HEAD CIRCUMFERENCE REFERENCES FOR SCHOOL AGE CHILDREN IN WESTERN ROMANIA

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HEAD CIRCUMFERENCE REFERENCES FOR SCHOOL AGE CHILDREN IN WESTERN ROMANIA (Abstract): Aims: To provide head circumference references for school-aged children in western Romania, and compare them with references from other European countries. Methods: A total of 2742 children, aged 6-19 years, from Timis county, were examined by medical students, between February 2010-June 2011. Head circumference references were constructed by Cole’s LMS method with LMSChartMaker software. The Romanian 3rd, 50th and 97th percentiles for head circumference were compared with recent references from Belgium and Germany. Results: Generally, boys show significantly larger head circumference compared to girls at any age. The head circumference increments between 6 and 19 years are < 1 cm/year. Head circumference increments decrease in increasing age of the children. In girls, adult head circumference is reached at the age of 16 years, whereas head circumference growth continues, in boys, slowly until 18 years. The comparison of Romanian head percentiles with those from Belgium and Germany revealed a smaller head circumference in Romanian children (both girls and boys). Conclusions: Comparing head circumference references from Romania to those from Germany and Belgium, we found lower median head circumference in Romanian boys and girls, that could be explained by a taller stature of boys and girls in Germany and Belgium compared to Romania. Keywords: HEAD CIRCUMFERENCE, CHILDREN, PERCENTILES, WESTERN ROMANIA.

Head circumference (HC) measuring and head growth evaluation constitute the most simple, inexpensive and readily available tools to assess the development of the central nervous system and identify neonates at risk of neurodevelopmental disorders (1). Furthermore, head circumference is an accurate indication of abnormal brain volume in later age, used mainly to screen for macro- or microcephaly and their various underlying pathologies (2). With knowledge of age-dependent head circumference-to-brain volume relationship, head circumference (in relation to age) can be an accurate indication of normalcy of brain size and growth in a clinical setting (3). Several studies also reported a direct relation between head size and intelligence, learning, nutritional status and brain development (4–6). Moreover, some studies suggest a relation between
head circumference and autism (7,8). A genetic study showed suggestive evidence of association between head circumference and adult intracranial volume, Parkinson's disease and other neurodegenerative diseases, indicating that a common genetic variant in the chromosome 17q21 region might link early brain growth with neurological disease in later life (9).

As research progresses, the clinical impact of HC measurements may become even more important. However, normative data for head circumference over the childhood and adolescence period are lacking for a Romanian population.

Therefore, the aim of this paper was to provide head circumference references for Romanian school-aged children and to compare them with references from other European countries.

MATERIAL AND METHODS

Studied population:
Timis is the largest county in the west part of Romania. According to the National Institute of Statistics, Timis county has an area of 8,697 km\(^2\).(10) The city of Timisoara is the largest in the county. When the present study started, in 2010, in Timis there were 67146 children attending school. We randomly chose 5 schools from Timisoara (enrolling 5676 students) to collect data for this study. The response rate was 50 %. Some students failed to be measured due to various reasons, including school absenteeism and conflicting school activities/responsibilities (certain classes were not interrupted for the measurements). A total of 2742 children, aged 6-19 years were examined by medical students, in the period February 2010 - June 2011.

Exclusion criteria:
Exclusion criteria were: genetic syndromes, cancer, or other chronic disease influencing growth, including children diagnosed with growth hormone deficiency, diseases affecting bone metabolism, cystic fibrosis, renal disease, congenital adrenal hyperplasia, and congenital heart defect with impairment of physical fitness.

Anthropometric techniques:
Prior to each data collection round, all examiners were trained in taking accurate measurements, according to international measurement techniques (11). Each child underwent anthropometric assessments (height, weight and head circumference) that were carried out during one day session. Head circumference was measured with a non-stretchable glass fiber tape measurer. The tape measurer was placed in a straight line from the supra-orbital position to the largest protuberance at the back of the head. Caution was taken to clear the auricles before measuring. The head circumference was recorded to the last completed millimeter. The age of children was rounded down when child’s age was years and 1-6 months and rounded up when the age was years and 7-12 months.

Statistical analysis
Growth reference construction
Data were cleaned and validated with SPSS, PC program (version 19.0 - SPSS Inc., USA). Outliers were checked carefully for possible mistakes of data recording. None of the outliers was considered to be biologically implausible. Descriptive statistics were run on all the variables. Statistical significance was considered when p<0.05. Growth references for head circumference were constructed with the lambda, mu, sigma (LMS) method and LMSChartMaker Light software (12). The LMS method (lambda, mu, sigma) summarizes the
changing distribution by three curves representing the median (μ), coefficient of variation (σ) and skewness (λ), the latter expressed as a Box-Cox power (13). We decided to fit the following percentiles: 3rd, 15th, 25th, 50th, 75th, 85th and 97th, for head circumference in relation to age. We made this choice in order to enable comparison with head circumference references from other European countries.

