Correction system effectiveness of the children physical development of early and younger preschool age with psychomotor disorders (on the example of posture)

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Abstract

Purpose: to reveal the reliability of the effectiveness of the developed author's system for correcting the physical development of young and preschool children with psychomotor disorders.

Material and methods. A total of 208 children of early (2-3 years) and younger preschool (3-4 years) age with psychomotor disorders took part in the study. Specially organized studies of the effectiveness of the system of corrective physical education for children of early and younger preschool age with psychomotor disorders were conducted during 2019 - 2021. They took place in specialized preschool education institutions, as well as kindergartens of the combined type in the city of Odesa, Odesa region, as well as in the cities of Kramatorsk, Kharkiv, Mykolaiv, Balaklia (Kharkiv region). I also summarized my own long-term (over 25 years) experience of individual rehabilitation activities with the specified contingent of children in the Odessa Movement Rehabilitation Center. All children were divided into two groups: 108 from experimental groups and 100 from control groups.

Results. Summarizing the analysis of the results of the dynamics of physical development indicators of children with psychomotor disorders (on the example of the study of their posture), we should conclude that almost all the indicators of children from the experimental groups had a marked improvement in results, which in the absolute majority of cases was confirmed statistically (P<0,01‒0,05). Children from control groups also demonstrated some improvement of physical development indicators, but it was by no means confirmed by the methods of mathematical statistics (P>0,05).

Conclusions: the conducted formative pedagogical experiment confirmed the reliability of the effectiveness of the developed author's system of correction of physical development of children of early and early preschool age with psychomotor disorders in comparison with the traditional system of their education.

Key words: children, psychomotor disorders, physical development, posture, diagnosis, correction of posture disorders, adaptive physical education

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Анотація

Володимир Беседа. Ефективність системи корекції фізичного розвитку дітей раннього і молодшого дошкільного віку з порушеннями психомоторики (на прикладі постави)

Мета: виявити достовірність ефективності розробленої авторської системи корекції фізичного розвитку дітей раннього та молодшого дошкільного віку з порушеннями психомоторики.

Матеріал і методи. Всього в дослідженні взяли участь 208 дітей раннього (2 – 3 роки) та молодшого дошкільного (3 – 4 роки) віку з порушеннями психомоторики. Спеціально організований педагогічний експеримент щодо ефективності системи корекційного фізичного виховання дітей раннього і молодшого дошкільного віку проводився впродовж 2019 – 2021 рр. Дослідження відбувалося у спеціалізованих закладах дошкільної освіти, а також дитячих садках комбінованого типу м. Одеси, Одеської області, а також у містах Краматорськ, Харків, Миколаїв, Балаклія (Харківської області). Також узагальнювався власний багаторічний досвід індивідуальної реабілітаційної діяльності із зазначеннями контингентами дітей в одеському Центрі реабілітації рухом.

Результати. Резюмуємо аналіз результатів динаміки показників фізичного розвитку дітей з порушеннями психомоторики (на прикладі дослідження їхньої постави), слід зробити висновок, що майже за всіма показниками діти з експериментальних груп мали помітне покращення результатів, яке в абсолютній більшості випадків було підтверджено статистично (P<0,01–0,05). Діти з контрольних груп також продемонстрували деяке покращення показників фізичного розвитку, але воно не було підтверджено методами математичної статистики (P>0,05).

Висновки: проведений формувальний педагогічний експеримент підтвердив достовірність ефективності розробленої авторської системи корекції фізичного розвитку дітей раннього та молодшого дошкільного віку з порушеннями психомоторики у порівнянні з традиційною системою їхнього фізичного виховання

Ключові слова: діти, порушення психомоторики, фізичний розвиток, постава, діагностика, корекція порушень пості, адаптивне фізичне виховання

Аннатоция

Владимир Беседа. Эффективность системы коррекции физического развития детей раннего и младшего дошкольного возраста с нарушениями психомоторики (на примере осанки)

Цель: выявить достоверность эффективности разработанной авторской системы коррекции физического развития детей раннего и младшего дошкольного возраста с нарушениями психомоторики.

