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RESEARCH ARTICLE

COMPARISON BETWEEN KINESITHERAPY, MAGNETIC FIELD AND THEIR COMBINATION FOR CEREBRAL MOTOR DISORDERS IN EARLY CHILDHOOD

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Abstract

Introduction:- There are no comparative studies between kinesitherapy, magnetic field, and their combination for cerebral motor disorders in early childhood. There is a consensus on the short-term but not on the long-term efficiency of magnetotherapy. There is a consensus on kinesitherapy but not on its optimal frequency.

Aim: The first purpose of the study is to compare the short and long-term effects of kinesitherapy, magnetic field, and their combination for cerebral motor disorders in early childhood. The second purpose was to determine the optimal frequency of kinesitherapy.

Material and methods:- Seventy-four children (age 6.91 ± 4.78 m; corrected age 6.40 ± 5.08 m) with cerebral motor disorders participated in the study. The followed-up periods were two weeks and six months. Four of the groups were physiotherapeutic. One group was the control. The control group, consisting of 15 children, received once-daily placebo magnetic therapy for two weeks. The magnetotherapy group, including 14 children, received once-daily magnetotherapy for two weeks. The kinesitherapy group consisted of 18 children. They received once-daily kinesitherapy. The group with kinesitherapy + placebo magnetic therapy included 15 children. They received once-daily placebo magnetic therapy and once-daily kinesitherapy for two weeks. The combined group (kinesitherapy with magnetotherapy) consisted of 15 children. They received once-daily magnetic therapy and kinesitherapy for two weeks. The groups with kinesitherapy received instructions to perform it as often as possible at home. The following factors were registered and analyzed: pathological and primitive reflexes, kinesiography tests, cranial ultrasound, and frequency of kinesitherapy.

Results:- At the beginning of the follow-up, there was no difference between the five groups regarding all factors ($P > 0.05$). The combined group with kinesitherapy and magnetic field showed the best results at the end of the second week and the sixth month ($P < 0.05$). The group with kinesitherapy and placebo magnetic therapy showed the second-best results ($P < 0.05$). The results of the kinesitherapy group were worst than the previous groups but better than the control group ($P < 0.05$). At a frequency of kinesitherapy twice daily, the binary index of kinesiography tests was 0.102, primitive reflexes - 0.308, and cranial ultrasound - 0.487. At a frequency of kinesitherapy three times daily,

the binary index of kinesiography tests was 0.833, primitive reflexes - 0.955, and cranial ultrasound - 0.651.

Conclusion:- Cranial ultrasound revealed relatively stationary morphological changes. However, the developing nervous system in cerebral motor disorders at early childhood showed significant positive dynamics and plasticity, verified by kinesiography tests, primitive and pathological reflexes. The best results showed the combined group with kinesiography and magnetic field. The effects of kinesiography and magnetic field upgraded over each other. Twice daily frequency of kinesiography achieved insignificant effectiveness, while three times daily - significant. The recommendation for cerebral motor disorders in early childhood to perform kinesiography at least three times daily is very important.

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Introduction:-

Cerebral movement disorder is the most common impairment in childhood [1-3]. It covers a wide range of central motor manifestations - from the norm to pathology [1-3]. Frequently there is a varying degree of asymmetric muscle imbalance [1-3]. The static muscles are prone to shortening, hypertonicity, spasticity, and rigidity [1-3]. The dynamic muscles are prone to elongation, weight loss, hypotonus, dystonia, hypotrophy, and atrophy [1-3]. Other pathological signs are developmental delay, primitive and pathological reflexes, pathological gross motor skills, pathological global and reciprocal movements, central coordination disorder, and cerebral palsy [1-3]. Cerebral movement disorder is a working and transient diagnosis for children with pathological manifestations or increased risk [1-3]. It emphasizes the risk for cerebral palsy and the need to include early rehabilitation procedures [1-3]. Their delay increases the risk of regression to cerebral palsy, loss of cortical connections with corresponding functions, and development of secondary complications [1]. The problem with making a justified decision about early rehabilitation is that, unlike neurological illness in the developed nervous system, signs remain masked until the structures are mature enough to declare them [1,4,5]. Detection of children with a developmental disorder, such as cerebral palsy, at an early age, is notoriously difficult [5]. Early developmental delays do not disappear but may regress with age [4]. Developmental delay is an umbrella term used to describe a suboptimal neurodevelopmental outcome that impacts function in one or more domains but does not limit participation and is not associated with the characteristic motor types of CP [4]. For assessment purposes, a mild delay is between 1 and 2SD below the mean, moderate delay by scores between 2 and 3SD below the mean value, and severe delay as scores more than 3SD below the mean value on standardized clinical assessment tools norm-referenced to corrected age [4]. In infants, clinical signs and symptoms of cerebral palsy emerge and evolve before two years of age; therefore, combinations of tools should be necessary to predict risk in conjunction with clinical history [1]. Until the new millennium, the words unpreventable, incurable, and untreatable were synonymous with cerebral palsy [1]. At present, cerebral palsy cannot yet be cured [6].

