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Methodology of "artificial control environment" in the process of physical exercise for children with disabilities: theoretical justification and practical application

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Abstract

Purpose. The purpose of the study is to systematize and substantiate theoretical knowledge and the results of practical experience in the use of technical means and methodological techniques of the “artificial control environment” in the process of physical exercise for children with disabilities.

Material & Methods. The study involved 8 boys and 11 girls with hearing impairments aged 8 years. *Research methods:* analysis of scientific literature, pedagogical experiment. During the study of the ability to maintain static-dynamic balance of the body of the examined children with hearing impairments, we used the stabilography method..

Results. The data accumulated in the course of the experiment laid the basis for the technology of design and implementation of methodical techniques proposed in the study, means of "artificial control environment" in the process of adaptive physical education of children of primary school age with hearing deprivation, aimed at the development of static and dynamic balance of the body, orientation. The data accumulated in the course of the experiment laid the basis for the technology of design and implementation of methodical techniques proposed in the study, means of "artificial control environment" in the process of adaptive physical education of children of primary school age with hearing deprivation, aimed at the development of static and dynamic balance of the body, orientation in space. The components of the author's technology are the goal, objectives, methodological principles of physical education, special pedagogical principles of adaptive physical education, and the tasks set in the study serve as a projection of three periods and stages of its implementation with the use of appropriate fitness equipment within the framework of preventive health measures.

Conclusions. The breadth of the transformation processes and tangible shifts observed today in the paradigm and systematics of adaptive physical education are determined by the significant influence of the latest theoretical and methodological problems and “preemptive innovations”, the planes of implementation of which are not only software products, but also technologies and management systems. The proposed study substantiates the content and basic provisions of the technology for designing and implementing methodological techniques and means of an “artificial control environment” in the process of adaptive physical education of primary school children with hearing loss.

Key words: adaptive physical training, children with disabilities, hearing deprivation, design, artificially fused midsection, static and dynamic balance of the body.

Introduction

Recent years have demonstrated – given the change in scientific research paradigms in the humanitarian sphere – an intensification of the discussion regarding the integration of the phenomenon of the “artificial control environment” methodology into the process of adaptive physical education (APE) (Khmelnytska, 2006; Aloshina et al. 2023; Savlyuk et al. 2024). At the current stage of the development of the sphere of physical culture and sports of Ukraine, A. N. Laputina (1995) is called the founder of the scientific paradigm of the "artificial control environment". The scientist's achievements include the substantiation of the methodological foundations of the scientific paradigm of the "artificial control environment", the creation of its conceptual and categorical apparatus, the development of principles, basic functions, as well as priority problems of this field of knowledge (Laputin 2009). Доробки A N. Laputina (1995) and his followers (Kashuba et al. 2018; Aloshina et al. 2023) contain a biomechanical paradigm of the integrative object-subject sphere of the correctional and preventive dimension, in particular the statement that the external environment where a person is forced to perform movements has a special diversity and, in general, significantly affects not only the quality, but also the nature and direction of human motor activity (Kashuba et al. 2018; Savlyuk 2018). Taking this into account, the application of the “artificial control environment” methodology in the field of physical culture and sports appears as a convincing scientific trend in its relevance (Savlyuk 2022).

Material and methods of research

Study Design

The study was conducted at the Department of Theory and Methodology of Physical Education of the Vinnytsia State Pedagogical University named after M. Kotsiubynsky, the Department of Physical Culture and Sports of the Volyn National University named after Lesya Ukrainka. The studies were conducted in compliance with the requirements of the Helsinki Declaration of the World Medical Association "Ethical Principles for Medical Research Involving Human Subjects of Research".

Subjects

The study involved 8 boys and 11 girls with hearing impairments aged 8 years, who were randomly divided into main groups (MG_1, MG_2)

and control groups (CG_1, CG_2). *Research methods:* analysis of scientific literature, pedagogical experiment. During the study of the ability to maintain static-dynamic balance of the body of the examined children with hearing impairments, we used the stabilography method, carried out with the help of a computer stabiloanalyzer with biological feedback "Stabilan-01-2" - to perform the Romberg test (the pose of the subject - standing in a closed stance (heels and toes together), arms forward, fingers spread apart) with open eyes. The resulting indicator of the stabilogram analysis was the amplitude (mm) and frequency (Hz) of oscillations - the general center of gravity (GCG) of the body in the sagittal (y) and frontal (x) planes; the area of GCG oscillations (mm2); the length of the trajectory of the GCG movement of the body (mm) in the sagittal (y) and frontal (x) planes; the speed of GCG ($mm \cdot s^{-1}$).

Statistical data analysis

All data obtained in the empirical study were processed using mathematical statistics methods (Kashuba et al. 2020). The method of descriptive statistics was used to process research data, systematize them, make them visual in the form of graphs and tables, and quantitatively describe them using the most important statistical indicators. The objects of calculation were the sample arithmetic mean, standard deviation S, and for samples whose distribution did not correspond to the normal law, the median, lower and upper quartiles Me (25%; 75%).