Материал и методы. Всего в исследовании приняли участие 208 детей раннего (2-3 года) и младшего дошкольного (3-4 года) возраста с нарушениями психомоторики. Специально организованные исследования эффективности системы коррекционного физического воспитания детей раннего и младшего дошкольного возраста с нарушениями психомоторики проводились на протяжении 2019–2021 гг., Харьков, Николаев, Балаклея (Харьковской области). Также обобщался собственный многолетний опыт индивидуальной реабилитационной деятельности с указаным контингентом детей в одесском Центре реабилитации движением. Все дети были распределены на две группы: 108 – составили экспериментальную и 100 – контрольную.

Результаты. Резюмируя анализ результатов динамики показателей физического развития детей с нарушениями психомоторики (на примере исследования их осанки), следует заключить, что почти по всем показателям дети из экспериментальной группы имели заметное улучшение результатов, которое в абсолютном большинстве случаев было подтверждено статистически (P<0,01–0,05). Дети контрольной группы также продемонстрировали некоторое улучшение показателей физического развития, но его достоверность не была подтверждена методами математической статистики (P>0,05).

Выводы: проведенный формирующий педагогический эксперимент подтвердил достоверность эффективности разработанной авторской системы коррекции физического развития детей раннего и младшего дошкольного возраста с нарушениями психомоторики по сравнению с традиционной системой их физического воспитания

Ключевые слова: дети, нарушение психомоторики, физическое развитие, осанка, диагностика, коррекция нарушений осанки, адаптивное физическое воспитание
Introduction

In today's conditions, against the background of a constant increase in the number of children with psychomotor disorders, the diagnosis of physical development plays a primary role in the development of strategies and tactics for further corrective measures. In correctional pedagogy, Yefimenko [1] defined the theoretical and methodological foundation for the correction of the musculoskeletal system in children by means of adaptive physical education, proved the need for comprehensiveness in the prevention and correction of violations of the motor sphere using scientifically based diagnostics. The following achievements of the scientist are particularly valuable for our research: he was able to combine the objectivity of clinical tests accepted in neurology with significant pedagogical possibilities of game testing, which is of great importance when working with children of early and younger preschool age with psychomotor disorders. In order to obtain from such children reliable information about the state of their physical development during testing, it is necessary to create a comfortable situation for them with an interesting game activity. This, first of all, will allow the teacher to establish positive contact with the child, and fully complete the test task itself. Secondly, it is game motivation against the background of dosed dramatization of the author's plot tests that will significantly increase children's motivation for collecting motor and game activities. The results that children will show in such conditions will be more objective compared to those that a child would demonstrate without proper motivation. We also consider the method of topographic diagnosis of plantograms developed by the author to be very valuable, which allowed us to find out the type of arch of children's feet during the research (normotonic, hypotonic, hypertonic, dystonic, asymmetric, etc.). It is clear that the peculiarities of the condition of the arches of children's feet play a significant role in building their posture both in statics and during movement. We consider the original classification of movement disorders in children proposed by the author, which includes the following typological subgroups: cerebral (craniocerebral) type, cervical (cervical) type, lumbar (lumbar) type, as well as combined types (cerebral-cervical, cervical-lumbar, cerebral - lumbar, cerebral-cervical-lumbar). But a special value in the author's methodology of the scientist is his persistent introduction into the correction process of the total game method, which is not typical for purely medical rehabilitation. The author recommends that each lesson on the correction of physical development be conducted on the basis of the following postulates: the plot of the lesson, its imagery, role-plays of children in accordance with the selected fairy-tale images; sufficient range and degree of emotionality; dosed dramatization, fairy-tale therapy, use of the energy potential of the unconscious through the involvement of appropriate children's archetypes in motor and game activities. In the context of the above, we are impressed by the author's original technology developments in the new aesthetic and health trends created by him - horizontal plastic ballet (plastic show) and pair and group body training of adults and young children, which were based on the principle of conformity to nature, the phylogenetic principle of motor children's development, the evolutionary method of their physical development. Its fundamental difference from the generally accepted methods is that the author proposes to observe a fundamentally different sequence of mastering basic movements by children, which reflects the logic of the evolution of the animal world (phylogeny) and basically repeats the natural sequence of the formation of movement patterns in a child of the first year of life (early ontogenesis): from lying-horizontal positions at the beginning of the class to vertical, gravitational, shock-shaking positions at the end of the class [1].