Historically, the diagnosis of cerebral palsy is possible between the ages of 12 and 24 months [1]. Early diagnosis begins with a medical history and includes neuroimaging, standard neurologic and motor assessments. Premature children have worse performance in all developmental indicators than children born full-term [1,4]. In the diagnostic and classification of cerebral motor disorders, the following kinesiography tests are most often used: Gross Motor Function Classification System (GMFCS) [7-9]; Manual Ability Classification System (MACS) [7,10]; CFCS – Communication Function Classification System (CFCS) [11,12]; EDACS – Eating and Drinking Ability Classification System (EDACS) [11]; Gross Motor Function Measurement (GMFM) [13-15]; Bimanual Fine Motor Function (BFMF) [7,16,17], and fidgety movements [7,16,17]. The clinical picture of cerebral motor disorder includes retardation of motor development, abnormal positional reactivity, changes in muscle tone of hypo-, hyper-, and dystonic nature, the persistence of pathological and primitive reflexes, reflex hyperexcitability, strabismus, and eating problems [4,6,8,18-23]. Cranial ultrasound supports the diagnosis of cerebral movement disorders and monitors them until the fontanelle closes [18,24]. The following are pathologic findings: abnormalities of brain development, diffuse non-cystic central white matter abnormalities, ventricular dilation, prolonged rupture of membranes, focal or diffuse hyperechogenicity, intracranial hemorrhages, cortical or periventricular atrophic lesions, and multicystic encephalomalacia [18].

Over 64 different therapeutic approaches are present in clinical settings for cerebral motor disorders [1]. This number is much higher by adding experimental interventions at the research level [1]. Commonly used active kinesitherapy methods in cerebral motor disorders are Vojta and Bobat therapy [9,11,15,25-27]. Massage is the most often applied passive kinesitherapy method [28,29]. The magnetic field is the most commonly used physical factor. The following effects are considering: stimulates axonal reinnervation, improves oxygen deposition in tissues, stimulates oxidative processes, improves microcirculation, increases the permeability of cell membranes, accelerates biochemical reactions, and have anti-edematous action [14]. There are no comparative studies between kinesitherapy, magnetic field, and their combination for cerebral motor disorders in early childhood. There is a consensus on the short-term but not on the long-term efficiency of magnetotherapy. There is a consensus on kinesitherapy but not on its optimal frequency. The first purpose of the study is to compare the short and long-term effects of kinesitherapy, magnetic field, and their combination for cerebral motor disorders in early childhood. The second purpose was to determine the optimal frequency of kinesitherapy.

Material And Methods:-

Seventy-four children (age 6.91 ± 4.78 m; corrected age 6.40 ± 5.08 m) with cerebral motor disorders participated in the study. The followed-up periods were two weeks and six months. Four of the groups were physiotherapeutic. One group was the control. The control group, consisting of 15 children, received once-daily placebo magnetic therapy for two weeks. The magnetotherapy group, including 14 children, received once-daily magnetotherapy for two weeks. The kinesitherapy group consisted of 18 children. They received once-daily kinesitherapy. The group with kinesitherapy + placebo magnetic therapy included 15 children. They received once-daily placebo magnetic therapy and once-daily kinesitherapy for two weeks. The combined group (kinesitherapy with magnetotherapy) consisted of 15 children. They received once-daily magnetic therapy and kinesitherapy for two weeks. The groups with kinesitherapy received instructions to perform it as often as possible at home. The following factors were registered and analyzed: pathological and primitive reflexes, kinesiologic tests, cranial ultrasound, and frequency of kinesitherapy.

