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ORIGINAL PAPER

Effect of Physiotherapy on Preterm Neonates and its Results on Five-Year-Old Children, According to GMFM – GMPM Evaluation Scales

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ABSTRACT

Objective: *The purpose of this study is to emphasize the necessity and possibilities of early intervention and physiotherapy rehabilitation of premature infants, as they are reflected in five-year olds according to the gross motor function measure (GMFM) and gross motor performance measure (GMPM) evaluation scales for gross function and quality of movement. In addition, the present study examined the importance of using assessment tools for children who have received or not therapeutic intervention, through which both the child's abilities and appropriateness of the help received by him/her are evaluated based on individual needs.*

Material and methods: *Our specific exploratory process was carried out through a literature review as well as a process of primary research, in order to obtain and collect all necessary information and data which would finally lead us to the nearest and best conclusions. Our goal was to collect 20 complete and graded GMFM and 20 GMPM assessment tests, so that our research was based on a satisfactory sample of participants. In the next year, the scores received by participants were recorded and analyzed using the statistical software program SPSS (Superior Performance Software System). The analysis was performed through descriptive and inductive statistical analysis in the SPSS statistical program. Specifically, the SPSS version 20.0 and specifically the one-way ANOVA variance analysis and the Tukey's parametric test were used for the statistical analysis of the results.*

Results: *The use of physiotherapy care was found to be important for premature infants, as the level of statistical significance was set at $p < 0.05$, while the data were reported as average. The final overall scores of the evaluations (on average) were higher in the group who received early intervention and specialized physiotherapy intervention from the first day after birth.*

Conclusions: *The effect of physiotherapy on premature infants is positive in five-year-old children, who have completed almost all their developmental stages at that age. These benefits become apparent not only in*

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a better handling of kinetic patterns and sequences but also in the ability to execute kinetic models, conquer developmental motor stages and perform them with quality in terms of alignment, sequence, synergy of movements, separation and stability.

Keywords: premature infants, preterm pregnancy, physiotherapy in preterm infants, physiotherapy and prematurity, physiotherapy results in preterm infants, GMFM rating scale, GMFM-88, GMPM, GMFM in preterm infants.

INTRODUCTION

Prematurity is the single most important cause of death in the first month of life, which accounts for over 75% of pediatric deaths in the neonatal period (1-3). As the second leading cause of death in children under five, prematurity remains a global health problem. In addition, prematurity is associated with learning and motor difficulties as well as vision and hearing problems, contributing to about half of all disabilities in children (4).

Early physiotherapy treatment (PT) intervention is supported to enhance the development of infants with cerebral palsy (CP) by promoting motor and sensory-motor experiences and preventing musculoskeletal complications (5). Several approaches to optimize the development of premature infants have been adopted by therapists, which include complementary stimuli and environmental modifications such as those used in personalized developmental care and neonatal assessment programs. Another method is a problem-oriented developmental intervention that uses therapeutic manipulation and postural support. This clinical approach appears to be primarily based on the neurodevelopmental approach (6).

In the mid to late 1900s, medical and technological advances in neonatal care led to a reduced neonatal mortality rate and increased survival rates for infants with very low birth weight, resulting in increased cases of CP, respiratory disorders, cognition and blindness. Early intervention programs have been established to address the developmental needs of these neonatal intensive care survivors, with the aim of stimulating and normalizing their development (7).

Premature birth leads to prematurity, which is the most common reason for infants to stay in the neonatal intensive care unit (ICU) (8). Prematurity is associated with medical complications such as respiratory distress syndrome (RDS), hyperbilirubinemia, gastroesophageal reflux disease (GERD), intra-abdominal bleeding (peritoneal leukemia) and retinopathy (RO) (9). These side effects are of great concern and should be treated with care to avoid further deterioration of the neonate's quality of life as he/she grows up. Thus, the early physical therapy approach emerges and plays an important role in the care of newborns (10, 11).

The term "early intervention" refers to the multidisciplinary services provided to children from birth to the age of six, in order to promote the child's health and well-being, enhance emerging abilities, minimize developmental delays and rehabilitate existing disabilities, while preventing functional deterioration and promoting adaptive upbringing and family functioning (12-14). Thus, this case study evaluated the effect of early intervention on high-risk infants with delayed developmental milestones along with longer stay in ICU (15).

