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PHYSIOTHERAPY FOR CHILDREN WITH MICROCEPHALY AND PSYCHOMOTOR DELAY

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Abstract: *Microcephaly is a brain developmental disorder characterized by reduced brain size, associated with abnormalities in cell proliferation. Pathophysiological analysis of this condition highlights the mechanisms by which the adequate generation of neurons, a process essential for establishing brain size and organization, is disrupted. Genetic studies have demonstrated that primary mutations involved in microcephaly frequently affect genes encoding centrosome proteins, suggesting a critical role for them in neurogenesis. Centrosomal dysfunction disrupts cell division, leading to abnormal cortical development, making microcephaly a key model for studying cortical formation and neuronal regulation.*

Key words: *microcephaly, neurogenesis, centrosomes.*

1. Introduction

Microcephaly represents a neurodevelopmental condition marked by a markedly diminished cranial circumference relative to normative standards for age and sex [1], [4], [7], [11].

This disorder indicates, in most instances, inadequate cerebral development during the prenatal or early postnatal stages.

Scientific attention toward microcephaly has grown substantially due to its genetic and molecular associations.

Research within neurobiology has emphasized the essential contribution of cellular proliferation and differentiation to the establishment of brain size. [13].

Microcephaly is a neurodevelopmental condition characterized by a cranial circumference markedly lower than the average values for age and sex, commonly below −2 standard deviations and, in severe cases, below −3 standard deviations.

This disorder generally indicates inadequate cerebral development, being correlated with decreased brain volume and diverse structural abnormalities. From a clinical perspective, microcephaly may be identified at birth (congenital form) or may develop postnatally as a consequence of pathological mechanisms influencing brain maturation [3], [14].

From a pathophysiological perspective, microcephaly results from diminished

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proliferation of neural progenitor cells, disrupted neuronal migration, or enhanced apoptosis during embryonic development.

These processes contribute to simplified cortical gyration and impaired neuronal connectivity. Neuroimaging investigations commonly demonstrate abnormalities including lissencephaly, heterotopias, or intracranial calcifications, depending on the underlying etiology [1], [12].

Clinical manifestations vary from mild presentations, with nearly normal cognitive development, to severe forms associated with intellectual impairment, epilepsy, motor dysfunctions, and sensory deficits. Prognosis is largely determined by the underlying etiology and the extent of cerebral injury. Clinical assessment comprises anthropometric measurements, neurological evaluation, imaging investigations, and genetic testing, being essential for determining the etiology and therapeutic management.

No curative therapy currently exists for microcephaly, and treatment focuses on symptom alleviation and the support of child development through multidisciplinary interventions, including occupational therapy, speech therapy, and neurological rehabilitation. Prevention remains fundamental and involves prenatal monitoring, vaccination, avoidance of exposure to risk factors, and management of maternal infections.

1.1. Pathology of Microcephaly

Their origin may be genetic or acquired through the teratogenic effects of factors acting during the embryo-fetal period. Consequently, they may represent developmental abnormalities of the nervous system arising during the embryonic stage or lesions resulting from the harmful influence of predominantly infectious, traumatic, or metabolic factors during the fetal and perinatal periods.

Congenital malformations involving the brain, cerebellum, brainstem, or spinal cord are, in most cases, caused by defects in neural tube closure or by abnormalities in the differentiation and maturation of the cerebral hemispheres, as observed in microcephaly.

Congenital abnormalities of the central nervous system, characterized by considerable anatomical and clinical variability, may become clinically evident during the neonatal period or later throughout childhood through manifestations of varying severity, since some forms are incompatible with life or progress with profound intellectual deficits.

Microcephaly may be present at birth or may develop during the first years of life. As cerebral growth is directly related to cranial growth, individuals affected by this disorder frequently present intellectual disability, impaired motor function, speech disturbances, abnormal facial morphology, seizures, and growth retardation, together with reduced learning capacity and limitations in daily functioning, balance impairment, swallowing difficulties, visual abnormalities, and hearing deficits [5, 6], [8, 9].