It is common knowledge that the first formation of posture in a child is completed at the age of approximately 7 years. At the same time, the posture of children with psychomotor disorders is of particular importance, since it is a complex reflection of the features of their general physical development and the movement disorders they have. It is in the period of preschool childhood that children should fully develop eight basic motor modes: lying down, crawling, sitting, standing, walking, climbing, running, jumping. The timely formation and development of these basic movements is the foundation of the physical development of preschoolers, which stimulates their development of the appropriate motor qualities: strength, flexibility, speed, dexterity and endurance. The motor readiness of children stimulates the overall biological physical development of children, affects the formation of all important morpho-functional components of the musculoskeletal system. In this regard, Xin et al. [2] emphasize that preschool children are in a critical period of formation of basic motor skills that depend on their physical activity. It is clear that the physical activity of children with psychomotor disorders is significantly limited by the peculiarities of their mental development, a decrease in communication and general motor activity. In this regard, the following research should be considered very relevant.
In sports metrology, Bersenev [4] rightfully insists on mandatory diagnosis of the state of the spinal column, because it is precisely on this that the spatial organization of the human body in statics and dynamics depends. It is necessary to know the primary coordinates of the human body in space in order to organize their purposeful correction in the future, or to take them into account when performing complex coordination movements.

In rehabilitation, Nosova [5] assigns a significant role to the use of massage manipulations in the restoration of lost motor functions, and we share this position with the author, because for many years we have been practicing massage gymnastics developed by us - a peculiar combination of the possibilities of traditional massage manipulations with the significant potential of physical exercises. With this approach, massage manipulations are a kind of preparatory part for further full-fledged exercise: muscles relax or, on the contrary, acquire the necessary elasticity, blood circulation in them improves significantly, the temperature of muscle fibers increases, which positively affects the contractile capabilities of muscles. At the same time, the child receives appropriate tactile and kinesthetic sensations, which enriches his sensory experience, forms a feeling of "schema of his body". After such preliminary preparation, the massage therapist begins to include in the corrective work first passive exercises that he himself performs with the child's limbs and trunk, and then passive-active exercises and active ones. In our opinion, massage gymnastics should be included in the list of means of physical education [6].

In posturology, Martini et al. [7] investigated postural control skills in children using the Movement Assessment Battery for Children Second Edition (MABC-2) and the VRRS stabilometric balance platform; they determined that difficulties with posture control have a direct negative impact on children's everyday life. We share this position of the authors, therefore, in our study of the correction of the physical development of children of early and younger preschool age with psychomotor disorders, the posture itself is taken as its comprehensive indicator. It reflects many factors of the state of the musculoskeletal system and physical development of the specified category of children: muscle tone, degree of mobility in the joints, strength of muscle groups, body asymmetries, anthropometric features, somatotype of the child, supporting capacity of the lower limbs, condition of the vault feet, dynamic stability, pathological curvatures of the vertebral trunk, etc. Liu et al. [8] claim that the application of robotics in motor functions will be a new direction of virtual reality (VR) therapy for children with cerebral palsy in the future, which we partially agree with. Despite technological progress in various fields, including medicine and pedagogy, we consider the main condition of full-fledged physical rehabilitation to be independent, conscious, purposeful and motivated performance by children of all necessary for household, educational and work adaptation of motor activities. Motivation can be both internal and external. In the first stages, external motivation from the teacher, computer or robot can dominate. But in the future, the internal motivation, generated by the child on the basis of his new opportunities, upbringing and awareness, should gain more and more emphasis. This approach is shared by Decavele et al. [9], who determined that combined rehabilitation (regular physical therapy and special games) had a positive effect on individually defined therapy goals, dynamic sitting balance and standing exercises in children with cerebral palsy, but the durability of the effect depends on continuous individually targeted physical therapy. Musiyenko et al. [10, 11] established that engaging in adaptive physical education of children with autism made it possible to overcome most of the motor impairments, which created the prerequisites for improving higher nervous activity and behavior, improving psychophysical condition, and increasing the quality of life. Syahputri & Sukoco [12] identify the leading role of the game model of learning in improving kinesthetic perception, game intelligence and cooperation between children, which is based on kinesthetic perception.