The purpose of the present study is to evaluate the necessity and possibilities of early intervention and physiotherapy rehabilitation of premature infants, as they are reflected in five-year-olds according to the scales of evaluation of gross motor function measure (GMFM) and gross motor performance measure (GMPM) (16). In addition, we examined the importance of using assessment tools in pediatric receivers or non-receivers of a therapeutic intervention, through which both the child's abilities and appropriateness of the help received by him/her were evaluated based on individual needs. ❑

MATERIALS AND METHODS

Data collection was performed using GMFM – GMPM scales as assessment tools for children's kinetic evaluation (16). The GMFM scale

includes 88 tests (supine, prone, quadruped, knee and upright) and GMPM comprises 20 GMFM selected quality assessment questions (17, 18).

For the needs of our research, 20 premature infants who were born in the University Hospital of Larissa or in one of the Private Obstetrics Clinics of the Prefecture of Larissa between 2016-2017 were selected and divided into two equal groups: 10 subjects in the experimental group and 10 in the control group.

The experimental group included the newborns who received early intervention during their stay in NICU and neurodevelopmental therapy according to Bobath method immediately after their exit from NICU (19) up to the age of five. The control group included infants who either did not receive any form of treatment until the age of five or joined a physiotherapy program after the first or second year of life.

After the final form of the groups was finalized, the five-year-old children were evaluated by the physiotherapists. Children's evaluation was privately performed by the pediatric physiotherapist (Mrs. Konstantina Skanika) during 2021–2022 one year period, since the children would be five years of age according to the GMFM–GMPM rough mobility evaluation scale.

Statistical analysis

Superior Performance Software System (SPSS) version 20.0 was used for the statistical analysis of the results, namely the one-way ANOVA variance analysis and the Tukey's parametric test. The level of statistical significance was set as $p < 0.05$ while the data are presented as average. ❑

RESULTS

Demographic data

The sample of this study consisted of 20 children aged five years who were prematurely born between 34 and 37 weeks of gestation but without the presence of brain damage or other genital abnormalities.

Regarding the demographic data, it was observed that the largest percentage of pediatric participants to our research were born at the age of 35 weeks (40%), followed by those born at 36 weeks (30%), 34 weeks (25%) and lastly, 37 weeks (5%).

TABLE 1. Total number of participating children and their distribution by gestational weeks and GMFCS

Children	Age	Diagnosis	Weeks of pregnancy	GMFCS
1	5	Prematurity	35	II
2	5	Prematurity	35	II
3	5	Prematurity	35	I
4	5	Prematurity	36	II
5	5	Prematurity	36	I
6	5	Prematurity	34	II
7	5	Prematurity	34	II
8	5	Prematurity	35	II
9	5	Prematurity	37	I
10	5	Prematurity	36	II
11	5	Prematurity	36	I
12	5	Prematurity	34	II
13	5	Prematurity	36	I
14	5	Prematurity	34	II
15	5	Prematurity	35	I
16	5	Prematurity	35	II
17	5	Prematurity	36	I
18	5	Prematurity	35	I
19	5	Prematurity	34	II
20	5	Prematurity	35	I

The children included in our study had a GMFCS I or level II. That is, these children at the age of five walk independently at home, at school and outdoors. They are capable of climbing stairs without support or even carrying a load, running or even jumping, showing deficits mainly in speed, balance or timing. On the other hand, level II pediatric participants to the GMFCS

