Walking in CG and EG before and after the Experiment

Before the experiment, the differences in the quality of locomotion control between CG and EG were statistically insignificant, and after it, the EG respondents demonstrated better results in all registered directions: forwards, backwards, to the right, and to the left.

The extent of errors in walking decreased by the end of the experiment in the backwards-downwards direction by 14% in the CG and by 22.6% in the EG ($p < 0.01$), in the left-right directions and vice versa – by 22.2% ($p < 0.01$) and 28% ($p < 0.01$), respectively.

The analysis of locomotor movement control under various conditions of sensory control indicates an improvement in its quality by the end of the experiment: in

the CG, with the use of visual and auditory feedback channels, and in the EG – also when performing a memory task (Fig. 2).

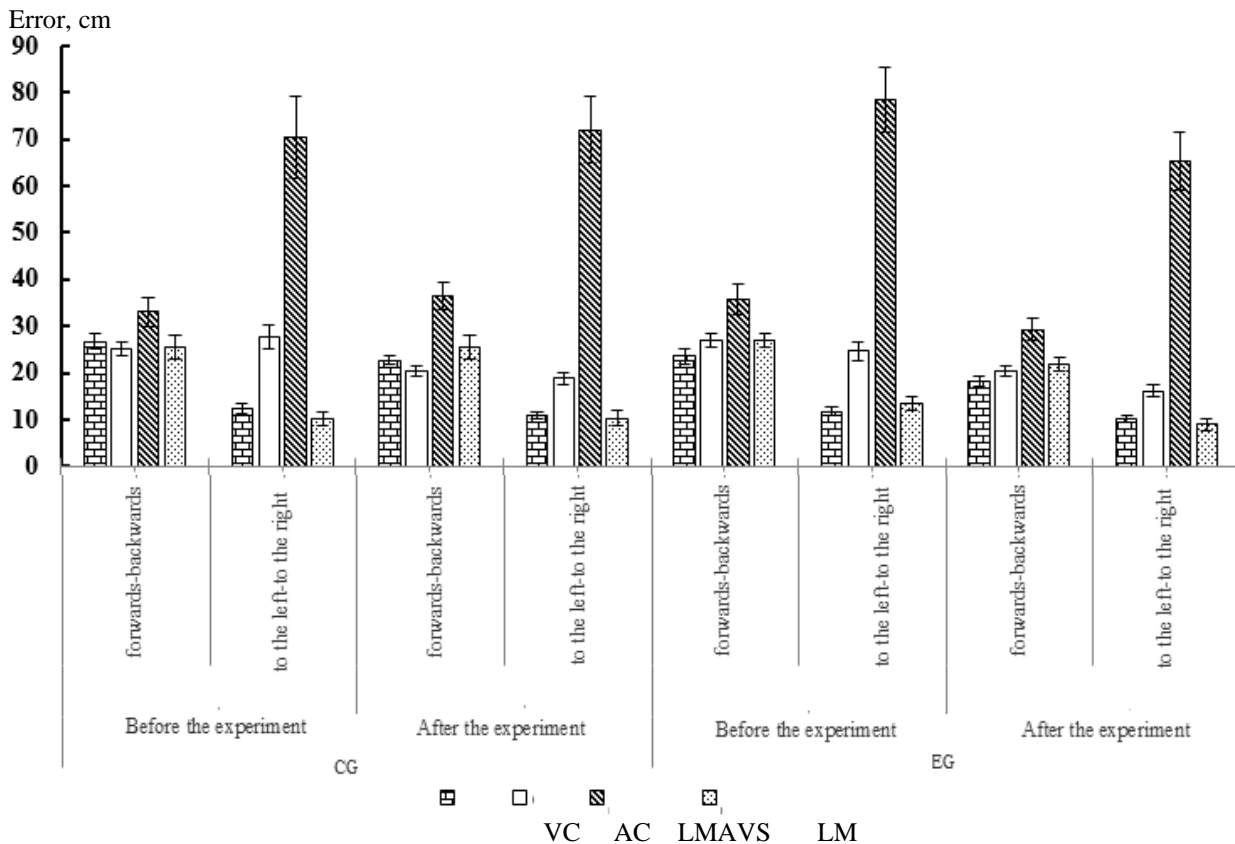


Fig 2. Errors in Walking Alone the Line in Different Conditions of Sensory Control in CG and EG Students at the Beginning and at the End of the Experiment