The samples formed in the focus of the study were tested for compliance with the normal distribution law using the Shapiro-Wilk W-test of consistency, which is more powerful than other criteria for testing the hypothesis of the normal distribution of small and medium-sized samples.

The statistical significance of the difference between sample indicators corresponding to the normal distribution law was calculated using the Student t-test.

In the planes of the formative experiment, the statistical significance of the difference between independent samples was determined on the basis of the nonparametric two-sample Mann-Whitney U-test, and for dependent samples - the Wilcoxon signed-rank T-test (Z-statistics were also used).

To establish the statistical significance of the difference between samples, the reliability level P=95% was chosen (significance level - p=0.05), although individual hypotheses were tested at a higher reliability level P=99% (significance levels p=0.01).

For mathematical and statistical processing and analysis of the data, the computational and graphical capabilities of the Statistica (StatSoft, version 14.0) and Microsoft Excel 2010 application packages were used.

The purpose of the study is to systematize and substantiate theoretical knowledge and the results of practical experience in the use of technical means and methodological techniques of the “artificial control environment” in the process of physical exercise for children with disabilities.

Results of the study

In this work, we consider the methodological basis as a developing "artificial control environment" to be such an educational environment that is capable of providing a set of opportunities for self-development of all subjects of the APE process of primary school children with hearing deprivation. We state the logic of interpreting the "artificial control environment" as developing in the case of providing this environment with opportunities, firstly, for satisfying and developing the subject's own needs at all hierarchical levels; secondly, for the assimilation of social values by the individual and its organic transformation into internal potentials.

It should be noted that the pedagogical organization of the developing “artificial control environment” is the optimal organization of the system of connections between all elements of the educational environment; the organization of such connections that provide a set of opportunities for the personal self-development of all subjects of the educational process (Laputin et al. 1999).

Let us turn to the principles of organizing the “artificial control environment”.

The principle of organizing the complexity and heterogeneity of the "artificial control environment" lies in the pedagogical expediency of such an organization, in which the environment provides subjects of the educational process with various opportunities for development (heterogeneity) of perceptual, cognitive and practical "channels" of contacts with the world (complexity).

The principle of orientation towards the actualization potential of the "artificial control environment" presupposes the pedagogical expediency of organizing such an environment that stimulates the action of the corresponding psychological mechanisms of personal development of primary school children with hearing deprivation.

The principle of organizing a personally adequate "artificial control environment" is determined by the pedagogical expediency of organizing such an environment, ensuring the development opportunities for all subjects of the educational process, taking into account their age, gender and other specific individual characteristics.

Another principle – *the principle of development of thought-forms* – regulates the construction and use of methods for developing a system of representations, in particular, it involves the formation of a system of ideas of the individual about the world based on scientific information, and works of art, fiction, philosophical and religious teachings, etc. Consequently, it is obvious that the system of ideas about the world arises on the basis of not only experimental activity and its logical comprehension, but also images that arise as a result of its emotional and aesthetic assimilation.

According to the logic of research considerations, we note that the "epicenter" of the design of the "artificial control environment" is the "point of interpenetration" of the spatial-subject, social, technological components of the pedagogical environment and the subject of the educational process. Around this "epicenter" is organized a "zone of developmental opportunities", significant for the process of APE of children of primary school age, in particular with hearing deprivation.

Thus, the design of the spatial-subject component of the "artificial control environment" is based on a system of requirements for its effective organization, namely: 1) heterogeneity and complexity of the environment; 2) connectivity of functional zones; 3) flexibility and controllability of the environment; 4) ensuring the symbolic function of the environment; 5) individualization of the environment; 6) authenticity of the environment.

The "artificial control environment" of individuals interacting with each other must be problem-organized and promote: (1) cognitive search (production of new knowledge); (2) personalized search (vector of orientation of the individual and his/her activity); (3) technical and technological search (selection of instrumental methods and means); (4) search for criterial and procedural knowledge (subject and technological competence); (5) ideological search (formation of prevailing values).

In turn, the professional culture of a specialist in the field of APE, a direct executor and implementer of methodological techniques and means of the "artificial control environment", can be presented in the form of an educational system consisting of four significant components, namely: the culture of mutual knowledge (self-presentation, empathy, social reception), the culture of mutual understanding (interpersonal reflection), the culture of interaction (organization of productive joint activities and interpersonal communication), the culture of activity-based co-creation (coordination of intentions-dispositions of the addresser and the addressee). Project methodology and anthropic educational technologies, where the structure of educational activity is subject to construction in the context of the activity-based nature of knowledge and the reflexive-personal culture of thinking of a specialist, are significant factors in this context. It is known that knowledge becomes useful only after systematization (auto-reflection) of experience, that is, in the case of a person's ability to adapt this knowledge to the performance of another task, to turn it into a working tool (technology).

The concept of "professional competence of a specialist in the field of APE technologies" is related to the "pedagogical compendium", that is, a "conceptually folded" (generalized and systematized branch of specialized knowledge), technologically mastered system. The compendium forms a fundamentally unclosed series (open system) of innovations with the ability to unfold into infinity. APE technologies expand (diversify) the natural (bodily organized) and socio-cultural nature of man, and do not subordinate it to themselves.