In neonates with microcephaly, brain weight is reduced to approximately 250–300 grams, compared with the normal weight of 350–400 grams; in adults affected by microcephaly, brain weight is frequently below 300 grams, whereas the normal adult brain weighs between 1100 and 1500 grams [10]. The incidence of microcephaly ranges from 0.6 to 1.6 cases per 10,000 births, figure 1.

Fig. 1 . *Microcephaly in children*, [16]

1.2. Types of microcephaly

Primary (hereditary) microcephaly is of genetic origin and is frequently linked to chromosomal abnormalities such as Down syndrome, Patau syndrome, and Edwards syndrome. It can also be observed in rare genetic conditions, including Smith-Lemli-Opitz syndrome, Meckel syndrome, and Cornelia de Lange syndrome. From a pathogenetic perspective, primary microcephaly is characterized by an imbalance between the proliferation of progenitor cells and programmed cell death (apoptosis). Disruption of neuronal progenitor cell proliferation—resulting from defects in mitotic processes, alterations in the cell cycle, or impaired DNA damage response pathways—leads to a decreased production of neurons and glial cells in the developing brain [15].

In contrast, secondary (non-hereditary) microcephaly arises due to external factors that disrupt normal cerebral development. These may include congenital infections transmitted from mother to fetus, such as cytomegalovirus, herpes simplex virus, varicella, rubella, and Zika virus, as well as episodes of oxygen deprivation occurring in utero or after birth. Additional causes involve severe nutritional deficiencies and exposure to harmful substances, including alcohol and various drugs during pregnancy.

Additional etiological factors comprise maternal phenylketonuria and exposure to ionizing radiation during the embryonic period.

Clinically, individuals with secondary microcephaly may exhibit progressive decline in motor and cognitive abilities, often accompanied by epileptic seizures, although in certain cases the clinical evolution may appear stable [1, 2, 3], [12], [14].

1.3. Clinical picture

One of the first clinical indicators suggestive of microcephaly is a cranial perimeter that falls below the normal reference range established for the child's age and sex. This parameter represents a key element in standard pediatric evaluations, as it reflects the development of both the skull and the underlying brain structures.

Head circumference is measured using a flexible tape placed around the most prominent part of the skull, following a standardized technique. The measurement is taken by aligning the tape with anatomical reference points, including the most anterior projection of the forehead and the most prominent point of the occipital region at the back of the head. This method ensures consistency and reliability in obtaining an accurate assessment of cranial growth.

The measured value is subsequently evaluated in relation to standardized reference charts derived from population norms, taking into account the child's age and sex.

In some instances, head circumference values may fall near the lower boundary of the normal range, which can still be considered within normal biological variation. However, in microcephaly, cranial measurements are persistently and markedly below the minimum expected limits, indicating a pronounced deviation from normal skull development and raising concern for impaired brain growth.

Newborns diagnosed with microcephaly generally present a reduced skull size associated with distinctive craniofacial features. The forehead is often narrow, flattened, and tilted posteriorly, while the supraorbital ridges appear more pronounced than usual. The ears may seem disproportionately large in relation to the head, and the anterior fontanelle is frequently reduced in size or completely absent, further highlighting the abnormal pattern of cranial development. Many children with microcephaly may initially be asymptomatic at birth, but subsequently develop epilepsy, cerebral palsy, learning difficulties, hearing impairment, and visual disturbances.

The diagnosis and assessment of microcephaly are necessary to identify the underlying etiology, detect possible associated conditions, and contribute to prognostic evaluation. A comprehensive medical history and a complete physical examination represent the initial steps in the assessment of a child with microcephaly. An accurate prenatal history, including detailed information regarding maternal illnesses, infections, medication use, and exposure to substances, constitutes an essential component of the evaluation.

The clinical history should also encompass the age of onset, the severity of the condition, and the family history, in order to identify other affected relatives and to detect possible underlying genetic or metabolic disorders. Measurement of parental head circumference is also important, as it may contribute to the diagnosis of familial microcephaly.

