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CLINICAL, ANAMNESTIC, AND ANTHROPOMETRIC PARAMETERS OF MICROCEPHALY OF VARIOUS ETIOLOGIES

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Background

According to current epidemiological data, the prevalence of microcephaly is approximately 2 cases per 1,000 live births; however, this estimate varies substantially depending on the diagnostic criteria applied, target population demographics, and consanguinity rates [2,6]. In populations with high rates of endogamous and consanguineous marriages characteristic, in particular, of certain regions in Central Asia the incidence of hereditary variants significantly exceeds global averages and can reach 1:1,000 [1,4]. Clinical diagnosis of microcephaly relies primarily on baseline anthropometry, specifically the systematic longitudinal measurement of head circumference plotted against standard percentile curves. Diagnostic criteria mandate a head circumference reduction below the 3rd percentile (-2 SD) or below the 0.4th percentile (-3 SD) in severe cases. Measurements must be recorded dynamically over at least three consecutive evaluations to accurately assess cranial growth velocity [3,5].

Objective

To evaluate the clinical, anamnestic, and anthropometric parameters of microcephaly across various etiological categories.

Materials and methods

The study cohort comprised 207 pediatric patients aged 3 months to 17 years, including 118 females (57.0%) and 89 males (43.0%). All participants were stratified into three distinct groups based on the etiological form of microcephaly: Group I (primary microcephaly, n = 95; 45.9%), Group II (secondary microcephaly, n = 87; 42.0%), and Group III (syndromic microcephaly, n = 25; 12.1%).

Age distribution analysis revealed that the predominant cohort in all groups comprised children aged 1–3 years and 4–7 years, collectively accounting for 65.5% of the total study population. This distribution reflects the typical age frame for seeking pediatric neurological consultation regarding microcephaly (Table 1).

Age Category	Group I (n=95) Female / Male	Group II (n=87) Female / Male	Group III (n=25) Female / Male	Total (n=207)

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Age Category	Group I (n=95) Female / Male	Group II (n=87) Female / Male	Group III (n=25) Female / Male	Total (n=207)
3–6 months	1 / 0	1 / 1	0 / 0	3 (1.4%)
6–12 months	2 / 0	2 / 0	1 / 0	5 (2.4%)
1–3 years	9 / 19	19 / 15	3 / 5	70 (33.8%)
4–7 years	21 / 11	16 / 8	5 / 6	67 (32.4%)
8–14 years	18 / 10	14 / 6	3 / 1	52 (25.1%)
15–17 years	0 / 4	3 / 2	0 / 1	10 (4.8%)
Total	51 / 44	55 / 32	12 / 13	207 (100%)

Note: In Group I, the difference in age distribution between females and males was statistically significant ($\chi^2 = 15.5$; $df = 5$; $p = 0.008$). In Group II: $\chi^2 = 2.6$; $df = 5$; $p > 0.05$; in Group III: $\chi^2 = 3.55$; $df = 4$; $p > 0.05$.

The mean age of patients was 6.54 ± 0.43 years (78.47 ± 5.1 months) in Group I, 5.7 ± 0.44 years (68.41 ± 5.39 months) in Group II, and 5.36 ± 0.66 years (64.32 ± 7.9 months) in Group III. Intergroup differences regarding mean age were statistically non-significant, confirming baseline comparability across all groups.

Notably, Group I demonstrated a statistically significant male predominance in older age categories (8–14 and 15–17 years), whereas females predominated in the 4–7 years subgroup ($\chi^2 = 15.5$; $p = 0.008$). Groups II and III exhibited no sex-specific differences in age distribution, underscoring distinct healthcare-seeking patterns specific to primary (hereditary) forms.

Results and discussion

Evaluation of maternal obstetric and gynecological history demonstrated a high prevalence of gestational complications across all study groups. According to the pregnancy and labor optimality scales (Kainer/Palchik system), an adverse perinatal history was documented in 94.4% of mothers in Group I, 86.1% in Group II, and 74.0% in Group III. All scores differed significantly ($p < 0.001$) from control values, whereas intergroup differences were not statistically significant (Table 2).