In the plane of designing pedagogical technology, which arises from the methodological techniques and means of the “artificial control environment”, logical-mathematical modeling should be used for:

1) forecasting the consequences of changing the method of action, conditions or methods in a situation where such a change is really associated with any risk or expenditure of funds;

2) studying complex systems within the framework of their improvement and more effective use;

3) becoming familiar with systems or conditions that, for example, do not yet exist in reality;

4) testing or demonstrating a new idea, system or method;

5) predicting the future and thus providing a basis for planning, forecasting and design.

In general, in the scientific community, design is perceived as a form of conscious creative activity, which is inextricably linked with such scientific categories as "project", "activity", "creativity". Taking this into account, design becomes an intellectual activity in its dimension, the vectors of which are research, prediction, forecasting, and assessing the consequences of certain ideas.

Design in the field of pedagogy, that is, pedagogical design, is accompanied by the creation of something fundamentally new in the content and solution of scientific and practical problems (pedagogical design is a function of any teacher, no less important than organizational, gnostic, i.e. the search for content, methods and means of interaction with students, or communicative) - regarding the problem of work, we are talking about the APE of updating the organization of the process in this way.

The process of designing the author's technology, naturally distinguished by a certain stage-by-stage nature, also had a range of stages in the proposed study. Let's consider them.

1. *The search and diagnostic stage* involved collecting information, as well as multi-aspect diagnostics of the static-dynamic resistance of the body of younger schoolchildren.

2. *Conceptual stage* – defining the project plan and objectives; problematization, i.e. outlining the problematic field of the latter; conceptualization, namely – developing a design strategy; identifying the designed object; establishing its indicators; clarifying the goals and formulating the design tasks; describing the expected design result; selecting criteria for assessing the success of the design activity.

3. *Design stage* – creation of a model, the so-called image of the designed object, with a description of the structure and characteristics; conclusion of a program for the implementation of project activities with a scientifically based selection of APE tools and methods, methodological techniques; implementation of methodological techniques and tools of the "artificial control environment", the possibility of obtaining the most useful result in achieving the set goals with the help of real resources.

4. *Control (reflective) stage* – implementation of the project activity program, correction of the project progress and actions of the participants; reflection on the project concept, its progress and results, determination of intermediate goals, i.e. real ways of checking the results obtained and the possibility of promptly identifying deviations and correcting actions.

5. *Transformative stage* – examination of the results of the project implementation; generation of a new idea, development of a strategy for further deployment of the process of APE of primary school children with hearing impairment.

Note that in the pedagogical dimension, all stages of project activity are equally important: each stage appears with the status of a component of the APE process, where, in addition to the design product, aspects of both diagnostics and the formation of values, norms, attitudes, as well as the initiation of communicative or creative abilities are manifested.

To build the technology for designing and implementing methodological techniques and means of an "artificial control environment" in the process of APE of primary school children with hearing impairments, the study selected as vectors the methodological provisions proclaiming the system-activity approach:

- ✓ the mental properties acquired by the child, characterizing his personal, social, cognitive development, are the result of the transformation of his external subject activity (play, educational, extracurricular) into internal mental activity according to the logic of development, which corresponds to the formula "from action to opinion";
- ✓ educational activity in all its forms is a priority for a primary school student;
- ✓ the content of educational activity (empirical or scientific concepts) determines the formation of a certain type of thinking in the child - empirical or theoretical;
- ✓ the child's assimilation of a system of scientific concepts is determined by the organization of his educational and cognitive activities by replacing the spontaneous organization of educational processes with pedagogical management;
- ✓ the purpose and object of the child's acquisition of a system of scientific concepts is educational activity, "the ability to learn", and the system of scientific concepts acquired in the course of such activity serves as a means for the child to perform vital tasks - in the context of the emergence and formation of a certain personal content of the process of acquisition of knowledge, skills and abilities;
- ✓ activity undergoes constant changes in the process of its development: it can transform into action and back, while action in the event of a change in its goal can become an operation and the like;
- ✓ the formation of educational activity is influenced by the social situation of development, which is associated with the need for pedagogical management of its content;
- ✓ educational activity appears as the interaction of children and the teacher, as the unity of learning and teaching, and this presupposes a transition from individual forms of its organization to group, collective forms and methods of organizing the educational process.

The presented author's technology of designing and implementing methodological techniques and means of "artificial control environment" in the process of APE of children of primary school age with hearing impairment consists of such components as goals, tasks, principles and periods.

The purpose of the above-mentioned author's technology is the formation of the statodynamic equilibrium of the body of children of primary school age with hearing deprivation in the process of APE..

The projection of the goal of the technology is the following tasks:

1) development of static-dynamic balance in children of primary school age with hearing deprivation in the process of APE;

2) instilling in children of primary school age with hearing deprivation the skills of correct posture in the process of APE;

3) achieving positive results in the process of forming the static-dynamic balance of the body of primary school children with hearing loss in the process of APE.