However, despite the presence of developments in determining the features of posture in children with special educational needs and methods of improving their physical development and general social adaptation, the system of correcting the physical development of children of early and preschool age with psychomotor disorders requires a more in-depth and comprehensive study, which led to relevance of this article.

The purpose of the study is to determine the reliability of the developed system for correcting the physical development of children of early and younger preschool age with psychomotor disorders (using the example of posture).

Material and methods

Participants

A total of 208 children of early (2-3 years) and younger preschool (3-4 years) age with psychomotor disorders took part in the study. Official
Permission was obtained from their parents for their participation in the pedagogical experiment.

Procedure (organization of research)

Specially organized studies of the effectiveness of the system of adaptive physical education for children of early and younger preschool age with psychomotor disorders were conducted during 2019 - 2021. They took place in specialized preschool education institutions, as well as kindergartens of the combined type in the city of Odesa, Odesa region, as well as in the cities of Kramatorsk, Kharkiv, Mykolaiv, Balaklia (Kharkiv region). He also summarized his own long-term (over 25 years) experience of individual rehabilitation activities with the specified contingent of children in the Odessa Movement Rehabilitation Center. All children were divided into two groups: 108 - the experimental group and 100 - the control group.

The developed system of adaptive physical education was implemented as part of the experiment by teachers who underwent preliminary face-to-face and remote counseling by the author of this study. Conducting a formative pedagogical experiment in all preschool education institutions was carried out according to a single developed scheme. A significant part of this program was implemented during the day in the appropriate forms of physical education of preschoolers, which include: morning gymnastics for awakening, fun physical education classes, physical education classes, horizontal plastic ballet (plastic show), daytime gymnastics for awakening, physical education corrective sketches, physical education entertainment, individual physical and corrective work with a child, physical leisure outside during a walk.

The leading role in the educational pedagogic experiment was assigned to the physical education instructor, who had previously received appropriate professional training from the author of the technology. Preschool educators were also involved in the formative experiment, who were consulted by the physical education teacher about their corrective work during wake-up exercises, walks, physical entertainment, etc.

At home, this work was continued by the parents in the form of combined movement and play activities. They received consultations both from the scientific supervisor of the pedagogical experiment and from the physical education instructor. The basis of this homework was pre-developed individual physical education correction sketches, the content of which reflected the specifics of the child's motor and mental disorders. Parents received consultations both from the head of the experiment and from the physical education instructor, who promptly resolved all the problematic moments that arose. This approach made it possible to ensure one of the main conditions of the experiment - the constancy and continuity of the corrective effects during each week, from morning to evening. The basis of the innovative correction vector in working with the children of the experimental group was an experimental program developed by the author of this study, which provided for the implementation of ten correction vectors: normalization of muscle tone; strengthening of the muscle corset; symmetrization (alignment) of the musculoskeletal system; harmonization of the state of musculo-fascial formations in the frontal plane (superficial frontal line (SPF) and superficial posterior line (PSL)); harmonization of the state of muscle-fascial formations in the sagittal plane (lateral lines (LL)); harmonization of the state of musculo-fascial formations in the horizontal plane; development of static endurance of the muscular corset; stabilization of the achieved post-correction state of posture (static mode); stabilization of the achieved post-correction state of posture (dynamic mode); stabilization of the achieved post-correction state of posture (stato-dynamic mode) [13].