The low-frequency pulsed magnetic field was applied transcranially with induction electrodes in the lateral position of the head. The power of the magnetic field was 8.00 milli-Tesla. Its frequency was 10 Hertz. The duration of the procedures was 10 minutes once daily. Their number was 10 in two weeks [14]. Vojta kinesitherapy included the following techniques: facilitation (exteroceptive and proprioceptive), reflex rotation, facilitated crawling, key positions, and trigger point pressure. The motor skills, age, clinical picture, and degree of disability determined the combination of techniques [11,15,25]. Bobat kinesitherapy included neuro-development treatment, "key" joints, fixation, handling, stimulation of balance, and reactions for straightening, development, and automation of motor skills in everyday life [9,26]. The massage was analytic [28-30]. Static muscles (with increased tone, shortening, rigidity, and spasticity) received inhibitory massage techniques [28-30]. Their dynamic antagonists (with the decreased tone, elongation, reduced strength, flabbiness, hypotrophy, and atrophy) received stimulating massage techniques [28-30].

Pathological and primitive reflexes, cranial ultrasound, and kinesiologic tests were recorded and analyzed in binary code. In pathology, the mark was 0, and in the absence of pathology - 1. If the pathological and primitive reflexes untimely appeared or disappeared, the mark was 0. The following cranial ultrasound findings were pathological: brain development, diffuse non-cystic central white matter abnormalities, ventricular dilation, prolonged rupture of membranes, focal or diffuse hyperechogenicity, intracranial hemorrhages, cortical or periventricular atrophic lesions, and multicystic encephalomalacia [18]. The following kinesiologic tests were used: Gross Motor Function Classification System (GMFCS) [7-9]; Manual Ability Classification System (MACS) [7,10]; Communication Function Classification System (CFCS) [11,12]; Eating and Drinking Ability Classification System (EDACS) [11]; Gross Motor Function Measurement (GMFM) [13-15]; Bimanual Fine Motor Function (BFMF) [7,16,17], and fidgety movements [7,16,17]. The separate kinesiologic tests were very dynamic. Their results varied a lot during the two-week and six-month follow-up. So, the result of all kinesiologic tests received an overall binary index by averaging. The frequency of kinesitherapy was in absolute value – the number of kinesitherapy procedures per day. Quantitative statistical analysis included ANOVA with multiple comparisons by the Bonferroni method. Qualitative statistical analysis included Pearson correlation analysis with multiple regression analysis.

Results:-

The ANOVA results showed that at the beginning of the follow-up, there was no difference between the five groups regarding all factors ($P>0.05$) (Figure 1). The combined group with kinesitherapy and magnetic field showed the best results at the end of the second week and the sixth month ($P<0.05$). The group with kinesitherapy and placebo magnetic therapy showed the second-best results ($P<0.05$). The results of the group with kinesitherapy were worst than the previous groups but better than the control group ($P<0.05$) (Figure 1). In all groups at the baseline level, the mean binary values of the kinesiology tests, cranial ultrasound, primitive and pathological reflexes, were comparable ($P>0.05$) but was significantly different at the end of the second week ($P<0.05$) and sixth month ($P<0.05$) (Figure 1). Follow-up dynamics showed the highest statistical significance regarding kinesiology tests ($P<0.0001$), followed by primitive reflexes ($P<0.001$), followed by pathological reflexes ($P<0.05$), and finally cranial ultrasound ($P>0.05$) (Figure 1).