The process of implementing the author's technology for designing and implementing methodological techniques and means of the "artificial control environment" in the process of APE of primary school children with hearing impairments is significantly influenced by the range of methodological principles of physical education and special pedagogical principles of APE. In the presentation of the material, we will focus on the consideration of the content of the special pedagogical principles of APE.

First of all, let us note that the *special pedagogical principles* of the APE are based on the symbiosis and integration of principles of related disciplines and laws of ontogenetic development. Let us reveal their essence.

The *diagnostic principle* implies taking into account the identified main defect, the qualitative uniqueness of its structure, the time and period of damage, the medical prognosis, indications and contraindications to physical exercise, as well as taking into account concomitant diseases and secondary deviations. In addition, the principle prescribes systematic monitoring of anthropometric parameters, the level of motor fitness, the dynamics of the formation of physical qualities and coordination abilities as objects of correction and development.

The following principle of *differentiation and individualization* allows a differentiated approach to adaptive physical education, characterized by the unification of children into somewhat homogeneous groups. It is essential that the medical-psychological-pedagogical commission is responsible for the primary differentiation, which will disperse children into typological groups based on similarity in age, clinical picture of the main defect, and parameters of somatic development. However, given the significant variability of physical fitness, motor experience, readiness for learning, qualitative and quantitative parameters of motor activity in typological groups (classes), the proper organization and conduct of physical education lessons requires a clearer differentiation of children with disabilities, which only a teacher is capable of. It is the teacher who is able to implement an individual approach to the student during teaching.

The core of the individual approach is attention to the characteristics inherent in a particular person, since individuality itself is a unique combination of the characteristics of one person in contrast to another. Such characteristics are dictated by gender, age, body type, motor experience, specific character, temperament, volitional qualities, the state of preserved functions - motor, mental, sensory, intellectual. The nature of individualization of the pedagogical process is connected with the fact that, relying on the specific abilities and potential of each child, to provide optimal conditions for his/her growth.

The principle of the corrective-developmental orientation of the pedagogical process is determined by the logic of the direction of pedagogical action not only to eliminate, smooth out, level out, weaken the physical and mental defects of children, but also to actively develop their cognitive activity, mental processes, physical abilities and moral qualities.

The essence of the principle of compensatory orientation of pedagogical influences is outlined by the replacement of insufficiently developed, changed or lost functions due to the transformation or increased use of preserved functions and the laying of bypass routes.

The principle of age adequacy is associated with age-related patterns of functioning of the human organism. It is known that each specific age in the integral ontogenesis of physical and mental development is uniquely original, i.e. it covers both noticeable "growth points" that generally determine development and the factors that limit it. The human function of movement demonstrates the stage-by-stage development of motor systems, the oscillatory nature of the latter, the synphasic nature of periods of accelerated development, and a high degree of individuality of motor manifestations. The combination of social and biological at each age stage reaches new "peaks", which finds its expression in the symbiosis of the levels of physical and mental development. The occurrence of a disorder entails a failure in the central regulatory mechanisms, which transforms the process of physical and mental development, and then forms age-related patterns of abnormal functioning of the child's body. The most significant of the latter are the following: the unity of the genetic course of development, maximum use of the potential of sensitive periods of development, taking into account the zone of proximal development.

At the present stage of development of the field of physical education and sports, the correspondence of the selection of means, methods, methodological techniques and the condition of those involved is related to the principle of adequacy.

The *principle of optimality* regulates the appropriately balanced volumes of possible psychophysical load, moderate stimulation of adaptation processes, caused by the strength and nature of external stimuli).

Regarding the essence of such a principle as the *principle of variability*, it should be noted that it is involved in a wide variety of content and possibilities of movement, because the actual meaning of variability implies the avoidance of monotony, the prevention of getting used to a uniform physical load.

The author's technology is notable for the selection of three periods, such as: introductory, main and supporting.

In the proposed study, the development of a technology for designing and implementing methodological techniques and means of an “artificial control environment” in the process of APE for primary school children with hearing impairments assumed increased attention to the specifics of the distribution of study time allocated to various types of program material for physical education lessons (hour grid).

The process of concluding a training program for children of primary school age with hearing loss was oriented towards ensuring a number of conditions related to the specifics of physical education of children of the specified age category with hearing loss, that is, its insufficiency. Considering that the goal of physical education of children with hearing impairments is the formation of movement skills, correction of physical development defects and motor skills, exercises using the latest fitness equipment and fitness methods were introduced into the program, which, in our opinion, contribute to the implementation of the conceptual tasks of the school program and enhance the effectiveness of targeted development of static and dynamic balance of the body of primary school children with hearing impairments, as well as improve spatial orientation, allow for the prevention of musculoskeletal disorders and general strengthening of the body.

The study provides for the duration of application of the author's technology for designing and implementing methodological techniques and means of an "artificial control environment" in the process of APE of primary school children with hearing impairments on a chronological section of 9 months during the school year: this period was stratified into three stages, the duration of which was 3 months each.