Methodical provision of adaptive physical education of children with psychomotor disorders was based on the following methods of physical and psychological correction of their condition: general relaxation of the skeleton (spinal column); release (overcoming local muscle clamps), methods of muscle-fascial tonic harmonization; methods of improving the motor and coordination complex and, in particular, the child's dynamic stability; release of the body's vegetative energy; presence in one's body (immersion in one's body); development of the ability to love (in the broad sense of the word); methods of psychological counseling (marital; joint children and parents; parents regarding children's problems; family, one of whose members is seriously ill (somatically or mentally); psychosomatic methods.

The children of the control group practiced according to the traditional system of physical education.

Before the start of the experiment and after its completion, a comprehensive diagnosis of the posture of children in the third and fourth years of life was carried out, because we believe that the state of the posture most comprehensively reflects the peculiarities of the physical development of children with psychomotor disorders. At the same time, the entire study consisted of several stages:

I – preliminary (familiarization with the child's family; collection of anamnestic data; pedagogical observation of the child);
II – initial diagnosis: visual-palpatory testing methods (visual inspection; photo and video recording of the features of the child’s posture); instrumental methods (anthropometry; slope; goniometry; plantography; detection of functional mobility of the vertebral column; determination of mobility in the joints of the lower extremities);

III – counseling teachers and parents of the child based on the results of diagnosis;

IV – formative pedagogical experiment;

V - final diagnosis.

**Statistical analysis**

The research used typical methods of mathematical processing of the results (arithmetic mean value, root mean square deviation, coefficient of variation, reliability coefficient, discrepancies according to the Student's criterion, growth rate of indicators).

Data were entered and analyzed using the Statistica computer program (version 10). Descriptive statistical analysis was performed by calculating percentages and p-values. The results were calculated for the variables and tabulated. The level of significance of the results was expressed using the p-value, where p<0.05 was statistically significant.

**Results**

Dynamics of changes in pathological curvatures of the spine in children aged 3-4 years with psychomotor disorders during a formative pedagogical experiment (n = 108)

<table>
<thead>
<tr>
<th>Plane of curvature</th>
<th>To, %</th>
<th>After, %</th>
<th>Dynamics of changes, %</th>
<th>Significance of differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>p</td>
</tr>
<tr>
<td>experimental group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal plane</td>
<td>53.2</td>
<td>44.7</td>
<td>-16.0</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Sagittal plane</td>
<td>20.9</td>
<td>15.8</td>
<td>-24.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Horizontal plane</td>
<td>4.8</td>
<td>4.2</td>
<td>-12.5</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>control group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal plane</td>
<td>51.8</td>
<td>46.9</td>
<td>-9.5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Sagittal plane</td>
<td>21.2</td>
<td>18.7</td>
<td>-11.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Horizontal plane</td>
<td>5.4</td>
<td>5.0</td>
<td>-7.4</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

p – the level of significance of the results

**Table 1**

Using the method of video recording in two planes (frontal (front, back) and sagittal (side - right/left), the peculiarities of maintaining posture during movement, in dynamics (using the example of walking) were studied. In children from the experimental groups, the placement of the feet on the support improved so:
- the asymmetry of the support of the left and right leg when walking decreased by 23.5% - 25.4% (P<0.05);
- equinus-tendencies (foot placement with emphasis on its front part) decreased by 17.2% - 20.9% (P<0.05);
- the varus (on the outer part of the foot) version of standing on the support decreased by 19.8% - 23.4% (P<0.05).

In children from the control groups, there was also an optimization of the position of the feet when walking on a support, but it was not statistically significant in all cases (P>0.05).

If we talk about the presence of additional, unnatural rotational movements of the shoulder and pelvic girdle, the children from the experimental group after the formative experiment had the following picture:
- the number of rotational movements to the left in the shoulder girdle relative to the conditional median line decreased by 16.8 - 19.2% (P<0.05);
- the number of rotational movements to the right in the shoulder girdle relative to the conventional midline decreased by 17.5-21.4% (P<0.05).