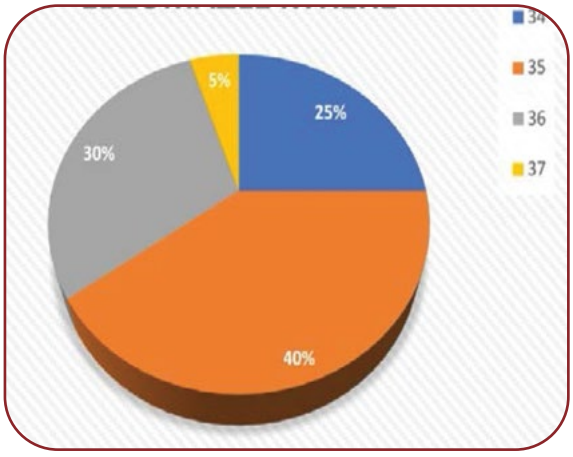

FIGURE 1. Percentages of participants' gestational weeks

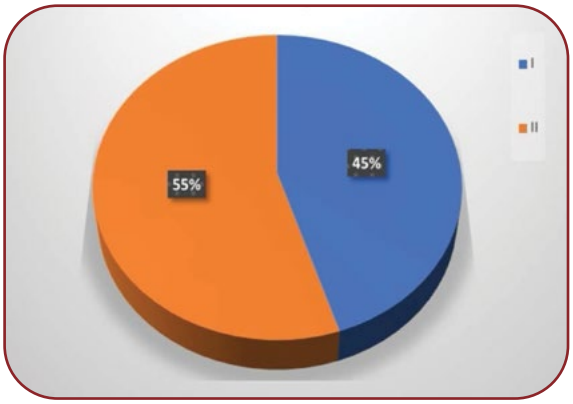

FIGURE 2. Classification of participating children using the GMFCS

assessment walk with restrictions, with support being needed when going up and down the stairs and when walking, mainly outdoors. Also, they have difficulty jumping and running. As shown in Figure 2, nine children were classified in level I of functioning on the GMFCS (55%) and the remaining 11 in level II (45%).

These 20 children selected for the study were divided into two groups: the experimental group (GEn = 10) and the control group (GCn = 10).

The experimental group included the newborns who received early intervention during their stay at NICU and neurodevelopmental therapy based on Bobath method immediately after their exit from NICU up to the age of five years. The control group included infants who either did not receive any form of treatment until the age of five or joined a physiotherapy program after the first or second year of life.

The distribution of children was not unequal and therefore, the comparison of the two groups was clear in terms of effectiveness of early intervention and physiotherapy treatment of premature infants (Tables 2 and 3).

GMFM coarse mobility assessment scale

The results of the experimental group during the evaluation are better visible than those of the control group, as the lowest score is 79.6% in the experimental group and 71% in the control group. On the contrary, the highest percentage score is 99% in the experimental group and 90.2% in the control group.

Therefore, we understand that the experimental group will show a better scoring average on the GMFM scale compared to the control group (Tables 4 and 5).

TABLE 2. Classification of participants to the experimental group

Children	Age	Diagnosis	Weeks of pregnancy	GMFCS
1	5	Prematurity	36	I
2	5	Prematurity	34	II
3	5	Prematurity	36	I
4	5	Prematurity	34	II
5	5	Prematurity	35	I
6	5	Prematurity	35	II
7	5	Prematurity	36	I
8	5	Prematurity	35	I
9	5	Prematurity	34	II
10	5	Prematurity	35	I

TABLE 3. Classification of participants to the control group

Children	Age	Diagnosis	Weeks of pregnancy	GMFCS
1	5	Prematurity	35	I
2	5	Prematurity	35	II
3	5	Prematurity	35	I
4	5	Prematurity	36	II
5	5	Prematurity	36	I
6	5	Prematurity	34	II
7	5	Prematurity	34	I
8	5	Prematurity	35	I
9	5	Prematurity	37	II
10	5	Prematurity	36	I

TABLE 4. Experimental group results based on GMFM assessment

Children	Age	Diagnosis	Weeks of pregnancy	GMFM
1	5	Prematurity	36	99.0%
2	5	Prematurity	34	89.8%
3	5	Prematurity	36	96.8%
4	5	Prematurity	34	85.6%
5	5	Prematurity	35	97%
6	5	Prematurity	35	91.2%
7	5	Prematurity	36	99.4%
8	5	Prematurity	35	86.0%
9	5	Prematurity	34	79.60%
10	5	Prematurity	35	93.6%

TABLE 5. Control group results based on GMFM assessment

Children	Age	Diagnosis	Weeks of pregnancy	GMFM
1	5	Prematurity	35	79.2%
2	5	Prematurity	35	77.8%
3	5	Prematurity	35	82%
4	5	Prematurity	36	85.4%
5	5	Prematurity	36	99.2%
6	5	Prematurity	34	77.6%
7	5	Prematurity	34	73.4%
8	5	Prematurity	35	71%
9	5	Prematurity	37	83.80%
10	5	Prematurity	36	78%

GMPM traffic quality assessment scale

Pediatric participants to both groups, in addition to the assessment of their gross mobility accor-