Thus, the first stage of application of the author's technology of designing and implementing methodological techniques and means of "artificial control environment" in the process of adaptive physical education of primary school children with hearing impairments provided for familiarization primarily with simple exercises requiring the use of fitness equipment, namely: a balance beam, a gymnastic stick and a fitball. Since the first stage of the implementation of the author's technology was accompanied by mastering 5 sets of exercises, the first 8 weeks of the first stage children learned to technically correctly perform the proposed exercises (the effectiveness of the latter directly depends on the level of performance of the selected physical exercises), and at the end of the 9-12 weeks of this same stage they had lessons organized according to the method of circuit training using various equipment and already known, previously learned exercises (enough exercises and clear execution of each exercise allowed not to waste time on learning it). It is noteworthy that at the end of each lesson of the first stage, children were involved in active games for attentiveness, agility and balance, which significantly improved their emotional background.

At the second stage of the application of the author's technology for designing and implementing methodological techniques and means of "artificial control environment" in the process of adaptive physical education of primary school children with hearing impairments, which, according to the model of the first stage, lasted 3 months, the priority task was the assimilation of more complex exercises using the same equipment and balancing hedgehogs. Since the II stage of the author's technology, like its I stage, regulated the development of 5 sets of exercises, the first 8 weeks of the II stage children learned to technically correctly perform new, more complex exercises, while at the 9-12 week cut, like at the previous stage, they attended lessons organized according to the method of circuit training using different equipment and already known, previously learned, more complex exercises. At the II stage, the practice of conducting at the end of each lesson outdoor games for attentiveness, agility and balance, effective for improving the quality of the emotional background, continued.

Stage III of the application of the author's technology of designing and implementing methodological techniques and means of "artificial control environment" in the process of APE of primary school children with hearing impairments lasted, by analogy with Stages I and II of the author's technology, 3 months (12 weeks), but provided for the assimilation of only 4 sets of exercises. However, the prerogative of Stage III was the task of teaching children to perform more complex exercises, special skills to operate several units of equipment at once. The purpose of such exercises was to reveal the level of improvement of children's physical qualities, the degree of their handling of objects, the development of a sense of balance and the ability to concentrate. An essential point of the III stage of the author's technology was the complication of the list of already known equipment with tennis balls.

In addition to the above, we note that at the I, II and III stages of applying the author's technology of designing and implementing methodological techniques and means of the "artificial control environment" in the process of APE of primary school children with hearing impairments for warm-ups, in physical education lessons, the following were used: mats for foot massage, coordination rings (at the I stage) and balancing massage hedgehogs (at the II-III stages).

The obtained data served as the basis for integrating the technology of designing and implementing methodological techniques, means of "artificial control environment" in the process of APE of primary school children with hearing deprivation, aimed at developing static and dynamic balance of the body, orientation in space (Kashuba, & Afanasiev, 2020).

To test the effectiveness of the author's technology, a molding pedagogical experiment was conducted.

To test the effectiveness of the author's technology, a molding pedagogical experiment was conducted.

Analysis of the results of the molding experiment indicates an improvement in the static-dynamic balance of the body (in the Romberg test with open eyes) in children with hearing impairments (MG1) after the introduction of the author's technology (Table 1).

Table 1. Characteristics of the static-dynamic balance of the body (in the Romberg test with open eyes) of 8-year-old boys with hearing impairments before and after the experiment (n=8), s

Group	Body balance indicators	Average statistical indicators									
		before the experiment					after the experiment				
		$\overline{x}$	S	Me	25%	75%	$\overline{x}$	S	Me	25%	75%
CG_1 (n=4)	GCM oscillation amplitude in frontal plane X, mm	24,25	0,50	24	24	24,25	23,75	0,50	24	23,75	24
	GCM oscillation amplitude in sagittal plane Y, mm	27,25	0,96	27,5	26,75	28	26	0,82	26	25,75	26,25
	GCM oscillation frequency in frontal plane X, Hz	2,75	0,50	3	2,75	3	3	0,00	3	3	3
	GCM oscillation frequency in sagittal plane Y, Hz	3,25	0,50	3	3	3,25	3,5	0,58	3,5	3	4
	Length of the GCM movement trajectory in the frontal plane X, mm	359,25	0,96	359,5	358,75	360	294	5,23	294	289,75	298,25
	Length of the GCM movement trajectory in the sagittal plane Y, mm	471,75	0,50	472	471,75	472	294	5,23	294	289,75	298,25
	GCM movement speed, $mm \cdot s^{-1}$	33,25	0,50	33	33	33,25	24,5	0,58	24,5	24	25
	GCM oscillation area, mm^2	1622,75	0,96	1622,5	1622	1623,25	1001,25	3,59	1000,5	998,75	1003
MG_1 (n=4)	GCM oscillation amplitude in frontal plane X, mm	25	0,82	25	24,75	25,25	23,25	0,50	23	23	23,25
	GCM oscillation amplitude in sagittal plane Y, mm	27,25	0,96	27,5	26,75	28	25,25	0,50	25	25	25,25
	GCM oscillation frequency in frontal plane X, Hz	3	0,82	3	2,75	3,25	3,5	0,58	3,5	3	4
	GCM oscillation frequency in sagittal plane Y, Hz	3,5	0,58	3,5	3	4	3,75	0,50	4	3,75	4
	Length of the GCM movement trajectory in the	359,5	0,58	359,5	359	360	290,75	0,96	290,5	290	291,25