The analysis of the results of the presence of rotational movements when walking in children from the control groups revealed some positive trends in their reduction, but they were not confirmed by the methods of mathematical statistics (P>0.05).

A separate analysis of the results was carried out regarding the presence of auxiliary movements of the head and trunk when walking in children with psychomotor disorders. After the pedagogical experiment, additional rotational movements in children from the experimental group significantly decreased, which was statistically confirmed in all variants (P<0.01 - 0.05). Children from the control groups also had some decrease in additional movements, but these positive changes were not confirmed by the methods of mathematical statistics (P>0.05) (Table 2).

Similar studies were conducted on the pelvic girdle of children with psychomotor disorders. In the experimental group, as well as in the shoulder girdle, a noticeable and statistically significant decrease in the number of rotational oscillations during walking was recorded:
- the number of rotational movements to the left in the pelvic girdle relative to the conventional median line decreased by 15.6-18.6% (P<0.05);
- the number of rotational movements to the right in the pelvic girdle relative to the conventional midline decreased by 16.5-20.3% (P<0.05).

Such a reliable reduction of unnecessary rotational movements in the pelvic girdle indicates an improvement in the functioning of the locomotor apparatus of children from the experimental group, which positively affects the efficiency of movement (in particular, the speed and purposefulness of walking). Reducing the twisting moments that occur in children when walking has a positive effect on the harmonization of children's posture, reducing the degree of imbalance of the spiral myofascial lines, which very often provokes scoliotic curvature of the vertebral column.

In children from the control groups, the indicators of unnatural rotational movements in the pelvic girdle almost did not change and remained at the initial level (P>0.05).

Table 2
Dynamics of changes in auxiliary movements of the head and trunk during walking in 3-4-year-old children with psychomotor disorders during a formative pedagogical experiment (n = 108)

<table>
<thead>
<tr>
<th>Topography of auxiliary movements</th>
<th>To, %</th>
<th>After, %</th>
<th>Dynamics of changes, %</th>
<th>Significance of differences</th>
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<tr>
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</tr>
<tr>
<td>experimental group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary movements of the head</td>
<td>18.2 – 16.7</td>
<td>12.5 – 14.0</td>
<td>31.3 – 16.2</td>
<td>&lt;0.01 – &lt;0.05</td>
</tr>
<tr>
<td>Auxiliary body movements</td>
<td>22.8 – 20.9</td>
<td>17.2 – 15.3</td>
<td>24.6 – 26.8</td>
<td>&lt;0.05 – &lt;0.05</td>
</tr>
<tr>
<td>control group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary movements of the head</td>
<td>17.9 – 16.2</td>
<td>16.6 – 14.1</td>
<td>7.3 – 13.0</td>
<td>&gt;0.05 – &gt;0.05</td>
</tr>
<tr>
<td>Auxiliary body movements</td>
<td>21.4 – 19.9</td>
<td>19.2 – 17.0</td>
<td>10.3 – 14.6</td>
<td>&gt;0.05 – &gt;0.05</td>
</tr>
</tbody>
</table>

p – the level of significance of the results

A separate analysis of the results was carried out regarding the presence of auxiliary movements of the head and trunk when walking in children with psychomotor disorders. After the pedagogical experiment, additional rotational movements in children from the experimental group significantly decreased, which was statistically confirmed in all variants (P<0.01 - 0.05). Children from the control groups also had some decrease in additional movements, but these positive changes were not confirmed by the methods of mathematical statistics (P>0.05) (Table 2).
Dynamics of changes in the condition of the arch of the feet in children of the experimental group after a formative pedagogical experiment (n = 108)