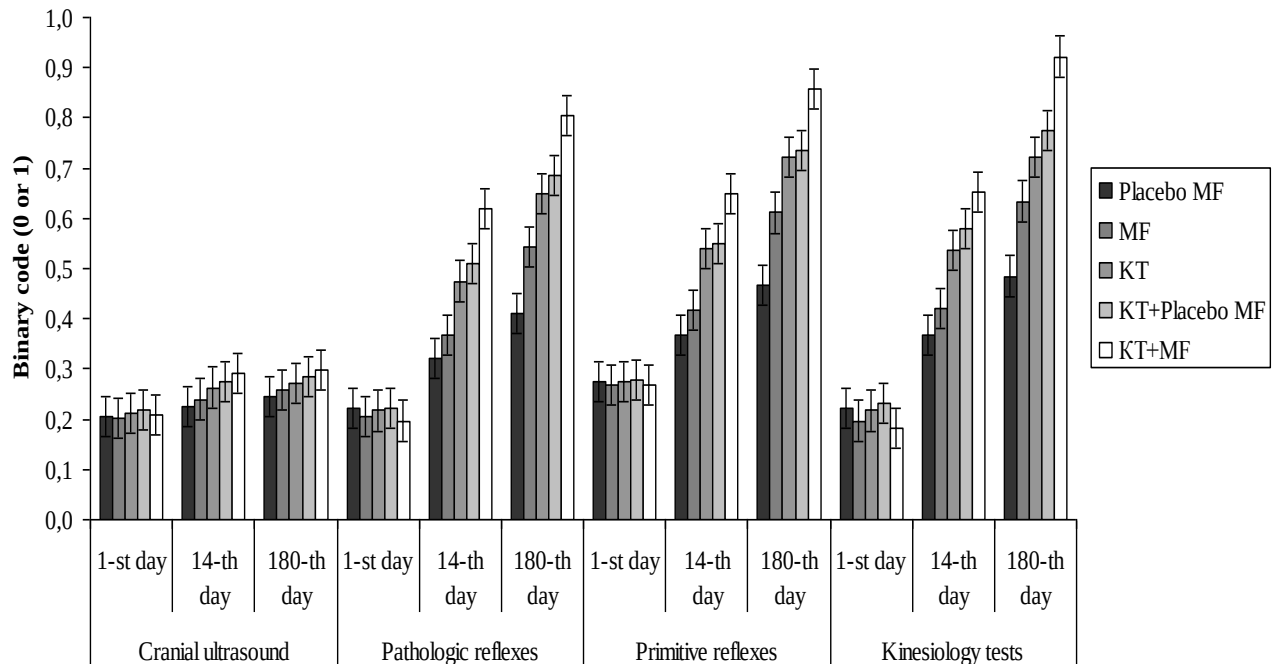


Figure 1:- Results from cranial ultrasound, kinesiology tests, pathological and primitive reflexes, registered in binary code (pathology - 0; norm - 1), at the beginning (1st day), after two weeks (14th day), and after six months (180th day) in the five groups: placebo magnetic field (placebo MF), magnetic field (MF), kinesitherapy (KT), kinesitherapy with placebo- magnetic field (KT + placebo MF) and kinesitherapy with the magnetic field (KT + MF).

The correlation between the frequency of kinesitherapy and kinesiology tests showed the highest statistical significance ($P=3.28E-36$). It was lower versus primitive reflexes ($P=1.11E-12$), even lower - versus cranial ultrasound ($P=2E-04$), and lowest - versus pathological reflexes ($P=4.18E-01$). Multiple linear regression analysis found that the frequency of kinesitherapy determined the results of kinesiology. The following was the regression formula (**Figure 2**):

$$\text{Kinesiology tests} = -1.36 + (0.731 * \text{daily frequency of kinesitherapy})$$

At twice daily kinesitherapy, the index of kinesiology tests averaged 0.102, while at three times daily – 0.833 (**Figure 2**).