References for height, weight and body mass index for western Romania, from the collected data are presented in another article (14).

**Comparison with references from other countries for head circumference**

Comparison with the chosen head circumference references was based on comparability with regard to statistical methods of constructing the reference. The 3rd, 50th and 97th percentile for head circumference were selected and compared with the data from: 2009 References for growth and pubertal development from birth to 21 years in Flanders, Belgium (15) and 2011 German head circumference references for infants, children and adolescents - KiGGS study (16).

**Ethical considerations:**

Because of the noninvasive nature of the protocol, consisting only of measurements that are a routine for school examinations (height, weight, head circumference), we used a passive consent or opt out method. Parents were fully informed about all study procedures through a school information meeting. Parents who refused the participation communicated this to the school principal. Prior to the measurement, the child was also asked whether s/he agrees with it. The children’s names were not included in the electronic data files. Examiners ensured the basic principles of confidentiality, privacy and objectivity throughout the process. The children were measured in a private room, boys and girls separately. The approval of the University’s Ethical Advisory Commission is in accordance with the Helsinki Declaration.

**RESULTS**

**Demographics**

After applying the exclusion criteria, 12 children were taken out of the database because they had either growth disturbances as a result of a primary disease (malignancies, endocrine diseases, etc.) or as a consequence of treatment (growth hormone, steroids). We also excluded 9 children that were older than 19 years. A total of 2742 children, aged 6-19 years were examined between February 2010-June 2011, from 5 public schools in Timisoara. The study evaluated 1071 boys (39.1%) and 1671 girls (60.9%), with a male/female ratio of 1:1.5. The mean values and SDs for body weight, height and head circumference in relation to age are shown in tab. I. The mean age was 12.99 years (SD=3.49); with a symmetric distribution (skewness = -0.098; kurtosis= -1.075).

The data showed a strong Pearson correlation between head circumference and height (r=0.583, p=0.000) and an even stronger correlation with age (r=0.815, p=0.000).

Smoothed percentiles for head circumference in centimeters, constructed with the LMS method, for boys and girls separately, are shown in tab. II and tab. III, respectively.

Graphical representation of smoothed percentiles for head circumference in centimeters, constructed with the LMS method, for boys and girls separately, are shown in figure 1 and 2, respectively.
### TABLE I
**Descriptive Statistics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (n=2742)</th>
<th>Girls (n=1671)</th>
<th>Boys (n=1071)</th>
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<td>Age (years)</td>
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<td>Weight (kg)</td>
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<td>Height (cm)</td>
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<td>156.4(18.5)</td>
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<td>BMI kg/m²</td>
<td>11.2-45.4</td>
<td>19.8(3.6)</td>
<td>20.2(4.3)</td>
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</tr>
<tr>
<td>Head circum-</td>
<td>52.94(2.2)</td>
<td>52.6(2.0)</td>
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</tbody>
</table>

### TABLE II
**Smoothed percentiles for head circumference (cm) for boys (n=1071)**

<table>
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<tr>
<th>Age</th>
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<th>M</th>
<th>S</th>
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<th>15th</th>
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<td>52.5</td>
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### TABLE III
**Smoothed percentiles for head circumference (cm) for girls (n=1671)**

<table>
<thead>
<tr>
<th>Age</th>
<th>L</th>
<th>M</th>
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<th>15th</th>
<th>25th</th>
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</table>
Head circumference references for school age children in Western Romania

Fig. 1. Head circumference graph percentile for boys age 6-19 years

Fig. 2. Head circumference graph percentile for girls age 6-19 years

The head circumference increments between 6 and 19 years are < 1 cm/year. Head circumference increments decrease with older age from 0.96 to 0.01 cm at age 18 years. Between ages 9 and 11 years in boys, the annual increments in head circumference increase again from 0.35 to 0.49 cm and thereafter decelerate gradually until age 17 years. In girls, the decrease in increment is progressive with older age, with increments < 0.2 cm after 9 years. From age 16 years onwards, the head circumference increments are still measurable in boys with at least 0.3 cm per year, but not in girls (<0.1 cm). At 19 years age, a median head circumference of 55.4 cm in boys and 53.5 cm in girls is attained. In general, boys show significantly larger head circumference compared to girls at any age.

For the purpose of comparison, we ana-
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alyzed the 3rd, 50th and 97th percentile for head circumference for Romanian (presented data), German KiGGS study (15) and Belgian (14) children age 6-19 years, as shown in figures 3., for boys and in figure 4., for girls.

![Fig. 3.](image1)  
Fig. 3. Comparison of 3rd, 50th and 97th percentile for head circumference for boys age 6-19 years from Romania – in blue, Germany in red (16) and Belgium in black (15).

