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RESEARCH ARTICLES

3d Corrective Space in the Physical Rehabilitation of Children with Musculoskeletal System Disorders

Espacio correctivo 3d en la rehabilitación física de niños con trastornos del aparato locomotor

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Abstract

In the article, the capability of the space category is considered as one of the main conditions of the matter's existence. We are referring to the length, width and height in their 3D unity. In order to increase the effectiveness of children's physical rehabilitation from a methodological point of view, we proposed to consider physical space as a conditional four-dimensional substance, including ehe subjective aspect of a specific motoric play situation perception of a child and a rehabilitation teacher. During the physical rehabilitation classes for children with musculoskeletal system disorders, after many years of practice, it was noticed that spatial parameters can be purposefully controlled to improve the correction efficiency of various motoric disorders. The authors propose to consider as a special phenomenon the corrective modelling of the internal hall architecture to solve the necessary pedagogical problems. The authors named this phenomenon corrective 3D space. In the process of empirical studies of this phenomenon, the authors came up with the following options for its use in the physical rehabilitation of the specified children contingent: an artificial decrease of the spatial parameters of the motoric play zone, an artificial increase of the spatial parameters of the motoric play zone, an artificial violation of the harmonious relationships of the spatial parameters of the motoric play zone (length, width and height), and an artificial complication of the spatial parameters of the motoric play zone for physical rehabilitation of the child. It turned out that the above options for purposeful changes in spatial parameters have a positive effect of increasing the effectiveness of the correctional process of physical rehabilitation of children with musculoskeletal system disorders. The usual passive physical space of the hall is transformed into a corrective 3D space that actively influences the rehabilitation process.

Keywords: corrective 3D-space, physical rehabilitation, children, musculoskeletal system disorders.

Resumen

En el artículo se considera la capacidad de la categoría espacio como una de las principales condiciones de existencia de la materia. Nos referimos al largo, ancho y alto en su unidad tridimensional. Con el fin de incrementar la efectividad de la rehabilitación física de los niños. Desde un punto de vista metodológico, nos propusimos considerar el espacio físico como una sustancia condicional de cuatro dimensiones, incluyendo el aspecto subjetivo de una situación de juego motriz específica percepción de un niño y un maestro de rehabilitación. Durante las clases de rehabilitación física para niños con sistema musculoesquelético Trastornos, después de muchos años de práctica, se notó que los parámetros espaciales se pueden controlar intencionalmente para mejorar la eficiencia de corrección de varios trastornos motores. Los autores proponen considerar como un fenómeno especial el modelado correctivo de la arquitectura interna del salón para resolver los problemas pedagógicos necesarios Los autores llamaron a este fenómeno espacio 3D correctivo. En En el proceso de estudios empíricos de este fenómeno, los autores propusieron las siguientes opciones para su uso en la rehabilitación física del contingente de niños especificado: una disminución artificial de los parámetros espaciales de la zona de juego motriz, un aumento artificial de los parámetros espaciales. de la zona de juego motor, una violación artificial de las relaciones armoniosas de los parámetros espaciales de la zona de juego motor (largo, ancho y alto), y una complicación artificial de los parámetros espaciales de la zona de juego motor para la rehabilitación física del niño. Resultó que las opciones anteriores para cambios intencionales en los parámetros espaciales tienen un efecto positivo al aumentar la efectividad del proceso correccional de rehabilitación física de niños con trastornos del sistema musculoesquelético. El espacio físico pasivo habitual de la sala se transforma en un espacio 3D correctivo que influye activamente en el proceso de rehabilitación.

Palabras clave: espacio 3D correctivo, rehabilitación física, niños, trastornos del sistema musculoesquelético.

Introduction

In the process of world evolution, three main conditions determine the existence of matter: space, time and motion. Based on this, we can assume the enormous potential of each of these conditions (in particular, space) and its impact on the environment and the person (child) in this environment. Unfortunately, the modern technological boom leads us to an increase in the number of various objects, training constructors, which begin to limit the space, reducing the effectiveness of its influence on the environment. In our opinion, we need to "release the space" (make it free), let it be realized in its original power, and then learn to manage its components to solve the assigned rehabilitation tasks.