<table>
<thead>
<tr>
<th>Peculiarities of the condition of the arch of the feet</th>
<th>To, %</th>
<th>After, %</th>
<th>After, %</th>
<th>Significance of differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normotonic type</td>
<td>8.7</td>
<td>12.1</td>
<td>+ 39.1</td>
<td>&lt;0.01, 2.704</td>
</tr>
<tr>
<td>Hypotonic type</td>
<td>17.0</td>
<td>21.8</td>
<td>+ 28.2</td>
<td>&lt;0.05, 2.536</td>
</tr>
<tr>
<td>Hypertensive type</td>
<td>52.4</td>
<td>41.9</td>
<td>- 20.0</td>
<td>&lt;0.05, 2.384</td>
</tr>
<tr>
<td>Dystonic type</td>
<td>21.9</td>
<td>24.2</td>
<td>+ 10.5</td>
<td>&gt;0.05, 1.829</td>
</tr>
<tr>
<td>Asymmetric type</td>
<td>68.2</td>
<td>44.7</td>
<td>- 34.2</td>
<td>&lt;0.01, 2.648</td>
</tr>
</tbody>
</table>

p – the level of significance of the results

Analysis of the results of a plantographic study of the features of the condition of the arches of the feet in children from the experimental group also revealed an improvement in indicators. Analyzing plantograms (prints of feet on paper) of children, we can see that for all their types there was a positive dynamic of quantitative results, which in four variants (normotonic, hypotonic, hypertonic and asymmetric types) had statistical confirmation of the reliability of changes (p<0.01 – 0.05), but not in one (dystonic type) (p>0.05) (Table 3).

In the control group, partial positive dynamics of changes in the condition of the arch of the feet were also recorded, but it was not confirmed by mathematical statistics methods (p>0.05).

**Discussion**

The analysis of the received data by the method of visual inspection of the posture in the standing position allowed to see the advantages of the developed experimental system for correcting the physical development of children with psychomotor disorders in comparison with traditional approaches already at the initial stage of the study. The exceptions were the indicators of posture asymmetry in the horizontal plane, which had no significant changes after the experiment (P>0.05). In our opinion, posture disorders in the horizontal plane should be considered the most complex, because their mechanism involves posture disorders both in the frontal and sagittal planes. That is, violations fixed in the horizontal plane are complex, and therefore more time and energy should be spent on overcoming them. Perhaps, if the formative pedagogical experiment had lasted longer, changes for the best in the horizontal plane would have been confirmed by the methods of mathematical statistics.

Beani et al. [14] evaluated postural control in children, determining the difference between typical and atypical development. Preyal et al. [15] state gross motor dysfunction and balance disorders in children with Down syndrome. Van et al. [16] suggest using a test protocol consisting of several individual tests and already existing validated test batteries and includes a vestibular assessment, a detailed motor assessment, eight neurocognitive tests, an assessment of cognitive-motor interaction, and also includes additional screenings to control for potential factors that interfere (for example, the state of hearing, intelligence, physical activity, etc.). Liu et al. [17] determined the importance of using inertial sensors to assess the static balance of preschoolers. At the same time, the angular velocity module is considered by them to be more reliable than the acceleration module. Jha et al. [18] found that virtual games in combination with physical therapy are very useful for the development of balance in children with bilateral spastic cerebral palsy. Similarly, Park et al. [19] found that the training of postural control in sitting using a virtual reality (VR) training program is more effective in improving sitting balance and trunk stability in children with cerebral palsy. Kachmar et al. agree with them. [20], who demonstrated an improvement in balance function in children with cerebral palsy after a two-week training course with personalized rehabilitation computer games: in the experimental group, TCMS scores increased by 4.5 points (SD = 3.5, p < 0.05 ), and DBT scores increased by 0.88 points (IQR = 1.03, p < .05). Hsieh [21] proposes to use the proposed new balance system to improve functional balance and reduce postural oscillations in children with cerebral palsy (oscillation path, F = 6.95, P = 0.011; oscillation area, F = 11.79, P = 0.001) board for personal computer games. But at the same time, Soyuer [22] proved that technological methods of balance assessment using the example of, in
particular, mobile applications show only 38% validity and 23% reliability in balance assessment.