In the EG, more pronounced positive changes occurred according to all investigated parameters: with the participation and functional deprivation of the visual (VC) and auditory (AC) sensory systems, on the basis of locomotor memory (LM) before and after vestibular stimuli (LMAVS). The increase of the accuracy with all forms of locomotion in the EG demonstrates the improvement in the motor coordination and functional state of the proprioceptive sensory system, improved sensory interrelations, an increase in the distraction tolerance of the skill, and an increase in the role of the mechanism in controlling the locomotion voluntary movement.

The increase in the distraction tolerance of the vestibular stimuli skill reflects the improvement of compensatory reactions damping the confounding factors. In the CG, these parameters have changed insignificantly.

Hand Accuracy Movements Reproduction

The obtained results reflect the ambiguous role of the sensory systems in motion accuracy control.

Positive changes in the reproduction of a ten-centimeter line on a paper with a hand under different conditions of sensory control occurred in female students of the EG: with the participation of the visual and auditory feedback channels, and memory - on the basis of proprioceptive afferentation (under conditions of “ignoring” the visual and auditory feedback channels) (Table 1).

In the CG, there was only the improvement of the quality of precise movements control with the involvement of fine motor skills under conditions of VC and LM. In turn, precise movements control with the involvement of the auditory sensory system worsened.

It should be noted that in both groups the role of the visual sensory system in correcting movements is leading both at the beginning and at the end of the experiment, and the role of the auditory sensory system decreases somewhat at the end of the experiment.

Table 1.

Extent of Errors in Reproduction of 10 cm Line with Different Sensory Systems Involvement Before and After the Experiment

Conditions	Statistical parameters	EG			CG		
		VC	AC	LM	VC	AC	LM
before	X	6.7	8.4	11.9	7.5	7.4	10.6
	±m	0.27	0.30	0.43	0.3	0.3	0.4
	n	465	477	459	576.0	568.0	568.0
after	X	4.5	5.3	8.8	6.7	7.8	9.9
	±m	0.27	0.24	0.51	0.3	0.3	0.4
	n	370	367	374	539	514	449
% of changes		48.9	58.5	34.9	11.9	-5.1	7.1
Student's t-test		5.80	8.03	4.60	1.78	0.88	1.19
p		<0.001	<0.001	<0.001	>0.05	>0.05	>0.05

NB: VC – visual correction; AC – auditory correction; LM – locomotor memory.

In the EG, sensory information from distant receptors started to “adjust” the program of motor regulation in the so-called “stage of afferent synthesis” (Sudakov, 1996) before repeating the movement in a more qualitative manner. At the end of the experiment, the students of the EG began to perform movements based on proprioceptive afferentation with functional deprivation of the visual and auditory sensory systems more efficiently.

Reduction of errors in controlling a local precision motion under various conditions of sensory control and interference indicates that the implemented program contributed to the improvement of sensorimotor interrelations and the decrease of sensitivity thresholds of sensory systems as well as to the improvement of the motor control quality.

The EG students’ precise movement mastering on the basis of visual feedback got accelerated. Therefore, at the beginning of the experiment the visual adjustment of the motion was effective up to 6 repetitions, then at the end, 4 repetitions were enough for shifting to the program mechanism of motor control and stabilizing the motion with less errors. In the CG, the visual adjustment of the movement at the beginning of the experiment was effective up to 7 repetitions, however, after the experiment, it was enough for them to make 6 repetitions.