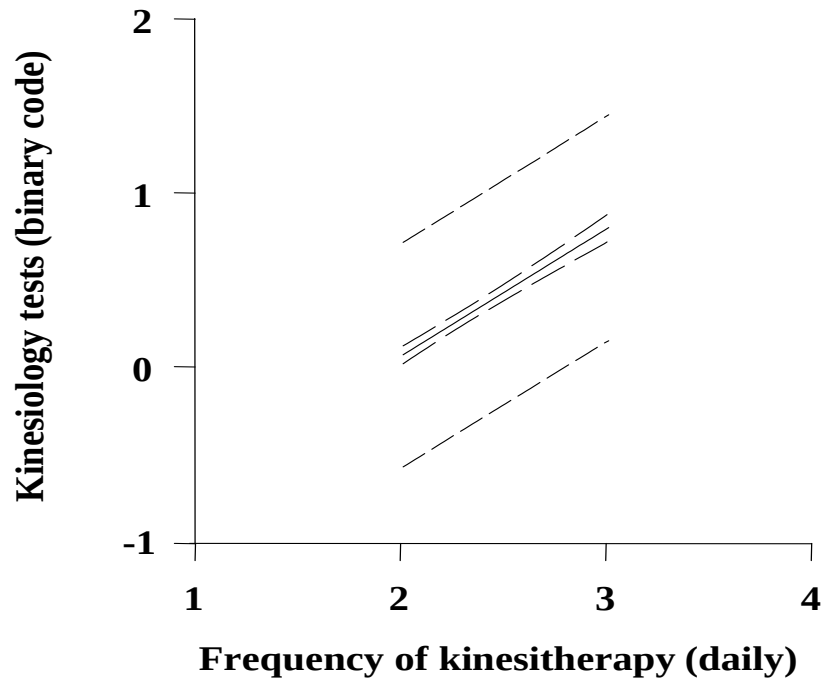


Figure 2:- Multiple linear regression analysis between kinesiology tests and the frequency of kinesitherapy.

Multiple linear regression analysis found that the frequency of kinesitherapy determined the results of primitive reflexes. The following was the regression formula (**Figure 3**):

$$\text{Primitive reflexes} = -0.986 + (0.647 * \text{daily frequency of kinesitherapy})$$

At twice daily kinesitherapy, the index of primitive reflexes averaged 0.308, while at three times daily – 0.955 (**Figure 3**).

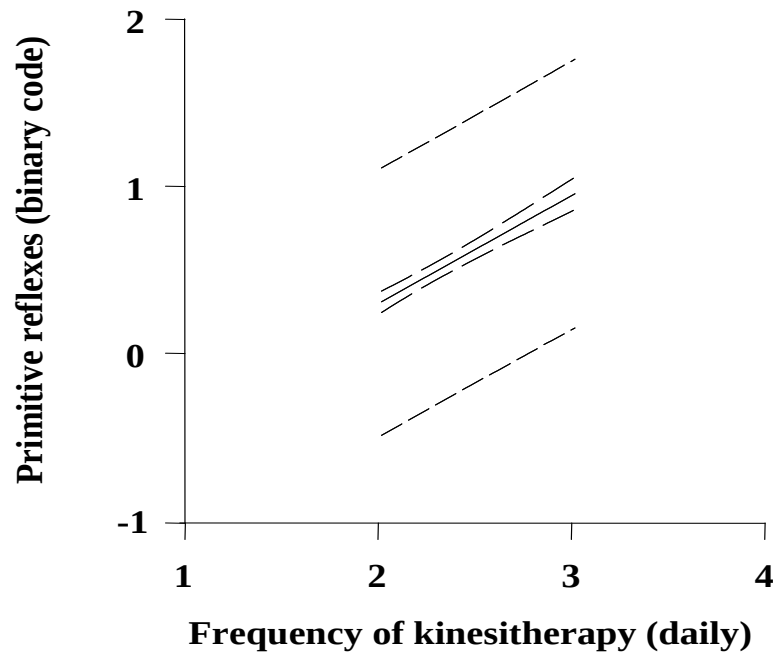


Figure 3:- Multiple linear regression analysis between kinesiology tests and primitive reflexes.

Multiple linear regression analysis found that the frequency of kinesitherapy determined the results of the cranial ultrasound. The following was the regression formula (**Figure 4**):

$$\text{Cranial ultrasound} = 0.159 + (0.164 * \text{daily frequency of kinesitherapy})$$

At twice daily kinesitherapy, the index of cranial ultrasound averaged 0.487, while at three times daily – 0.651 (**Figure 4**).

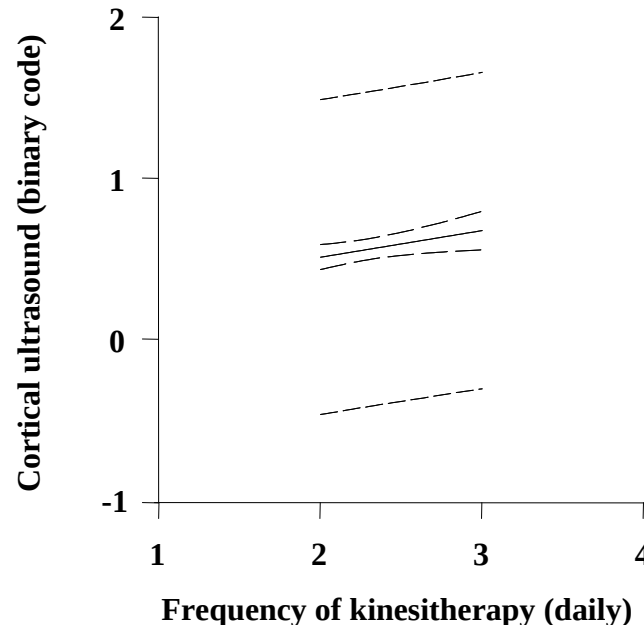


Figure 4:- Multiple linear regression analysis between kinesiology tests and cranial ultrasound.