Regarding the physical examination, the presence of dysmorphic facial features and other associated abnormalities may suggest a specific diagnosis or indicate the need for further investigations. Head circumference should be measured systematically and compared with previous values when available.

The American Academy of Neurology has issued clinical recommendations for the assessment of children diagnosed with microcephaly. In situations where the reduced head circumference is proportional to the child's height and body weight, and no neurological abnormalities or relevant familial history are present, a strategy of periodic clinical monitoring is advised. Metabolic investigations or genetic testing become necessary when neurological symptoms emerge or when there is evidence of progression in cranial growth impairment.

When microcephaly appears disproportionate or when the diagnosis cannot be clearly established after a complete clinical examination, neuroimaging is recommended as the subsequent diagnostic approach. This category of investigations comprises non-invasive techniques used to evaluate the structure and function of the central nervous system, offering objective information about brain morphology and development.

In recent years, genetic analysis has become an important tool in determining the underlying cause of microcephaly. Modern methods include targeted gene testing and whole-exome sequencing. Current data suggest that genetic testing, including chromosomal microarray analysis, can identify an etiological factor in approximately 15.3% to 52% of cases, depending on the studied population and diagnostic criteria. The prognosis is generally less favorable in children affected by intrauterine infections or by chromosomal or metabolic abnormalities. A retrospective study including 680 children showed that 65% presented intellectual disability, 43% developed epilepsy, and 30% had ophthalmological disorders.

Microcephaly may be identified before birth through prenatal ultrasonography, an imaging method that uses high-frequency sound waves processed by a computer to visualize the fetus, including its organs, tissues, and vascular structures. In most cases, however, detection is only possible in the third trimester, when cranial growth becomes more clearly assessable. During the examination, clinicians evaluate fetal images with particular attention to head size in relation to gestational age, looking for evidence of reduced cranial circumference.

In many situations, the definitive assessment is made either at birth or during early postnatal development. It is recommended that head circumference be measured within the first 24 hours after delivery, and the obtained values should be compared with the World Health Organization growth standards. Interpretation of these measurements is carried out by correlating them with gestational age, as well as with the newborn's weight and length, in order to provide a more accurate evaluation of overall growth patterns. Suspected cases require evaluation by a pediatrician, neuroimaging investigations, and serial monitoring of head circumference on a monthly basis, with comparisons to standardized growth charts.

Microcephaly is a neurodevelopmental disorder defined by a significantly reduced head circumference, which generally reflects inadequate brain development and may be associated with structural cerebral abnormalities [1,3]. Clinical manifestations and disease severity differ according to the underlying etiology, while management requires a multidisciplinary approach focused on symptom control and support of the child's development. The objective of this review was to offer an overview of the clinical, etiological, and neurodevelopmental characteristics of microcephaly, highlighting the significance of early diagnosis and preventive strategies [15]. The clinical presentation and severity of microcephaly vary considerably depending on the underlying cause, ranging from mild developmental delays to profound neurological impairments. Affected children may exhibit motor deficits, cognitive impairment, epilepsy, or sensory dysfunctions, according to the degree of cerebral involvement.

Given this heterogeneity, diagnosis and therapeutic intervention necessitate a careful and individualized evaluation. Management is fundamentally multidisciplinary, involving pediatricians, neurologists, physiotherapists, and other healthcare professionals. The main objective of treatment is to reduce symptom severity, improve functional capacity, and support the overall development and quality of life of the child.

2. Material and Methods

2.1. Date, place and subjects of the research

The research was conducted over a total

duration of seven months, starting in October 2024 with the initial clinical evaluation and concluding in April 2025, when the final assessment was carried out. This time frame allowed for the monitoring of functional changes and the progression of the patient throughout the intervention period.

The study focuses on a 6-year-old female patient who was diagnosed at birth with congenital microcephaly. In addition to this primary condition, the patient presents multiple associated neurological and developmental disorders, including neuropsychomotor delay, partial agenesis of the corpus callosum, as well as parieto-occipital parenchymal abnormalities, described as parencephaly. These combined impairments contribute to a complex clinical profile, requiring continuous evaluation and a multidisciplinary approach to management and rehabilitation.