Problem statement

We have been engaged in physical rehabilitation of children of early and preschool age for about 40 years now. This article will focus on this age group of children with musculoskeletal system disorders. Firstly, we will talk about children with neuro-orthopaedic pathology, i.e. suffering from cerebral palsy, as well as having various variants of spinal paresis of the torso and limbs. A sufficient number of studies have recently been carried out with respect to this children contingent (Efimenko, 2014, 2019; Mastukova, 1991; Moga, 2019, 2020; Kozevnikova, 2013; Glew, 2010; Gulati, Sondhi, 2018; Graham, Rosenbaum, 2016; Lee, Jin., Kang, Gaebler-Spira. & Zhang, 2019; Lieber, Roberts & Blemker, 2017; Mahmood, Habibullah & Babur, 2019; Nieuwenhuys, Papageorgiou, Schless, De Laet, Molenaers & Desloovere, 2017; Novak, McIntyre & Morgan, 2013; Pavão, Rocha, 2017 and others). However, they practically did not pay attention to the methodological substantiation and practical use of the possibilities of space (its three components) to increase the effectiveness of physical rehabilitation of children with musculoskeletal system disorder.

In this regard, we see it as relevant to preliminary investigate the theoretical possibilities of space as one of the fundamental conditions of the matter's existence in the context of their practical use to increase the effectiveness of physical rehabilitation of specified children.

Research questions

1. From the position of philosophy, formulate a methodology for the universal use of space to increase the effectiveness of physical rehabilitation of specified children.
2. From a practical point of view – to develop a methodological basis for the practical use of the possibilities of corrective 3D space in the physical rehabilitation of children of early and preschool age with neuro-orthopaedic pathology.

Purpose of the study

The purpose of this study is to form the preliminary foundations of the methodology of space usage to increase the effectiveness of physical rehabilitation of children with musculoskeletal system disorders and to develop methods (methodological techniques) for the practical use of corrective 3D space for overcoming children tonic disorders such as muscle hypertension, muscle hypotension, muscle dystonia and related disorders (stiffness in the joints, looseness in the joints, instability in the joints, etc.).

Research methods.

Theoretical methods:

– historical method of analysis and systematization of domestic and foreign experience was used to study the degree of scientific research and determine the possibilities of practical use of the philosophical basis in developing the physical rehabilitation system of children with musculoskeletal system disorders.

Practical methods:

– method of practical approbation of various variants of spatial parameters application in physical rehabilitation of children with musculoskeletal system disorders.

Findings.

Let's take a look at the category of space. There is an opinion (Aleksandrov) that deeper, more complete knowledge of space and time properties proves their objective reality, just as the variability of scientific knowledge about the structure and forms of matter, motion proves the objective reality of the external world. Real space is **three-dimensional**. The three-dimensionality of space is expressed in the fact that only three mutually perpendicular straight lines can be drawn through each point of space. Any material objects exist in three-dimensional space. No matter how big or small the objects of the world are, their movement can take place only in real space, which has three dimensions (Fig. 1).

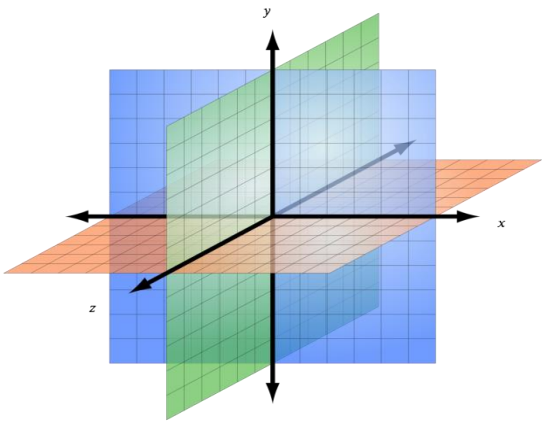

Figure 1. 3D Space

By analogy with real three-dimensional space, mathematics creates abstractions of four-dimensional, five-dimensional, etc., "spaces". It goes without saying that the so-called "multidimensional spaces" cannot be identified with real space, which is the root form of the matter existence and has only three dimensions. These abstractions of the so-called "multidimensional spaces" reflect the patterns of certain sets of things and their properties. In physics, for example, there is an idea of the so-called "phase space" with a very large number of dimensions, which, in addition to three spatial coordinates that characterize the position of every particle of any material system, also include quantities that express the momentum of these particles.