TABLE 6. Experimental group results based on GMPM assessment

Children	Age	Diagnosis	Weeks of pregnancy	GMPM
1	5	Prematurity	36	95.2%
2	5	Prematurity	34	81.8%
3	5	Prematurity	36	88.4%
4	5	Prematurity	34	80.8%
5	5	Prematurity	35	96.4%
6	5	Prematurity	35	81.2%
7	5	Prematurity	36	96.6%
8	5	Prematurity	35	78.28%
9	5	Prematurity	34	72.2%
10	5	Prematurity	35	87.8%

TABLE 7. Control group results based on GMPM assessment

Children	Age	Diagnosis	Weeks of pregnancy	GMFCS
1	5	Prematurity	35	75.2%
2	5	Prematurity	35	74.4%
3	5	Prematurity	35	69%
4	5	Prematurity	36	81.4%
5	5	Prematurity	36	77.8%
6	5	Prematurity	34	68.8%
7	5	Prematurity	34	71.4%
8	5	Prematurity	35	65.4%
9	5	Prematurity	37	66.4%
10	5	Prematurity	36	73.6%

ding to the GMFM, were also evaluated in terms of quality of their movements based on the GMPM.

It was observed that, during the evaluation of the quality of movements, the experimental group scored obviously better results than the control group. Thus, the highest score was 96.6% and the lowest one 72.2% in the experimental group, while in the control group the highest score was 81.4% and the lowest one 65.4% (Tables 6 and 7).

GMFM categories

The experimental group, who received physiotherapy care immediately after leaving the NICU, showed a higher average score *per* category than the control group, in addition to the overall score. This clearly proves that early intervention, particularly immediate physiotherapy care of premature infants, has a positive effect on both the gross mobility of children and effectiveness of movements – executions per movement level (Table 8).

Table 9 shows the average score of each GMFM category, including separation, coordination, alignment, weight transfer and stability of movements.

There was a significant difference in total motor ability between the two groups. The average of the total score was 92% in the experimental group and 80% in the control group. This great inter-group difference reflects the very positive effect of timely physiotherapy care offered to subjects of the experimental group from the day of their birth until the present time (Figure 3).

Participants to the experimental group had the highest score in the "horizontal position and rolling" category (100%), with a rounded average of 100%. In contrast, the control group obtained diffuse results, ranging from a maximum of 100% to a minimum of 89% success rate, with a rounded average of 96% (Figure 4).

For the "seated position" category, the results of both groups were relatively diffuse, with the difference that the score was 100% for 50% of

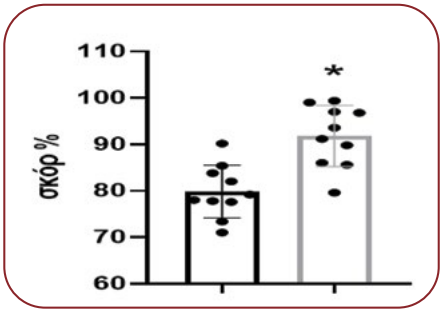

FIGURE 3. Average total score of the two study groups

Horizontal position and rollers %		Seated position %		Crawling and kneeling %		Fix%		Walking, running, jumping %		Total score	
GC	GE	GC	GE	GC	GE	GC	GE	GC	GE	GC	GE
96	100	91	97	79	92	73	88	60	82	80	92

TABLE 8. Mean group scores by GMFM category

Separation of movements %		Coordination %		Alignment %		Weight transfer %		Stability %		Total score	
GC	GE	GC	GE	GC	GE	GC	GE	GC	GE	GC	GE
76	90	73	85	71	85	73	85	71	85	72	86

TABLE 9. Mean group scores by GMPM category

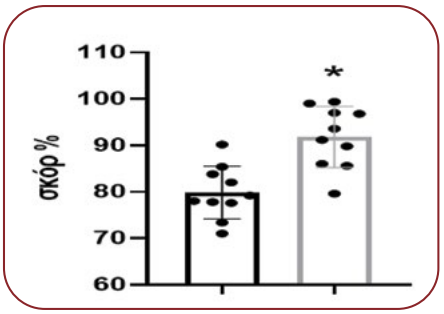

FIGURE 4. Average scores of the two study groups for the horizontal position and rolling category