	frontal plane X, mm										
	Length of the GCM movement trajectory in the sagittal plane Y, mm	472	0,82	472	471,75	472,25	290,75	0,96	290,5	290	291,25
	GCM movement speed, $mm \cdot s^{-1}$	33,5	0,58	33,5	33	34	24	0,82	24	23,75	24,25
	GCM oscillation area, mm^2	1620,25	1,71	1620,5	1619,5	1621,25	999	0,82	999	998,75	999,25

The calculations performed using the non-parametric Wilcoxon signed-rank T-test for dependent samples revealed the following features:

- ✓ it should be emphasized that the amplitude of GCM oscillations in the frontal plane of 8-year-old boys with hearing impairments CG_1 does not statistically significantly differ after the completion of the molding experiment (T=0; standardized statistics Z=1,34; p=0,180);
- ✓ also, the amplitude of GCM oscillations in the frontal plane of 8-year-old boys with hearing impairments MG_1 does not differ statistically significantly as a result of the experiment (T=0; Z=1,83; p=0,068);
- ✓ at the same time, after the completion of the experiment, statistically significant changes in the amplitude of GCM oscillations in the sagittal plane of 8-year-old boys with hearing impairments of both CG_1 and MG_1 were not established (T=0; Z=1,60; p=0,109);
- ✓ it should be noted that after the completion of the experiment, the frequency of GCM oscillations in both the frontal and sagittal planes in the examined boys of CG_1 did not change statistically significantly;
- ✓ as the analysis of the experimental data showed, in boys of MG_1 at the end of the experiment, there were no statistically significant changes in the frequency of GCM oscillations in either the frontal (T=0; Z=1,34; p=0,180) or sagittal planes (T=2; Z=0,53; p=0,593);
- ✓ after completion of the experiment, the length of the GCM movement trajectory in the frontal and sagittal plane of boys CG_1 and MG_1 did not change statistically significantly (T=0; Z=1,83; p=0,068);
- ✓ actual data indicate that under the influence of methodological techniques and means of the “artificial control environment” in the process of APE in children of the specified group, the quantitative assessment of the speed of GCM movement of boys CG_1 and MG_1 did not change statistically significantly (T=0; Z=1,83; p=0,068);
- ✓ at the same time, it was established that in boys CG_1 and MG_1, statistically significant differences in the quantitative assessment of the GCM oscillation area before and after the experiment were not recorded (T=0; Z=1,83; p=0,068).

Processing of the results of the molding experiment showed that in girls aged 8 with hearing impairments MG_1, the indicators of static-dynamic balance of the body improved (Table 2).

Table 2. Characteristics of the static-dynamic balance of the body (in the Romberg test with open eyes) of 8-year-old girls with hearing impairments before and after the experiment (n=11), s

Group	Body balance indicators	Average statistical indicators									
		before the experiment					after the experiment				
		$\overline{x}$	S	Me	25%	75%	$\overline{x}$	S	Me	25%	75%
CG_2 (n=5)	GCM oscillation amplitude in frontal plane X, mm	25,6	0,55	26	25	26	25,4	0,55	25	25	26
	GCM oscillation amplitude in sagittal plane Y, mm	27,4	0,89	28	27	28	27	0,71	27	27	27
	GCM oscillation frequency in frontal plane X, Hz	3,4	0,55	3	3	4	3,6	0,55	4	3	4
	GCM oscillation frequency in sagittal plane Y, Hz	3,6	0,55	4	3	4	3,8	0,45	4	4	4
	Length of the GCM movement trajectory in the frontal plane X, mm	383	0,71	383	383	383	324,2	0,84	324	324	325
	Length of the GCM movement trajectory in the sagittal plane Y, mm	427,4	0,55	427	427	428	348,2	0,84	348	348	349
	GCM movement speed, $mm \cdot s^{-1}$	31,2	0,84	31	31	32	29	0,71	29	29	29
	GCM oscillation area, mm^2	1398,6	0,55	1399	1398	1399	1088,8	0,84	1089	1088	1089
MG_2 (n=6)	GCM oscillation amplitude in frontal plane X, mm	27,5	0,55	27,5	27	28	25,3	0,52	25	25	25,75
	GCM oscillation amplitude in sagittal plane Y, mm	27,7	0,82	27,5	27	28	22,3	9,97	26	26	26,75
	GCM oscillation frequency in frontal plane X, Hz	3,3	0,52	3	3	3,75	3,7	0,52	4	3,25	4
	GCM oscillation frequency in sagittal plane Y, Hz	3,5	0,55	3,5	3	4	3,8	0,41	4	4	4
	Length of the GCM movement trajectory in the frontal plane X, mm	383,3	0,52	383	383	383,75	323,2	0,75	323	323	323,75