We find interesting the idea of the ***multidimensional nature of space***. Of course, we recognize the radical three-dimensionality of space as the main condition of the matter's existence. However, if ***situationality*** is also added to three-dimensionality at each specific moment of time, then some conditional four-dimensionality may appear, due to both the objective characteristics of the physical rehabilitation process of the child and the subjective experience of this process by the teacher-rehabilitologist and the child. For example, in one situation, a child will perform squats at the gymnastic ladder and feel some discomfort. The objective spatial component will be called 3D. The subjective background that fills this 3D shape, we will call S (Subjective). In this situation, the conditional four-dimensionality can be expressed by the formula $3D + S_1$. If the same child performs hang on the same ladder, then this situational option can be expressed by the formula $3D + S_2$. The objective spatial characteristics remained the same (the same ladder, the same length, width and height) but the child's emotional experiences changed in the different direction.

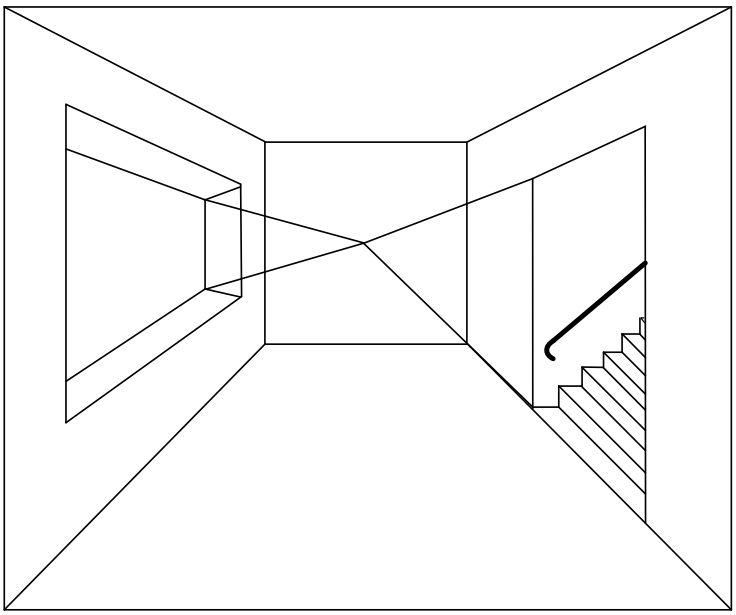

Figure 2. Objective three-dimensionality of the room

Summarizing the above example, we propose to attach an additional situational component to the objective three-dimensional representation of space, which can change (depending on the subjective perception of the given situation) by two actors: a rehabilitologist and a child. This can also include not only the emotional experiences of the participants in each specific situation, but also the planning by the teacher-rehabilitologist P (Plan), and the final correction result R (Result) obtained as a result of its implementation. Taking this into account, the spatial characteristics of a specific motoric game situation can now be expressed by the following formula: $3D_1 + S_1(P_1 + R_1)$ (Fig. 3).

We propose to call this new component «***Corrective 3D-space***». In its final form, our proposed formula will look like this:

Corrective 3D-space = 3D1+S1 (P1+R1)

Where:

$3D_1$ - objective three-dimensional space,

S_1 - the subjective experience of a given motor-game situation by a teacher- rehabilitologist and a child,

P_1 - the plan of the teacher- rehabilitologist for this situation,

R_1 - is the final correction result.

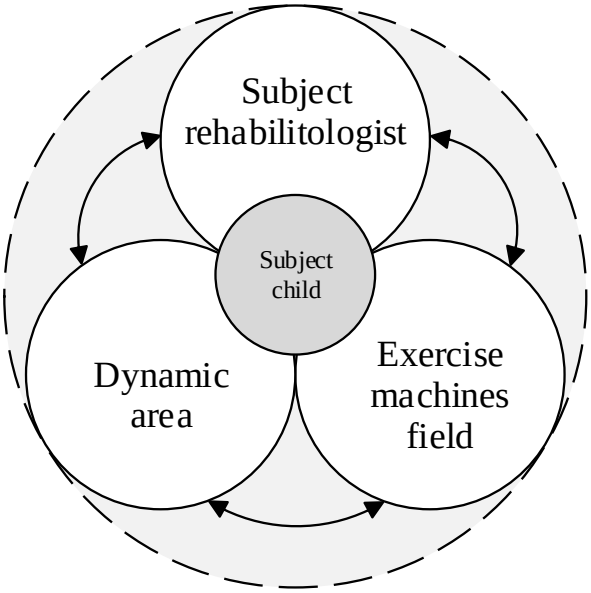

Figure 3. Correction 3D-space of real motor play situation

It is very interesting to consider here the concept of **"living space" and the theory of the psychological field developed in 1951 by Kurt Lewin** in the mainstream of Gestalt psychology. With its help, the scientist explained the features of human behaviour. The main conceptual positions are given below:

1. Each person (child) lives and develops in the psychological field of the objects around him.
2. Each object has its own valence for a person (child) – a kind of energy charge that causes a specific voltage that requires discharge. We are talking about an energetic physical field.
3. Human (child) behaviour is divided into volitional and field behaviour. Volitional field caused by internal needs and motives. behaviour field caused by external objects.
4. The course of human actions is entirely reduced to the specific conditions of the current field.