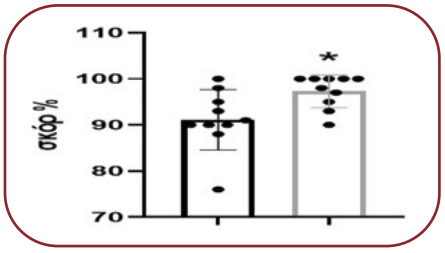

FIGURE 5. Average scores of the two study groups for the seated category

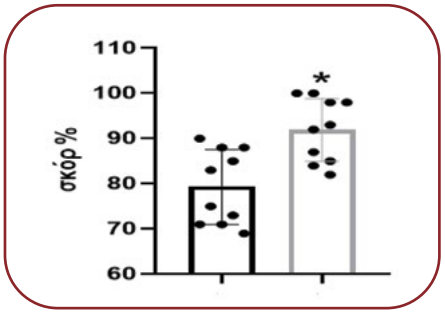

FIGURE 6. Average score of the two study groups for the quadruped and kneeling category

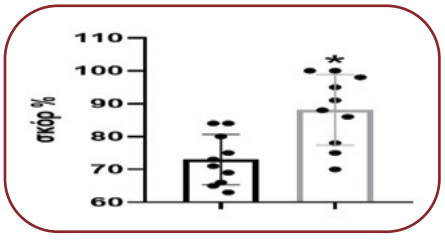

FIGURE 7. Average scores of the two study groups for the standing position category

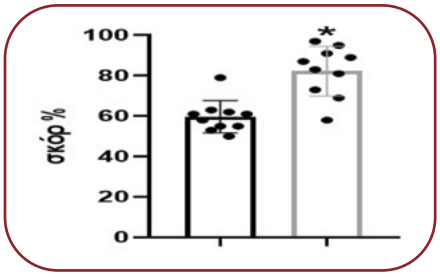

FIGURE 8. Total average scores of the two study groups for the walking, running and jumping category

participants and 90% to 98% for the remaining 50% children included in the experimental group (average 97%). In the control group, individual scores ranged from 76% to 100% (average 91%) (Figure 5).

For the "compression–four-legged position and kneeling position" category, the control group recorded an average score of 79%, with children's scores ranging from 69% to 90%, while the experimental group had an average of 92% and its members scored from 82% to 100% (Figure 6).

For the "standing position" category, the scores of the control group ranged from 63% to 84%, with an average score of 73%, while those of the experimental group ranged from 70% to 100%, with an overall average score of 88%, thus continuing its dynamic course in the successful test execution and showing an interesting significant comparison with the control group (Figure 7).

The last category of GMFM is defined "walking, running and jumping". Specifically, the experimental group reached an overall average score of 82%, with participants' scores varying between 58% and 97%. The control group showed an overall average of 60%, with a score range of 50% to 63% (around 60% for the majority of them) (Figure 8).

GMPM categories

GMPM traffic quality assessment showed overall average scores of 72% and 86% for the control group and the experimental one, respectively (Figure 9).

For the "motion separation" category, the experimental group had an overall average score of 90%, with the majority of participants being close to 90% and scores ranging from 98% to 76%. The control group had an overall average score of 76%, with a maximum score of 83% and a minimum one of 70% (Figure 10).

Then, the average of the total scores obtained by the two study groups for the "coordination" category is presented. Similarly, there is a clear inter-group difference. Thus, the experimental group continued to show a very good image, with an overall average score of 85% *versus* 73% in the control group (Figure 11).

For the "alignment" category, the overall average score was 71% in the control group and 85% in the experimental one (Figure 12).

For the "weight transfer" category, the experimental group proved to be significantly ahead of the control group regarding the total average score, which was 85% in the experimental group and 73% in the control one (Figure 13).