2.2. Patient assessment tests

1. Evaluation of manual dexterity, general motor organization and coordination –
2. Perle test;
3. Laterality test;
4. Perceptual-motor assessment based on color;
5. Perceptual-motor assessment according to shape;
6. Balance test.

2.3. Research procedure

The objectives of the rehabilitation program include:

1. Cognitive stimulation of the patient, achieved through imitation-based exercises and games, activities involving the classification of objects according to categories such as color, shape, and size, as well as coloring within outlines.
2. Social integration, supported through exercises focused on personal hygiene and daily living activities, including dressing and putting on footwear.
3. Development of gross and fine motor skills, through variations of walking and light running, as well as exercises involving grasping and manipulation.
4. Improvement of general coordination, using laterality exercises and applicative movement courses.
5. Sensory stimulation of vision and hearing, through activities involving music-based exercises and visual tracking of moving objects.

Table 1

Period, methods and techniques used and specific objectives

Period	Objectiv	Monday		Tuesday		Thursday		Friday	
		Exercise	Dosage	Exercise	Dosage	Exercise	Dosage	Exercise	Dosage
Month 1 October 1- 31	Cognitive stimulation through motor activities	Ex. 1 Ex .2 Ex. 3	Activities will be resumed until there are at least two successes	Ex. 4 Ex. 5 Ex. 6	Activities will be resumed until there are at least two successes	Ex. 7 Ex. 8	Activities will be resumed until there are at least two successes	Ex. 9 Ex. 10	Activities will be resumed until there are at least two successes
Month 2-3 November 1- 22	Development of fine and gross movements	Ex. 1 Ex. 2	Minimum 5 beads inserted	Ex. 3 Ex. 4	Activities will be resumed until there are at least two successes	Ex. 5 Ex. 6	Activities will be resumed until there are at least two successes	Ex. 7 Ex. 8 Ex. 9	2x10m 2x10m 3x5m
Month 4 January 9 - 31	Social integration through motor activities	Ex. 1	Activities will be resumed until there are at least two successes	Ex. 2 Ex. 3	5 min 5 min	Ex. 2 Ex. 3	10 min 10 min	Ex. 2 Ex. 3 Ex. 4	10 min 10 min 25 min
Month 5 February 1- 28	Developing balance	Ex. 1 Ex. 2	2x5 sec	Ex. 1 Ex. 3	3x5 sec	Ex. 2 Ex. 4	3x5 sec	Ex. 1 Ex. 2 Ex. 5	3x5 sec
Month 6 March 1-31	Development of upper and lower limb coordination	Ex. 1 Ex. 2	3x5 10 min	Ex 1 Ex. 2	3x5 3x5	Ex. 1 Ex. 2	3x6	Ex. 1 Ex. 2 Ex. 3	3x8
Month 7 April 1-25	Oculomotor development	Ex. 1 Ex. 2	30 min 30 min	Ex. 1 Ex. 2	30 min 30 min	Route 1	50 min	Route 2	50 min

3. Results and Discussions

The results were obtained after thorough evaluation of the patient during the rehabilitation program phase.

3.1. Perle Test

The scoring of this test is performed by comparing the time achieved by the subject, in seconds, for threading the 30 beads to the reference presented in Chapter II. “Manual skill rating”:

1. good = 75-100 percentile
2. Average = 30-70 percentile
3. Poor = 0-25 percentile.

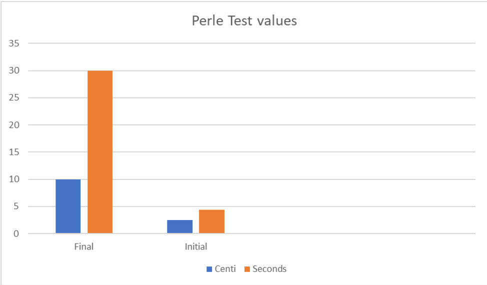

Fig. 2. *Perle test*

On the Perle Test, the patient scored 10th percentile at the initial evaluation, indicating poor manual dexterity, and on the final evaluation, he scored 30th percentile, indicating that manual dexterity had improved to average.