Lewin proceeded from the key position that the basis of human activity in various forms of its manifestation are needs (quasi-needs). Formed in the current situation in connection with the adopted intentions or goals, they direct human activity. The need creates a system of tension in the personality that strives to discharge. According to K. Lewin, this is the satisfaction of the need. The discharge of the need is carried out in a certain situation, which the author of the theory calls a psychological field. Each thing in this psychological field is characterized not by its physical properties, but in relation to the need of the subject, which determines the fact that one object has an incentive force, and the other does not have such an incentive force and has a negative valence. Thus, the objects of the field represent positively and negatively charged valences in relation to the need.

For our research, this concept has great importance, first of all, because the process of physical rehabilitation of children with musculoskeletal system disorders occurs in a certain object-spatial environment: in the hall, where next to the child there can be a step, fitball, trampoline, ladder, swing, toy. Only due to the selection of a toy (object) that the child likes, it is possible to enhance his corrective motoric play activity. For example, one of our children with cerebral palsy (Vladik O.) likes swinging on the “Airship” simulator (a suspended barrel with slings for manual gripping). There is a training structure that constantly attracts the mentally disabled child to the gym. This case demonstrates the concept of field behaviour.

For many years, the basis of our work with children was ***the play method, a kind of theatricalization of motoric play activity***. Rehabilitation classes were held in the form of a performance, a kind of physical culture fairy tale, with its main plot and the necessary dosed dramatization. The child's urge to resolve the dramatic situation modelled by the teacher in favour

of justice, goodness and truth greatly enhances the final correctional result. Thus, we already see two vectors that coincide in motivational orientation: subject - field (according to K. Lewin) and dramatization - play (according to N. Efimenko) or strong-willed (according to K. Lewin). These vectors can coincide and give significant results in physical rehabilitation.

Further, we want to consider one more amazing phenomenon, which this article is mainly devoted to – **the phenomenon of dynamic space** as a relatively autonomously existing substance. This does not mean the separate existence of space from time and motion. We mean the primordial ability of space to be itself from the very beginning, regardless of the objects in it (Ist Newton's concept). Two dual extremes can be identified here: on the one hand, there is a space that is densely filled with objects (which is observed today in gyms and physical rehabilitation centres), and, on the other, absolutely open (free) space. Try to answer the question – what space will motivate the child more strongly towards motoric play activity? According to our experience, it is the open space that immediately calls the child to fill its emptiness with motoric play manifestations. In this regard, remember the feeling that arose when you were alone on the edge of a huge (in the perception of a child) football field? At the same time, there was no one, there were not any balls. However, you really wanted (and perhaps you did) just run across this field from edge to edge on a diagonal and satisfy your need for relaxation, which arose at the sight of such a large and open space.

In this regard, we propose to introduce a new physical rehabilitation concept – open space (inviting space, attracting space, motivating space, engaging space). This is a relatively large space, free from objects and structures, in which no one is present. It is necessary initially to release the conditional *mesospace* (for example, the kindergarten's sports ground) and give it to take its place in the *macrospace* (on the common territory of the kindergarten). These two spaces should feel comfortable in the general cosmic megospace. Such alignment reminds the Russian toy – matryoshka when each small matryoshka is put into a large matryoshka and at the same time they do not embarrass each other.

And now let's move a child with musculoskeletal system disorders to this open space. In this situation, the child will often have a positive attitude to what he or she saw, a spatial field will arise that will entice the child to master this open space, i.e. to move. The child's body in this situation can be considered as a mini-space that interacts with the mesospace. These interactions should be comfortable for both spaces and this can be achieved by adjusting the three vectors of space (Fig. 1). We called the resulting subjective relationship between the child and open space – a dynamic space, which includes not only the physical three-dimensional space but also the subjective attitude to it, and the child's emerging motivation for motoric play activity.