Both, the effectiveness of sensory systems involvement in the correctional process, and the effectiveness of the influence of the pedagogical program on the speed of mastering

and the quality of local precise movement control are most evident in the first half of the test being performed.

The advantage of the EG in minimizing errors was more pronounced in the first 8 reproductions of movements for accuracy. In subsequent repetitions (from 9th to 16th), the errors were minimized and stabilized in both groups, and the role of vision in its correction decreased. Differences between CG and EG became less expressed.

In general, the leading role of vision in precise movements control can be observed in the students of EG and CG throughout the entire set of tests, both at the beginning and at the end of the experiment.

The high dependence of the extent of the errors made on the number of repetitions involving the visual feedback channel could be observed in the EG at the end of the experiment only in the first stage of the movement (from 1 to 8 repetitions), and in the second (from the 9th to the 16th repetitions) one it decreased (Table 2).

Reducing the correction role of vision with small reproduction errors indicates the formation of a program movement control mechanism in the process of improvement.

In general, the results reflect a relatively high speed of the formation of a local movement control program in the female students. The transition from external (visual and auditory) to internal (proprioceptive) feedback got accelerated; more qualitative compensatory reactions under conditions of confounding factors were formed. In the CG group, the changes were less significant ($p > 0.05$).

Table 2.

Dependence of the Movement Precision on the Number of Repetitions at the Beginning and End of Testing

Groups	Conditions	1-8 reproductions		9-16 reproductions	
		r*	Y*	r	Y
EG	The beginning of the experiment	-0.784. $p < 0.02$	10.24-0.606x	-0.905. $p < 0.0003$	7.38-0.399x
	The end of the experiment	-0.744. $p < 0.03$	8.036-0.687x	0.113. $p > 0.05$	3.41+0.056x
CG	The beginning of the experiment	-0.901. $p = 0.002$	12.965-0.928	-0.850. $p < 0.01$	13.257-1.136x
	The end of the experiment	-0.336. $p > 0.05$	6.98-0.139	-0.495. $p > 0.05$	5.33-0.092x

*NB: r – correlation coefficient, Y – regression equation.

Performing Precision Ballistic Movements

In order to study the regularities of the implementation of the program of movement with a clearly expressed final accuracy, tennis balls were used in fixed target throwing (rings of different diameters were applied as targets). The execution of such movements reflects the involvement of higher levels of regulation - C and D

(Bernstein, 1947). The high quality of fixed target throwing reflects the maturity of the target precision level (Bernstein, 1947, Gurfinkel, 1990).

According to the data shown in Fig. 3, a positive effect of the experimental program was best pronounced in fixed target throwing in the EG ($p < 0.01$).

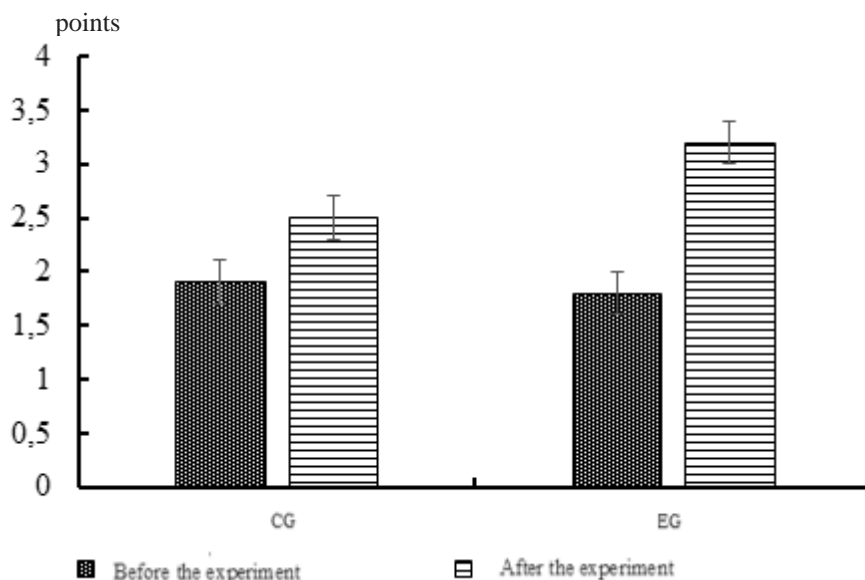


Fig. 3. The Respondents' Fixed Target Throwing Accuracy (points)