3.2. The laterality test

a. Hand dominance

Assessment: note which hand the child used:

1. R- right, when 5-6 trials were performed with the right hand
2. L- left, when 5-6 trials were performed with the left hand

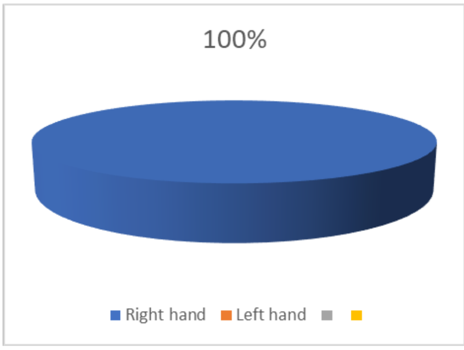

Fig. 4. *Hand dominance values - initial assessment*

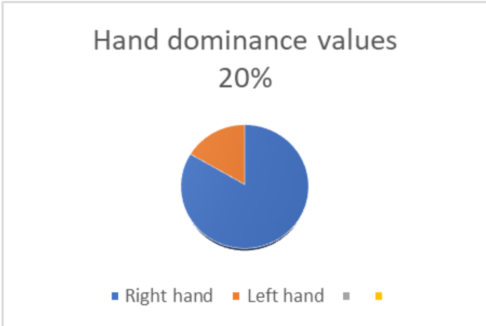

Fig. 5. *Hand dominance values - final evaluation*

The patient preferred to use his right hand, but during the program, he was able to use both his right and left hands, with a 20% improvement in his left hand.

b. Eye dominance

A piece of cardboard is required, in the center of which a hole of approximately 1 cm in diameter will be made. The examiner will instruct the child to perform several visual tasks using this opening, such as observing various objects placed in different areas of the room through the hole, looking outside through a window, or peering through a keyhole.

Evaluation is carried out by recording the eye predominantly used after each task: R – right eye, when the child performs the activity mainly with the right eye; L – left eye, when the left eye is predominantly used; and 2 – when the child alternates between both eyes, sometimes using the right eye and sometimes the left eye.

c. Lower limb dominance

The child will be asked to complete the following motor tasks:

– kicking a ball,
– stepping onto and climbing the stepper,
– jumping on a single leg.

Evaluation: after each activity, the preferred lower limb is noted as follows:

R – right, when the child mainly uses the right foot for all movements;

L – left, when the child mainly uses the left foot for all movements;

2 – when the child alternates between both feet during task performance.

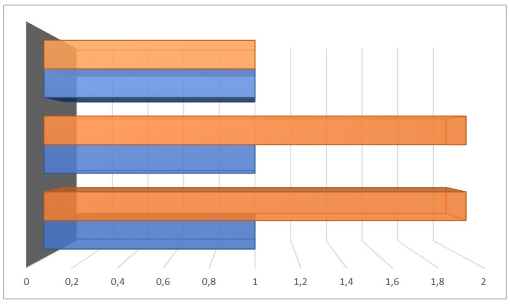

Fig. 6. *Lower limb dominance values at initial and final assessment*

3.3. Perceptual motor assessment based on color

The physiotherapist will mix a set of cubes in different colors, and the child will be asked to organize them according to color. The child has a maximum of 3 minutes to complete the task, at which point the activity is stopped. The test is deemed successful if the child is able to sort all the cubes within this 3-minute time frame.

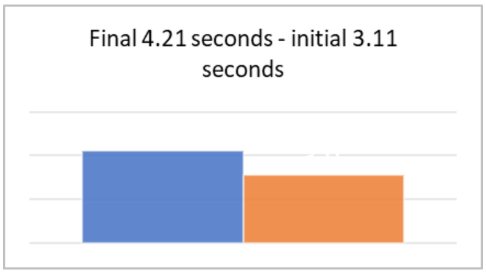

Fig. 7. *Values regarding perceptual motor assessment according to color – color distinction*

The subject demonstrated the capacity to correctly differentiate the primary colours and through steady improvement and enhanced concentration during the intervention, was able to comprehend and comply with the task requirements, ultimately finishing the assigned activity within the allotted time.