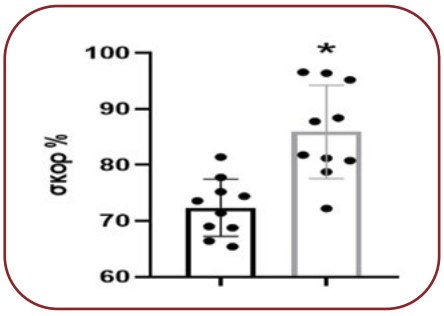

FIGURE 9. Total average scores of the two study groups on the GMPM scale

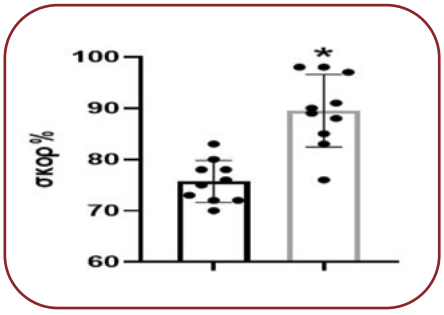

FIGURE 10. Total average scores of the two study groups for the movement separation category

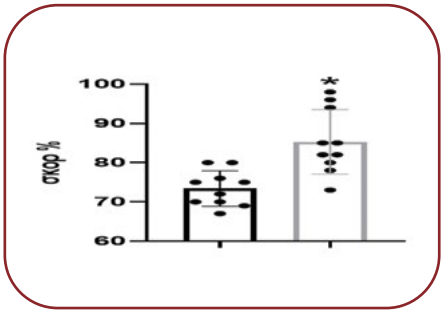

FIGURE 11. Total average scores of the two study groups for the coordination–movement synergy category

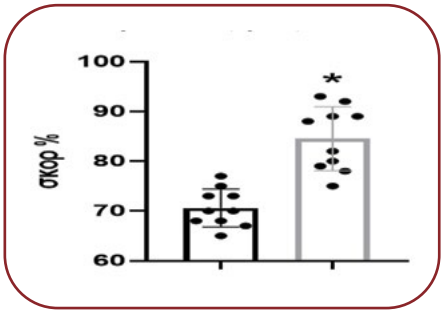

FIGURE 12. Total average scores of the two study groups for the alignment category

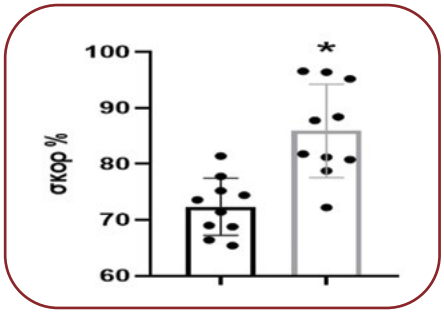

FIGURE 13. Total average scores of the two study groups for the weight transfer category

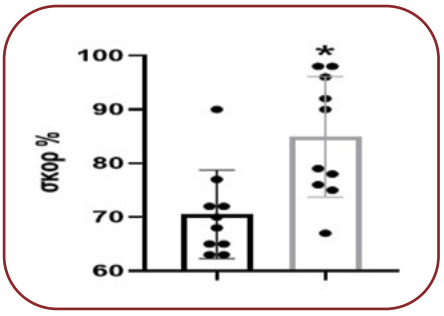

FIGURE 14. Total average scores of the two study groups for the stability category

Finally, for the "stability" category of the assessment tool, the overall average score was 71% in the control group and 85% in the experimental one (Figure 14). ❑

DISCUSSION

The aim of the present study was to analyze the effectiveness and importance of preterm neonatal physiotherapy care as a therapeutic intervention and its effects in five-year-old children according to the GMFM gross mobility assessment and evaluation tools and the quality of these movements according to the GMPM.

The sample of this quantitative study consisted of 20 children aged five years who were born prematurely but did not show any form of brain damage or some other disorder. In particular, the selected pediatric participants were born at 34–37 weeks of gestation, with the majority being born at 35 weeks of gestation. They were also classified in the Functional Classification System (GMFCS) at level I or II, with most of them belonging to level II.

First, children who met the inclusion criteria set by us were selected for the present research and divided into two equal groups (n=10). The experimental group included children who received an early intervention immediately after birth during their stay in NICU and started neurodevelopmental therapy according to Bobath method immediately after their exit from the NICU (20) up to the age of five years. In the control group, the majority of children either did not receive an early intervention and then did not receive any form of physiotherapy approach offered to premature infants until the age of five years or joined a physiotherapy program only after the first or second year of life.

The following year, participants' evaluation was privately done by Mrs. Konstantina Skanika as a pediatric physiotherapist. Permission to be evaluated with this assessment tool was sought from both parents and children. The evaluation was conducted during 2021–2022 one year period, after the children had reached five years of age according to the GMFM–GMPM rough mobility assessment scale.