The results demonstrate improved visual-motor coordination and better extrapolation prognostication of movements in the EG as compared to the CG.

“Flamingo” Keeping Balance Exercise

The number of imbalances in the Flamingo test in the CG by the end of the experiment tended to decrease,

and in the EG it has decreased significantly (Figure 4). The results reflect the positive effect of the experimental program on the quality of upright equilibrium (Bernstein, 1947).

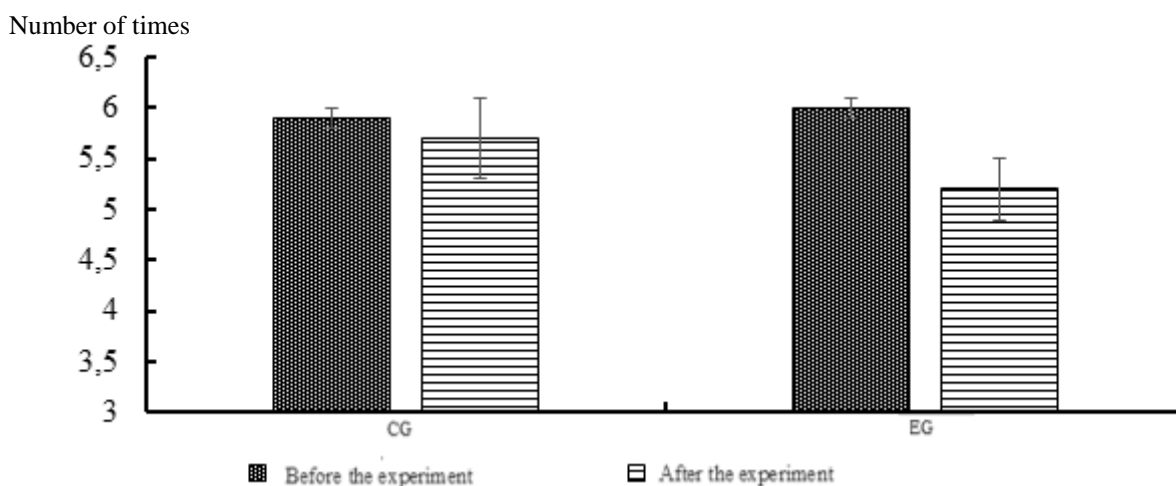


Fig. 4. Indices of CG Students' Motor Regulation in Counterpoise Test Before and After the Experiment

Discussion

In general, the research results reflect the positive impact of the designed experimental program (Dotsenko,

2011, Priymakov, 2010) on the quality and reliability of motor control, reserve capabilities of the motion control system of various levels and the coordination structure

(Bernstein, 1947, Dotsenko, 2011) using Flamingo test, walking in a straight line for accuracy in conditions of sensory deprivation, Tight-Rope Walking under conditions of sensory control, reproduction of 10 cm line on the paper under conditions of partial or complete sensory control, fixed target throwing, fixed target throwing.

Since most of the tests provided for the execution of movements under conditions of sensory limitations or stimuli aiming to evaluate balance and accuracy, the improvement of the quality of motor control under these conditions, more pronounced in the EG, can be regarded as a sign of increasing reserve capabilities and reliability of the motor functional system with a specific target function.

It also reflects the improvement of compensatory mechanisms for maintaining the motor function reliability, ensuring the execution of movements with given parameters under the action of confounding factors.