Discussion:-

The effects of kinesitherapy and magnetic field upgraded over each other because of the best results from the combined group. Each of the four interventions had a therapeutic effect that was significantly greater than the placebo effect, as evidenced by the better results in the four treatment groups compared to the control group after two weeks and after six months, at initial comparable parameters.

The results support the opinion of other authors that kinesitherapy has a short-term and long-term therapeutic effect [9,11,15,25-29]. In addition, the results of multiple regression analysis found that the frequency of kinesitherapy correlated with all other factors at very high statistical significance. Moreover, it turned out that the twice-daily frequency of kinesitherapy was insufficient (binary index significantly below 0.5), while three times daily was sufficient (binary index of all factors significantly above 0.5). Therefore, if parents rely on only one daily visit to a specialized pediatric kinesitherapy facility, there would be no effect. The frequency of kinesitherapy at least three times should be in the recommendations to parents. The instruction to perform kinesitherapy two or three times a day is incorrect, as parents most often tend to reduce the frequency instead of increasing it.

The magnetic field had a significant short-term (two-week) therapeutic effect, exceeding that of the placebo control - the magnetic therapy group performed better than the placebo control group in the second week of follow-up, at comparable values at baseline. Our results support the opinion of other authors that magnetic therapy has a short-term therapeutic effect [14]. Magnetic field had a significant long-term (six-week) therapeutic effect, exceeding that of the placebo control - the magnetic therapy group performed better than the placebo control group at the sixth month of follow-up, at comparable values at the start of follow-up. The finding that the control group also showed improvement after two weeks and after six months means a tendency for natural recovery in cerebral motor disorders in early childhood. Our results support the opinion of other authors about the plasticity of the nerve system in early childhood [1-14].

The finding that at the baseline, the average binary value of the kinesiography tests, cranial ultrasound, primitive and pathological reflexes was comparable while at the end of the second week and the sixth month, it was significantly different, showed that they had different dynamics. The probable reason that the statistical significance of the kinesiography tests was the highest was their fastest dynamics, both in the short and long term. Some of these tests were verified earlier in development and others later. Some of them persisted for a shorter time and others for a longer time. Therefore, despite the averaging of the results of all kinesiography tests, their dynamics were the fastest. Kinesiography tests changed during the two-week and six-month follow-up. It was necessary to replace missing data with corresponding missing statistical values.

The ANOVA results showed that primitive reflexes had faster dynamics versus pathological reflexes but slower dynamics versus kinesiography tests. The dynamics of the cranial ultrasound were insignificant for the six-month follow-up. Therefore, despite the relatively stationary morphological changes verified by cranial ultrasound, the developing nervous system in young children showed significant positive follow-up dynamics of kinesiography tests, primitive and pathological reflexes. The disadvantage of cranial ultrasound was its uselessness when closing the fontanelle. As a result, statistical replacement of missing data with missing statistical values was inevitable due to the impossibility of performing cranial ultrasound until the end of the six-month follow-up. Due to the lack of significant dynamics of cranial ultrasound, even its single successful performance (before closing the fontanelle) was sufficient to verify the finding.

Conclusion:-

Cranial ultrasound revealed relatively stationary morphological changes. However, the developing nervous system in cerebral motor disorders at early childhood showed significant positive dynamics and plasticity, verified by kinesiography tests, primitive and pathological reflexes. The best results showed the combined group with kinesiography and magnetic field. The effects of kinesiography and magnetic field upgraded over each other. Twice daily frequency of kinesiography achieved insignificant effectiveness, while three times daily - significant. The recommendation for cerebral motor disorders in early childhood to perform kinesiography at least three times daily is very important.

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