3.4. Perceptual-motor assessment according to shape

Visual discrimination exercise:

Materials: a set of 20 geometric shapes, uniform in both color and size, including squares, circles, triangles, and rectangles, with 5 pieces of each shape. The shapes are carefully prepared to ensure consistency, allowing the assessment to focus purely on visual perception and matching skills rather than being influenced by size or color differences.

Instructions: the shapes are arranged in a randomized order on a table in front of the child. The participant is asked to carefully observe the figures and identify those that are identical, separating them from the others. This task encourages attention to detail, visual-spatial reasoning, and the ability to categorize based on shape. The exercise also provides insight into the child's perceptual-motor integration and problem-solving strategies, as the way they approach grouping can reveal patterns in cognitive and motor planning.

The child is given 3 minutes to complete test.

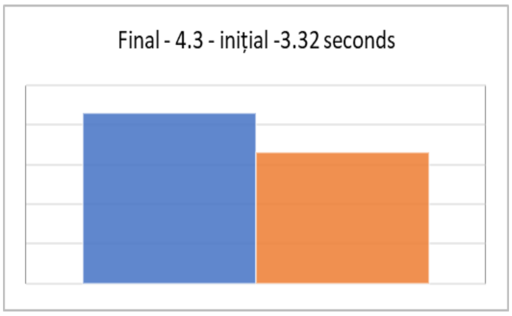

Fig. 8. *Values regarding perceptual motor assessment according to shape*

4.Balance test

The scoring scale for this test is defined as follows:

0 – not able to perform;

1 –performs with difficulty and requires physiotherapist assistance;

2 – performs independently, but with difficulty;

2 – performs independently, without difficulty.

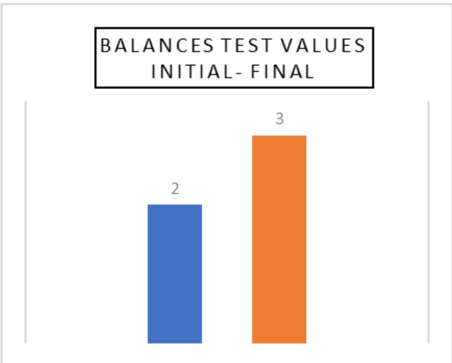

Fig. 9. *Balance test values*

Values recorded during the initial and final assessments show that at baseline the patient achieved a score of 2, indicating balance impairments and the ability to perform tasks independently but with difficulty. At the final assessment, an improvement was noted, the patient being able to carry out the tasks independently and without difficulty.

5. Conclusions

The implementation of an individualized and carefully structured exercise program, tailored to meet the patient's specific requirements, resulted in significant improvements across motor skills, cognitive abilities, and overall quality of life. In this particular case, the patient demonstrated a marked progression in balance: the initial assessment indicated a score of 2, reflecting the ability to perform tasks independently but with difficulty, which improved to a score of 3 at the final evaluation, indicating fully independent performance without difficulty. Additionally, manual dexterity showed noticeable advancement, evolving from a poor level of proficiency at the beginning of the program to a moderate level by the end, reflecting enhanced fine motor control and coordination.

Regarding hand laterality, gradual progress was recorded throughout the intervention: the patient initially relied exclusively on the right hand for task execution, while later beginning to incorporate the left hand as well, which reached approximately 20% involvement by the end of the program.

During the rehabilitation process, positive changes were also noted in the social and emotional domain, as the patient initially exhibited a reserved and anxious behavior, which gradually became more engaged over time.

In summary, microcephaly represents a complex neurodevelopmental condition characterized by diverse clinical presentations and varying degrees of severity depending on its underlying cause. Effective management requires an individualized, comprehensive, and multidisciplinary approach, aimed at maximizing functional abilities and promoting the child's overall development and quality of life.

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