Since we are dealing with the physical rehabilitation of children with musculoskeletal system disorders, it became necessary to transform this concept (dynamic space) into a new one – **correctional 3D space**. Now we need not only to motivate the child to a sufficiently longer motoric role activity in this space but also to carry out a purposeful correction of his motoric impairments. Based on our own practical experience, this can be achieved with the following:

- artificial reduction of the motoric play zone spatial parameters;
- artificial increase of the motoric play zone spatial parameters;
- artificial contravention of the harmonious relationships of the motoric play zone spatial parameters (length, width and height);
- artificial complication of the motoric play zone spatial parameters for physical rehabilitation of the child.

Let us consider more specifically the proposed methodological approaches to children with various disorders of muscle tone. We will take the first item of this conditional algorithm. It is known that a child with the spastic syndrome is recommended to take a grouping pose, or an embryo pose, to achieve general relaxation of the whole body and the necessary initial tonic harmonization. To do this, the teacher needs to reduce the length parameter of the space in which the child will assume a position lying on his back or on his side. In this variant, the rehabilitologist can place the child between two rollers, between two modules, between themselves and a roller or module,

between themselves and the wall. With the decreasing of the spatial parameter, the child must take a grouping pose, which is necessary to achieve a correction effect.

Space can be reduced using appropriate material forms: for example, place the child in a plastic basin, car camera, special plastic barrel, box, module, etc. to take a pose where he/she sits with ankles crossed and knees apart, which is close in biomechanical parameters to the embryonic position.

Using sand therapy, it is possible to form reduced parameters by preparing the wells of the appropriate size, where the child will be placed for posture treatment. You can also use reduced mounds to achieve a semi-embryo position while lying on your stomach. You can fill two sandy hills, placing them at a close distance, and place the child between them on his/her back on warm sand in the embryo or semi-embryo position.

A methodical technique with spatial parameters decrease in all three dimensions can be applied when exercising in a hammock during aerial yoga classes. The hammock is made of thin but durable fabric, which allows it to stretch, curl, sag. Additional slings help the teacher to form, with the help of this tissue and body weight, the necessary corrective postures based on a decreasing of the child's motoric play space, which is in the hammock.

In paired correctional techniques (baby yoga, paired body training, baby plastic show, dynamic gymnastics, etc.) of an adult and a child, the motoric play space decreasing is achieved by the corresponding actions of an adult aimed at forming the necessary corrective posture. In this case, the body of an adult can be considered as a kind of biological simulator on which the child is located.

The first direction of a minimized space modelling for a child's exercise can be considered as the formation of the initial position of an adult before the start of correctional training with a child with a spastic syndrome of motoric disorders:

1. The adult takes the initial position lying on his back and bends his lower limbs (while he can lean on the back on bent forearms), forming his body a kind of hammock, in which the child will sit in a bent embryonic position.
2. The adult takes the initial position on the side in the "semi-embryo" position - it is assumed that the child will take a similar starting position in front of the adult (with his back to him) for the necessary initial relaxation.
3. The adult takes the initial position on low all fours, bending the torso and limbs as much as possible (in the embryo position), and the child can lie on top of the adult along or across his/her body in the “semi-embryo” position, which will allows him/her to relax tense spastic muscles.
4. The adult takes the initial position sitting with bent legs, leaning on the floor from behind with straightened arms. To relax the muscles, the child can take the following positions: sitting on the hips of the adult and repeating his original position, or lying on his stomach on the bent knees of the adult facing him.
5. The adult takes the initial position, sitting ankles crossed knees apart, bending the torso and upper limbs to support the child (wrapping his arms around him) on his hips in a similar position.
6. The adult takes the initial position on middle “all fours” (on the palms and knees), while the child can crawl under the adult and take a pose on low all fours (embryo pose), sitting along or across the body of the teacher or one of the parents.
7. An adult takes the initial position on high all fours on bent upper and lower limbs. The child is placed under the adult in the following positions: on low all fours, on medium fours with flexed trunk and upper limbs; sitting in Turkish, sitting in a grouping position and the like.
8. The adult takes the initial position on low knees, while the child is positioned with his stomach across the knees of the adult in the "semi-embryo" position.

Now we will consider the methodological possibilities of a purposeful artificial space increasing the motoric play corrective zone, in which the child will be periodical during the lesson. This area includes the following:

- Artificial increase of space (length) for the initial position of the child in order to stretch spasmodic muscle groups.