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Warnier & Lambregts [29] made a meta-analysis of the indicators of "balance" 5 and "walking" 4, which made it possible to conclude a relatively promising intervention for the rehabilitation of children with cerebral palsy in the form of the VRT (virtual reality) technique. Regarding additional violent movements, the data obtained in the study allow us to draw a preliminary conclusion that they are to a greater extent necessary-compensatory, overcoming which requires a longer time than was predicted by conducting a formative pedagogical experiment. In the studies of Moghaddas et al. [30] analyzed three-dimensional neck kinematics in individuals with chronic idiopathic neck pain during functional tasks. At the same time, the pain group had less thoracolumbar rotation to the left than the control group (MD = -2.14, 95% CI -4.41 to 0.13, p = 0.064). The pain group had a higher peak neck segment flexion velocity than the control group for all tasks (MD - 3.09; 95% CI -5.21 to -0.10; P = 0.004). Needham, Naemi, & Chockalingam [31] described lumbopelvic coordination in the transverse plane during the gait cycle using data visualization techniques. Using colored bars and data bars, the authors classified commonalities and differences in coordination patterns between segment connections and between individuals in a large data set.

Discussing the results of plantography, we note that against the background of positive changes (an increase in the number of children with normotonic feet; a decrease in the number of children with hypertonic feet; an increase in the number of children with hypotonic feet; a decrease in the
number of children with asymmetric feet), there was also an increase in the number of children with diatonic type feet, which cannot be attributed to positive changes in their condition. We consider the decrease in the number of children with hypertensive type of feet to be an important proof of the effectiveness of the proposed author's research system for correcting the physical development of children with psychomotor disorders.

As is well known, the hypertensive variant of disorders in the feet occurs as a result of suppression at various levels of the central nervous system, that is, central motoneurons. Also, the child's mental stress can be the cause of this condition in the feet. That is, we should talk about the neurogenic and psychogenic nature of such disorders. A decrease of almost 10% in the number of children with hypertensive variant of the feet in a relatively short period of time indicates the sufficient effectiveness of the developed correction system. It is clear that the decrease in the number of children with hypertonic type of feet was transformed into an increase in the number of children with natural hypotonic foot condition and mixed dystonic condition. The last position should be considered a transitional one in order to obtain a larger number of children with normotonic and hypotonic foot conditions in the future.

The second important indicator of the effectiveness of the proposed system of adaptive physical education for children of early and younger preschool age should be considered a significant (by 23.5%) decrease in the number of children with an unnatural asymmetric type of standing, which is the basis of the formation of postural disorders of the scoliotic type. As you know, scoliotic posture and scoliosis have a negative impact on the child's health and development, so we consider the obtained results quite significant in the results of the research. In children from the control groups, indicators of the condition of the arch of the feet and the type of standing did not show statistically significant positive changes (P>0.05), which only confirms the insufficient effectiveness of the traditional system of correction of the physical development of children with psychomotor disorders.

Chang et al. [32] based on motor skill surveys of 734 children found the validity of the Children's Motor Skills Quotient (CMSQ) using descriptive statistics and Rasch analysis, where unidimensionality, local independence, person measure and task difficulty hierarchy were used, and children showed different probabilities by gender and age. Interesting are the studies of Sánchez-Soler et al. [33], who identified differences in the psychomotor development of children conceived naturally and children conceived with the help of assisted reproductive methods.

Summarizing the analysis of the results of the dynamics of indicators of physical development of children with psychomotor disorders (using the example of a study of their posture), it should be concluded that for almost all indicators, children from the experimental groups had a noticeable improvement in results, which in the absolute majority of cases was confirmed statistically (P<0.05). Children from control groups also showed some improvement in physical development indicators, but it was not confirmed by mathematical statistics methods (P>0.05).

**Conclusions**

Thus, summarizing the results of the conducted research, it should be stated that the conducted formative pedagogical experiment confirmed the reliability of the effectiveness of the developed author's system for correcting the physical development of children of early and younger preschool age with psychomotor disorders (using the example of posture) in comparison with the traditional system of their physical education.

**Conflict of interest**

The authors declare that there is no conflict of interest.

**References**

1. Yefimenko MM. Basics of corrective physical education of children with musculoskeletal disorders. Dr. Diss., Kyiv; 2014. (in Ukrainian)


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