Periodic elimination of vision when performing a movement activates the proprioceptive sensory system, strengthens the role of visual afferentation in the subsequent reprogramming of a motion in the afferent synthesis stage, facilitates the acceleration of mastering the precise movement, its automation, and increasing the compensatory capabilities in the control system.

The role of visual and auditory afferentations in correction by locomotor precise movement decreases at the end of the training.

In case of mismatch errors, a transition to an autonomous (internal - software) motor control contour with domination of the proprioceptive feedback channel (Pryimakov, 2010; Dotsenko, 2004) is carried out.

High-quality execution of movements in conditions of functional deprivation of visual and auditory sensory

systems, the effect of confounding factors and interference by the EG students reflects the increase in compensation reserves and the reliability of regulatory mechanisms in the precise movements control system during the experiment.

Conclusions

1. The applied methodical and organizational approaches to physical education of the female students helped to increase reserve capabilities of their locomotor system, to show higher results in motor tests.

The increase of the quality of the control of the movements of various coordination structures by the end of the experiment under the influence of confounding factors reflects the growth of the compensatory reserve capabilities of the motor system that ensure the reliability and quality of motor control.

2. The speed of movements mastering, the effectiveness of compensatory reactions, the stability and reliability of retaining qualitative parameters of motion in the optimal range under the influence of confounding factors, the increase of the role of the software mechanism in the control system of the voluntary movement weakly dependent on sensory information in stable conditions of its realization, decrease of sensory ties in the motor control system (in accordance with the “least interaction” principle) can be considered as the criteria for the reserve capacity of the respondents’ motor system.

The prospects of further research of the reserve capabilities of the human motor function involve the search for new ways to improve coordination mechanisms for controlling movements of various levels, the development of appropriate assessment and prognostic mathematical models, and normative scales for assessing the motor function.

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УДОСКОНАЛЕННЯ МЕТОДИКИ НАВЧАННЯ ТОЧНИХ РУХІВ СТУДЕНТІВ У ПРОЦЕСІ ФІЗИЧНОГО ВИХОВАННЯ

Мета – дослідження надійності функціонування і резервів системи управління рухами різної координаційної структури у студенток в процесі фізичного виховання (ФВ). У дослідженнях взяли участь 136 студенток віком від 17 до 19 років. Вони були поділені на 2 групи – контрольну (КГ) й експериментальну (ЕГ). Студентки КГ відвідували заняття з фізичного виховання (ФВ) відповідно до державної університетської програми. В ЕГ додатково реалізовувалася програма, спрямована на підвищення надійності і резервів системи управління рухами. Основу її склали фізичні вправи підвищеної координаційної складності з елементами новизни, що виконуються з музичним супроводом. Тривалість досліджень склала один навчальний рік. Виявлено позитивний вплив експериментальної програми ФВ на прояв моторної функції студенток ЕГ. Удосконалення управління точними рухами в ЕГ характеризувалося підвищенням якості рухового регулювання, збільшенням швидкості переходу до програмного механізму регулювання в стабільних умовах реалізації рухів, зростанням потужності компенсаторних перебудов для збереження надійності моторної функції в ускладнених умовах. Це свідчить про підвищення резервних можливостей системи управління рухами і є одним із критеріїв цих резервів. Установлено, що провідними критеріями резервних можливостей системи управління рухами різної координаційної структури є: швидкість переходу до програмного механізму управління точними рухами в стабільних умовах функціонування; потужність і ефективність компенсаторних реакцій, що забезпечують стійкість системи управління точними рухами при сенсорних обмеженнях і подразненнях; надійність утримання якісних параметрів руху в оптимальному діапазоні при дії перешкод; зниження сенсорних взаємозв'язків у системі управління рухом у стабільних умовах функціонування (принцип «найменшого взаємодії»).

Ключові слова: студентки, управління, точні рухи, сенсорна депривація, компенсаторні реакції, фізичне виховання.

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