	Length of the GCM movement trajectory in the sagittal plane Y, mm	427,3	0,82	427,5	427	428	347	0,63	347	347	347
	GCM movement speed, $mm\cdot s^{-1}$	31,5	0,55	31,5	31	32	28,5	1,38	28,5	27,25	29,75
	GCM oscillation area, mm^2	1398,7	0,52	1399	1398,25	1399	924,2	399,8	1087,5	1086,25	1088

The calculations performed using the nonparametric Wilcoxon T criterion made it possible to identify the following features.:

- ✓ it should be emphasized that the amplitude of GCM oscillations in the frontal plane in 8-year-old girls with hearing defects CG_2 does not statistically significantly differ after completion of the molding experiment (T=2; Z=0,53; p=0,593);
- ✓ at the same time, after the completion of the experiment, statistically significant changes in the GCM oscillation amplitude in the sagittal plane of 8-year-old girls with hearing impairments CG_2 were not established (T=3,5; Z=0,55; p=0,584);
- ✓ it is very important that after the completion of the experiment, the GCM oscillation amplitude in the frontal plane of girls MG_2 statistically significantly improved (T=0; Z=2,20; p=0,028);
- ✓ • it should be noted that after the completion of the experiment, the amplitude of GCM oscillations in the sagittal plane of the girls of the MG_2 group statistically significantly decreased (T=0; Z=2,02; p=0,043);
- ✓ the actual data indicate that under the influence of the methodological techniques and means of the “artificial control environment” on the process of APE in girls of the specified group, there was no statistically significant change (T=2; Z=0,53; p=0,593);
- ✓ as the analysis of the experimental data showed, at the end of the experiment, the girls of MG_2 did not experience statistically significant changes in the frequency of GCM oscillations in the frontal (T=2,5; Z=0,91; p=0,361) and sagittal (T=0; Z=1,34; p=0,180) planes;
- ✓ after the introduction of the author's technology, the girls of MG_2 who were engaged in the experimental technology showed a statistically significant improvement in the length of the GCM movement trajectory in the frontal and sagittal planes (T=0; Z=2,20; p=0,028);
- ✓ at the same time, statistically significant positive changes in the length of the GCM movement trajectory in the frontal and sagittal plane of CG_2 girls were established (T=0; Z=2,02; p=0,043);
- ✓ after the experiment, the assessment of the GCM movement speed indicator of the examined girls both CG_2 (T=0; Z=2,02; p=0,043) and MG_2 girls (T=0; Z=2,20; p=0,028) increased statistically significantly;
- ✓ a statistically significant difference in the GCM oscillation area indicators was also revealed after the experiment of CG_2 girls (T=0; Z=2.02; p=0.043) and MG_2 girls (T=0; Z=2,20; p=0,028).

Discussion.

The perception of children with disabilities in society is an indicator of the development of its consciousness (Aloshina et al. 2023), and then the integration of the latter into society is a targeted process of transmitting social experience taking into account the characteristics and needs of various categories of children with disabilities with their active participation (Giannotti al. 2018), as well as creating appropriate conditions for this, which leads to the involvement of children with disabilities in all social systems provided for their healthy peers (Winnick, 2005), and active participation in the most important areas of life and activity of society in accordance with age and gender (Burdayev 2018). The latest approach to social integration is related to the preparation of children with disabilities for entering society, as well as the preparation of their own society to accept such persons (Kashuba et al. 2017). Consideration and meticulous analysis of specialized literature on the problems of correctional and preventive work in the AFV (Savlyuk 2018) gives grounds to assert the special relevance of the latter for the scientific community in the chronological section of recent years (Kashuba et al. 2019; Savlyuk 2024).

The methodological basis of the study covers the philosophical, general scientific, particular and specific scientific levels.

The *philosophical level* of the methodological basis of the proposed study represents a spectrum of well-known provisions on the cause-and-effect relationship.

At the *general scientific level*, the methodological basis of this study is laid by theories and concepts that are valid for a number of fundamental and particular disciplines that constitute the basic knowledge of general scientific methods.

The specific scientific level of the methodological base of the said study is designed for such methodological concepts as: theories and methods of adaptive physical education; theories and methods of physical education of children of primary school age; theories and methods of health and therapeutic physical education; anatomy, biomechanics and physiology of man.

At the specific scientific level, pedagogical, instrumental and mathematical-statistical research methods were used to provide the methodological basis of the study.

Conclusions. The scope of the currently observed transformation processes and tangible shifts in the paradigm and systematics of adaptive physical education is determined by the significant influence of the latest theoretical and methodological problems and "preemptive innovations", the planes of implementation of which are not only software products, but also technologies and control systems. The proposed study substantiates the content and main provisions of the technology of designing and implementing methodological techniques and means of "artificial control environment" in the process of adaptive physical education of primary school children with hearing deprivation.