The evaluation was carried out in a private place with the appropriate examination conditions and equipment. The timing of the assessment was chosen after consultation with the parents, so that the children could rest; also, there was no presence of third parties who could distract the subjects' attention, so the children were able to remain calm and focused. The evaluation time did not exceed one hour and 15 minutes, with the majority of participants succeeding to complete the tests within a maximum of one hour.

Every child's details (name, date of birth, weeks of pregnancy, date of assessment, age, diagnosis and GMFCS level) were noted on the assessment form.

Subsequently, each child began to perform the tests by command or by demonstration when the command could not be understood. Whenever a child found it difficult to fully respond to a test, a second chance was given to repeat the test.

Tests were divided into five categories, according to the GMFM evaluation forms, depending on the level of movement of the test: 1) horizontal position and rolling; 2) seated; 3) Bussoulima and Gonipeti; 4) posture; and 5) walking, running, and jumping.

The GMFM evaluation form contains 88 tests classified according to the above categories (17 tests in the first category, 20 in the second category, 14 in the third category, 13 in the fourth category and 24 tests in the fifth category). Each test is scored from 0 to 3, where:

0: does not start the operation;
1: starts the operation;
2: completes it partially; and
3: fully completes it.

In this form, the children were evaluated based on their ability to perform the test regardless of how they used it. At the end of the GMFM based evaluation process, the total score of each category and its calculation in percentage (%) was noted as well as the total average of the categories in percentage, which was the overall score/performance of the examined child.

The Quality Assessment Form (GMPM) was used in conjunction with the Rough Mobility Assessment Form (GMFM) (21). The GMPM is based on the GMFM rating. The child's details are filled in on the form again and the child's score on the GMFM in the respective test. It contains 20 GMFM tests and is divided into the five above-mentioned categories (four tests in each category) in which the examiner should grade the quality of the child's movement in the corresponding test. The scoring method ranges from 1 to 5, where:

1: completely pathological;
2: moderately pathological;
3: mildly pathological;
4: not constantly normal;
5: constantly normal.

These 20 tests contained in the form evaluate the child in terms of: 1) separation of movements; 2) synergy – synergy of movements; 3) alignment; 4) weight transfer; and 5) stability.

Finally, the GMPM evaluation form contains a table of distribution and score of each test in the respective above categories. With the help of this table, the percentage score of each category was calculated as well as the total average score of the categories, which was the final score. In this assessment, the tests that the child did not perform were removed, thus giving us a picture of the quality of the child's movement based on his motor activity (motor activities that the child had not mastered or developed were not measured or evaluated and they were not included in the calculation of scores).

The GMFM as well as the GMFM enabled us to evaluate the child both as an overall picture and individually in each respective category (Tables 6 and 7).

Once the evaluation process was completed and the required measurements were performed, the percentage score of each category was calculated as well as the total percentage score of all participants in both evaluation tools (GMFM, GMPM). The aggregate data were then categorized into tables, depending on the group and the tool used for assessment (Tables 4, 5, 6 and 7). In addition, two tables were created, one

for each rating scale (GMFM, GMPM) (Tables 8 and 9). ❑

CONCLUSIONS

When evaluating the gross mobility of the two groups (GMFM) as well as the qualitative characteristics of these movements (GMPM), the difference between participants' scores and overall performance is clear, with the experimental group being constantly superior to the control group in what regards the overall scores and, in most cases, the individual ones.

The effect of early physiotherapy care for premature infants on the quantitative and qualitative development of the gross movements of a child (22, 23) at the age of five seems to be crucial, considering that the main goal of treatment is to conquer the developmental stages of normal development in the best possible time before the age of two, as well as the acquisition of quality traffic standards. Therefore, both GMFM and GMPM partly contain categories on which early physiotherapy and treatment of premature infants is based until the "catchup".

Thanks to the immediate physiotherapy care for a premature newborn, immediately after leaving the NICU, the child acquires the basics and main characteristics in order to develop his/her motor repertoire and functionality in normal movement patterns, thus reproducing movement patterns that show synergy, smoothness and rhythm.

That is why the role of the physiotherapist is valuable, as the results show significant improvements in various aspects of health. Finally, studies demonstrate the importance of the GMFM and GMPM models, which are widely used to measure changes in gross motor function over time in children with mobility difficulties. ❑

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