Optimality Scale	Group I (n=95)	Group II (n=87)	Group III (n=25)	Control (n=35)

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Optimality Scale	Group I (n=95)	Group II (n=87)	Group III (n=25)	Control (n=35)
Pregnancy Optimality (max 35 pts)	22.9 ± 1.1*	23.3 ± 0.9*	22.9 ± 1.0*	35.8 ± 1.1
Labor Optimality (max 17 pts)	10.2 ± 0.7*	10.4 ± 0.8*	11.3 ± 0.7*	17.5 ± 0.2

*Note: * Statistically significant difference compared to control group ($p < 0.001$).*

Trimester-specific risk factor analysis demonstrated that 1st trimester complications were significantly more prevalent in Group I (57.7%) compared to Group II (37.9%; $\chi^2 = 8.03$; df = 1; $p < 0.005$). Conversely, 3rd trimester complications occurred significantly more frequently in Group II mothers (58.6%) compared to Group I (37.9%; $\chi^2 = 7.82$; $p < 0.005$) and Group III (32.0%; $\chi^2 = 5.52$; $p < 0.02$) (Table 3).

Risk Factor	Group I (n=95)	Group II (n=87)	Group III (n=25)	Total (n=207)
1st Trimester – Total Complications	56 (57.7%)	33 (37.9%)*	11 (44.0%)	100 (48.3%)
• TORCH infections	5 (5.3%)	2 (2.3%)	1 (4.0%)	8 (3.9%)
• Anemia	11 (11.3%)	7 (8.0%)	2 (8.0%)	20 (9.7%)
• Acute respiratory viral infections	15 (15.5%)	8 (9.2%)	4 (16.0%)	27 (13.0%)
• Early gestosis / toxemia	14 (14.7%)	9 (10.3%)	3 (12.0%)	26 (12.6%)
2nd Trimester – Total Complications	42 (43.3%)	23 (26.4%)**	6 (24.0%)	69 (33.3%)
3rd Trimester – Total Complications	36 (37.9%)	51 (58.6%)***	8 (32.0%)^	93 (44.9%)
• Late gestosis / preeclampsia	9 (9.3%)	19 (21.8%)	2 (8.0%)	30 (14.5%)

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Risk Factor	Group I (n=95)	Group II (n=87)	Group III (n=25)	Total (n=207)
• Oligohydramnios	9 (9.3%)	6 (6.9%)	0 (0.0%)	15 (7.2%)

*Note: Differences vs Group I: * $\chi^2 = 8.03$; $p < 0.005$; ** $\chi^2 = 6.25$; $p < 0.05$; *** $\chi^2 = 7.82$; $p < 0.005$. Differences vs Group II: ^ $\chi^2 = 5.52$; $p < 0.02$.*

Thus, early gestational complications (1st trimester) were most critical in mothers of primary microcephaly patients, whereas 3rd trimester complications—predominantly severe late toxemia and conditions linked to chronic fetal hypoxia—dominated in secondary microcephaly. These findings align with underlying pathogenetic mechanisms: primary microcephaly stems from early neurogenesis disorders, whereas secondary forms result from late hypoxic-ischemic insults.

Labor Characteristics and Neonatal Status: Prematurity (<37 weeks gestation) was documented in 15 infants (15.8%) in Group I, 14 (16.1%) in Group II, and 3 (12.0%) in Group III, showing no statistically significant intergroup variation. Median gestational age among preterm infants was 35 (28; 36) weeks in Group I, 35.5 (31; 36) weeks in Group II, and 36 (35; 36) weeks in Group III. Delivery dynamics differed significantly between cohorts (Table 4). Severe labor patterns (43.2%), prolonged labor (4.2%), and birth trauma (12.6%) were significantly higher in Group I and absent in Groups II and III. Cesarean delivery rates were markedly elevated in Group III (32.0%) compared to Group I (7.4%; $\chi^2 = 10.98$; $p < 0.001$) and Group II (10.3%; $\chi^2 = 7.07$; $p < 0.01$).

Parameter	Group I (n=95)	Group II (n=87)	Group III (n=25)
Uncomplicated / Mild delivery	28 (29.5%)	43 (49.4%)*	12 (48.0%)
Moderate delivery complications	19 (20.0%)	9 (10.3%)	0 (0.0%)
Severe delivery complications	41 (43.2%)	26 (29.9%)	5 (20.0%)**
Cesarean section delivery	7 (7.4%)	9 (10.3%)	8 (32.0%)***^
Prolonged labor	4 (4.2%)	0 (0.0%)	0 (0.0%)
Traumatic labor / Birth injuries	12 (12.6%)	0 (0.0%)	0 (0.0%)

*Note: Differences vs Group I: * $\chi^2 = 7.6$; $p < 0.01$; ** $\chi^2 = 4.49$; $p < 0.05$; *** $\chi^2 = 10.98$; $p < 0.001$. Differences vs Group II: ^ $\chi^2 = 7.07$; $p < 0.01$.*

Mean birth weight was 2,940 ± 60.4 g in Group I, 2,782.18 ± 75.2 g in Group II, and 2,766 ± 89.8 g in Group III. Differences in birth weight were non-significant, with mean values across all

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groups clustering near the lower bound of physiological norm (2,600–4,000 g), reflecting a generalized systemic impact on intrauterine development.