![Fig. 4.](image2)  
Fig. 4. Comparison of 3rd, 50th and 97th percentile for head circumference for girls age 6-19 years from Romania in blue, Germany in red (16) and Belgium – in black (15).

The comparison of 3rd, 50th and 97th percentile for head circumference in, both, boys and girls, age 6-19 years from Romania, Germany (16) and Belgium (15), shows that Romanian children have a smaller head circumference when compared to their peers in Germany and Belgium. Mean difference between German and Romanian head circumference in children is 1.4 cm for boys (2.56% of median
Head circumference references for school age children in Western Romania

German head circumference) and 1.4 cm girls (2.61% of median German head circumference), while between Belgian and Romanian head circumference it is 1 cm (1.84% of median Belgian head circumference) in boys and 1.2 cm in girls (2.24% of median Belgian head circumference). Greater mean differences (>1 cm) in head circumference are seen between the Romanian compared to German and Belgian children especially after the age of 14 years in boys and after 13 years in girls.

Considering that the differences in head circumference in children between countries could be due to different genetics, we looked at height differences between children from these countries. Height data from Belgian study (15) show that Belgian boys are taller that Romanian peers with an average of 1 cm, while Belgian girls are taller with 1.2 cm in average, when compared with Romanian girls (14). When correlating the difference in height with difference in head circumference between Belgian and Romanian children, data revealed a strong Pearson correlation for girls (r=0.834, p=0.000) and poor correlation for boys (r=0.291, p=0.000).

DISCUSSION

The sex-specific head circumference-for-age percentiles presented here are the first reference values from a sample of Romanian children, for the age range 6 through 19 years. In general, boys show significantly larger head circumference compared to girls at any age. As expected, the head circumference increments between 6 and 19 years are small (<1 cm/year) (15,16). Head circumference increments decrease with growing age. In girls, adult head circumference is reached at the age of 16 years, whereas head circumference growth continues, in boys, slowly until 18 years. This finding is consistent with previous studies (15,17,18). However, a study from the Netherlands showed that head circumference marginally increases until age 21 years in boys (19).

After 6 years of age until age 9 years, in boys, head circumference growth occurs in relatively constant increments per year, however, a growth spurt in head circumference follows, from 9 to 11 years and appears to be closely related to the puberty. Similar findings were published in the German KiGGS study (15) and a Japanese longitudinal study from birth to 15 years of age, who found an adolescent growth spurt in head size (20). However, in our study we did not detect similar findings for girls, but a steady decrease in head circumference increment after the age of 9 years.

The comparison of Romanian head percentiles with those from Belgium and Germany revealed a smaller head circumference in Romanian children (both boys and girls). The pattern of head size growth is particularly different in Romanian girls when compared with their peers from Germany and Belgium, showing the slowing of growth for the Romanian girls, after 13 years, when compared with the growth pattern of their peers. Considering that the differences between the 50th and the 3rd percentile, represent 6.11% of median head circumference, the difference between German, Belgian and Romanian peers (ranging from 1.8-2.6% of median head circumference) would represent approximately a 15 percentiles distance, that is significant. A plausible explanation for this discrepancy could be due to genetic factors. Height has a good correlation to head circumference (20). Therefore, we looked at height differences between populations and
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found that Belgian boys and girls are taller than Romanian peers, with 1 cm, in average. However, observing correlation between differences in height and in head circumference we found inconclusive results: a good correlation for girls and poor correlation for boys. A clear conclusion could not be drawn regarding the relation between height and head circumference, thus, further studies might be needed.

**Study limitations**

The sample of children in this study is representative for the west part of Romania; however, it cannot be extended for the entire population of the country. Another limitation of the study is that it does not provide data from birth to 6 years age group. Head circumference can be influenced by multiple factors: gestational factors (such as, mother nutrition (22), socio-economic status (4), period of gestation, iodine intake during pregnancy (23)), and genetic syndromes, or factors influencing puberty etc. These factors were not evaluated in this study.

The genetic background has a major role in determining both height and head circumference in a population; however, we did not investigate the ethnic background of the studied population. Results from the latest census of population, in 2011, in the Timisoara 81.4% are Romanian, 4.9% are Hungarians, 0.7% are Roma, 0.2% are Ukrainians, 1.3% are Germans, 1.5% are Serbians and 10% have other ethnicity (10). Although, the genetics of these populations are different and have an impact on head circumference, the percent of different ethnicities is not high enough to influence the study results. Further studies are needed to elucidate the impact of ethnic background on head circumference.

**CONCLUSION**

The study shows sex specific head circumference-for-age references for a Romanian population, thus allowing a description of the head size growth from 6 to 19 years. Comparing references from Romania to those from Germany and Belgium, we found a significantly lower median head circumference in both Romanian boys and girls, that could be explained by a taller stature of boys and girls in Germany and Belgium compared to Romania. A more widespread study should be carried out by including children from different regions of Romania.

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**REFERENCES**