Author's contribution

Conceptualization, O.S.; methodology, S.K.; software, A. H.; check, S.K.; formal analysis, A. H.; investigation, O.S.; re-sources, L. Y.; data curation, A. H.; writing – rough preparation, O.S.; writing – review and editing, L. Y.; visualization, S. K.; supervision, L. Y.; project administration, M. K. All authors have read and agreed with the published version of the manuscript.

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References

Aloshina, A., Savlyuk, O., & Petrovich, V. (2023). The development of the static fluid body of children from the West is heard as a change of mind in the development of technology for the design and implementation of methodological techniques of “piecemeal core” in the process of adaptive physical development izichnogo vyhovanya. *Physical training, sports and health culture in daily life.* №3(63). pp. 77–94. https://doi.org/10.29038/2220-7481-2023-03-27-31

Burdayev, K. (2018). Formation of statodynamic posture of children of primary school age with hearing impairment in the process of adaptive physical education. [dissertation]. Dnipro. 220 p.

Giannotti, E., Merlo, A., Zerbinati, P., Prati, P., Masiero, S., & Mazzoli, D. (2018). Safety and long-term effects on gait of hemiplegic patients in equinovarus foot deformity surgical correction followed by immediate rehabilitation: a prospective observational study. *European Journal of Physical and Rehabilitation Medicine*, 55(2), 169-175 https://doi.org/10.23736/s1973-9087.18.05290-5

Kashuba V, & Savlyuk S. (2017). Biological prerequisites for the development of the concept of the formation of the spatial organization of the body of children 6–10 years old with vision deprivation: Biologi calpre conditions for the development of the formation concept of spatial organization of the body of the children with vision deprivation. *Journal of Education, Healt hand Sport formerly Journal of Health Sciences*. Kazimierz Wielki University in Bydgoszcz. Poland, №7.7.1095–1112.

Kashuba, V.O., & Popadyuha, Yu.A. (2018). Biomechanics of the spatial organization of the human body: modern methods and means of diagnosis and restoration of disorders: monograph. Kyiv: Center of educational literature; 751 p.

Kashuba V., Kholodov S., Bakanichev O. (2019). The paradigm of biomechanical monitoring of the spatial organization state of human body. *Molodyzhny naukovy visnyk of Lesya Ukrainka East European National University*. Lutsk, Issue 34, 14-20.

Kashuba, V., Goncharova, N. & Nosova, N. (2020). The biomechanics of spatial organization of human body: theoretical and practical aspects. *Theory and Methods of Physical education and sports*. Kyiv, No 2, 67-85.

Kashuba, V., Stepanenko, O., Byshevets, N., Kharchuk, O., Savliuk, S., Bukhovets, B., Grygus, I., Napierała, M., Skaliy, T., Hagner-Derengowska, M., & Zukow, W. (2020). Formation of Human Movement and Sports Skills in Processing Sports-pedagogical and Biomedical Data in Masters of Sports. *International Journal of Human Movement and Sports Sciences*, 8(5), 249-257. https://doi.org/10.13189/saj.2020.080513

Kashuba, V., & Afanasiev, D. (2020). Dynamics indicators of supporting – spring properties of a foot in the children of primary school age with derivation of hearing during process of adaptive physical education under influence of author's technology on prevention of violations the biomechanical properties of foot. *Pedagogy and Psychology of Sport*, 6(4), 56-63. http://dx.doi.org/10.12775/PPS.2020.06.04.006 .

Khmelnytska, I.V. (2006). Computer systems for controlling the motor skills of 7-10-year-old schoolchildren with hearing impairments in the programming of physical education classes. [dissertation]. K. 220 p..

Laputin, A N. (1995). Didactic biomechanics: problems and solutions. *Science in Olympic Sport*, 2(3), 42–51.

Laputin, A. N., & Kashuba, V. A. (1999). The forming of mass and gravitational interactions of human body during the ontogenesis. *Znannya Ukrainy*. 200 p.

Laputin, A. N., & Kashuba, V. A. (2009). Kinetics of human body. *Physical education, sport and health culture in modern society*, 4, 40-9.

Savlyuk, S.P. (2018). Prevention and correction of disorders of the spatial organization of the body of children aged 6–10 years with deprivation of sensory systems in the process of physical education]. [dissertation]. K., 460 p.

Savlyuk, O. (2022). Morphological characteristics of children 6–10 years of age based on hearing loss. *Physical culture, sports and the health of the nation*, 14(33),115-120. https://doi.org/10.31652/2071-5285-2022-14(33)-115-120

Savlyuk, O., &Aloshina, A. (2023). Amplitude-frequency indicators of body strength in children 6-10 years of age. *Physical culture, sports and the health of the nation*, 15 (34), 65-75. https://doi.org/10.31652/2071-5285-2023-15(34)-65-75

Savlyuk, O., & Aloshina, A. (2024). The effectiveness of the author's technology aimed at the development of static and dynamic balance of the body, children of young school age due to hearing deprivation in the process of adaptive physical training. *Physical culture, sports and the health of the nation*,17 (36), 96-105. https://doi.org/10.31652/2071-5285-2024-17(36)-96-105

Winnick, J. P. (2005). Adapted physical education and sport. Champaign: Human Kinetics, 574 p.

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