Head circumference (HC) at birth differed significantly: Group I – 34 (33; 35) cm; Group II – 34 (31.5; 35) cm; Group III – 30.5 (29.25; 31) cm ($p < 0.001$ vs Groups I and II). Patients in Group III (syndromic form) demonstrated the most severe HC deficit at birth, consistent with the severity of structural anomalies typical of chromosomal disorders.

A significant correlation between birth HC and birth weight was observed in Group I ($r = 0.475$; $p = 0.001$) and Group II ($r = 0.68$; $p = 0.001$); however, no correlation was found in Group III ($r = 0.06$; $p > 0.05$). The absence of correlation in the syndromic group indicates that HC deficit in this etiology is predominantly driven by genetically determined neurodevelopmental malformations rather than general somatic intrauterine growth restriction.

Anthropometric parameters at examination

At the time of study enrollment, all patient cohorts demonstrated significant deficits in key anthropometric parameters relative to age-matched norms (Table 5).

Parameter	Group I (n=95)	Group II (n=87)	Group III (n=25)
Body weight, kg	14 (11; 18)	12 (8.5; 18)	13 (10.5; 17.5)
• Deviation from norm, %	−29 (−41.5; −11.8)	−32 (−40.8; −20.1)	−29 (−37.8; −1.87)
• Z-score	−2.18 (−4.3; −1.24)	−2.6 (−4.04; −1.6)	−2.5 (−3.1; −0.13)
Height / Length, cm	97 (80; 112)	92 (76; 110)	91 (74.5; 106)
• Deviation from norm, %	−16 (−21.9; −6.8)	−14 (−20.6; −7.5)	−13 (−22.3; −4.9)
• Z-score	−3.9 (−6.1; −1.7)	−3.5 (−5.3; −1.9)	−4.0 (−5.6; −1.2)
Head Circumference (HC), cm	45 (43; 47)	44 (41; 47)	41 (39; 42.5)*^
• Deviation from norm, %	−10.9 (−14.7; −7.8)	−11.0 (−16.2; −7.9)	−19.7 (−22.7; −13.3)*^

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Parameter	Group I (n=95)	Group II (n=87)	Group III (n=25)
• Z-score	−3.8 (−5.01; −2.7)	−3.8 (−5.5; −2.7)	−6.7 (−7.7; −4.5)*^

*Note: * Statistically significant vs Group I ($p < 0.001$); ^ Statistically significant vs Group II ($p < 0.001$). Intergroup differences for weight and height were non-significant.*

A highly significant ($p < 0.001$) head circumference deficit was observed in Group III (syndromic microcephaly) relative to Groups I and II: median HC in Group III was 41 (39; 42.5) cm compared to 45 (43; 47) cm and 44 (41; 47) cm in Groups I and II, respectively. The HC Z-score in Group III (−6.7) was substantially lower than in Group I (−3.8) and Group II (−3.8).

Correlation analysis between anthropometric parameters revealed a strong positive relationship between height and weight across all groups ($r = 0.752$, 0.537, and 0.831, respectively; $p = 0.001$ for all). Head circumference correlated significantly with height ($r = 0.358$, 0.422, 0.684; $p = 0.001$) and body weight ($r = 0.396$, 0.377, 0.596; $p = 0.001$) across all groups. This correlation was most pronounced in Group III, reflecting the tight nexus between brain pathology severity and systemic growth restriction in syndromic forms.

Conclusions

1. No statistically significant intergroup differences were observed regarding height and weight deficits, although all three cohorts demonstrated substantial growth failure (weight Z-score range −2.18 to −2.6; height Z-score range −3.5 to −4.0), indicating a global impairment of physical development across all etiologies of microcephaly.

2. In syndromic microcephaly, head circumference reduction reaches maximum severity (HC Z-score median −6.7), significantly exceeding the deficits observed in primary and secondary forms.

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