- Working with spherical surfaces that stimulate the extension of the limbs and stretching of the spasmodic flexor muscles.
- Artificial height increase of the playing objects-stimulus location to enhance the tendencies to straighten and extend the flexed limbs of a child with a spastic syndrome.
- Increasing the distance length that the child must overcome in the classroom by various means: by rolling, crawling, moving on the buttocks, squatting, kneeling, on the feet, and the like.
- Height increases to which the child must climb, independently or with the help of an adult, by various means, using a Swedish ladder or other climbing structure.
- Increasing the length and height of the throwing trajectory of various objects.

We will proceed to consider in more detail the correctional 3D space artificial increase by using spherical surfaces. Traditional stuff includes stuffed rollers of various diameters: from 20 - 30 cm to 45 - 55 cm. In this range, the following pattern is observed: the larger the roller diameter, the more spherical its supporting surface, the greater extension effect will be observed. This will help to achieve the desired corrective effect.

From our own experience, we can give an example of using a plastic barrel with a volume of about 40 - 50 litres, which has proven itself very effective in the corrective work with children with spastic movement disorders. The barrel construction is more rigid, which gives the child confidence when he is on top of it in a supine position. The barrel rolls better back and forth, which enhances the correction effect.

Modern technical capabilities make it possible to use spherical barrel-shaped foam modules, designed in different colours to attract attention and motivate a child to a motoric play activity.

Speaking about the artificial length increase to increase the effectiveness of physical rehabilitation of children with the spastic syndrome of motoric disorders, it is worth mentiontioning the effective use of fitballs of different diameters: from 45 cm to 100 cm and more. The child is placed on the fitball in the supine position, after which the teacher performs sequential swinging back and forth, to the sides, shaking, a combination of swinging with shaking.

An artificial length increase of the body and motoric play space can also be achieved if the child is stretched by two specialists along the longitudinal line of the body: two arms and two legs, the arm and leg of the same name, the opposite arm and leg (diagonal version). Thus, the correction potential of increasing the length of the conventional 3D space is used.

In a similar way, it is possible to implement the correctional possibilities of artificially increasing the motoric play zone width in which the child is here and now. On the fitball, you can not only stretch the child's body (his spasmodic flexor muscles) in the direction of length but also spread the upper and lower limbs in both directions, overcoming the tension in the adductor muscles that bring limbs together. In addition, when the trunk is extended, the height of the back deflection will increase, which will also additionally stretch the muscles of the superficial frontal myofascial line.

With deliberate distortion and complication of the spatial parameters of the conditioned correctional 3D space, the child's coordination abilities are stimulated, which is very important for children of early and preschool age with a spastic type of motoric disorders (especially with cerebral palsy). This deliberate complication can be achieved in different ways:

A. Artificial narrowing of the movement path for the child.
B. Artificial increase of the supporting surface on which the child will move.
C. The presence of artificial horizontal or vertical obstacles in the path of a child's movement.
D. An artificial complication of the space for the child's movement: using a non-standard trajectory for movement, changing the width and height of the conditional "corridor", where the child will move, combining horizontal and vertical obstacles like a "maze" and the like.

As we can see, in the version of the correctional 3D space, the contradiction between the dual opposites is harmoniously resolved: a relatively spacious free space is temporarily filled with the necessary number of objects (simulators) to create more favourable conditions for the physical rehabilitation of this children.

Conclusion

Having analyzed theoretically from the standpoint of materialism and idealism, the concept of space in its three-dimensional unity, and admitting the dialectical interaction of the material and the ideal, we proposed to consider the phenomenon of space as a conditional four-dimensional substance, which includes both three traditional objective parameters of space and the subjective aspect of the relationship to the certain motoric play situation of the child and the teacher-rehabilitologist. This conceptual approach is based on the theory of the psychological field of K. Levin. We proposed the concept of dynamic space, which functions due to the arising spatial psychological field.

In practical terms, we considered options of using the capabilities of the corrective 3D space to increase the effectiveness of physical rehabilitation of children with neuro-orthopaedic movement disorders: an artificial reduction of the motoric play zone spatial parameters, an artificial increase of the motoric play zone spatial parameters, an artificial contravention of the harmonious relationships of the motoric play zone spatial parameters (length, width and height), an artificial complication of the motoric play zone spatial parameters for physical rehabilitation of the child.

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