

## Somatic development of children with visual impairment

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**ABSTRACT** The effect of sensory organ diseases on physical growth is not an issue that is frequently discussed in auxology. The aim of this study was to evaluate the physical growth of children and youth suffering from sight deficiency or blindness in respect of the degree of disability, its etiology, and therapies applied in the course of treatment. The study involved 288 subjects (126 girls and 162 boys) aged 6 to 19 years, recruited from Centers for Blind and Partially Sighted Children in Wrocław and Cracow (Poland). The material provided the following anthropological data: height and body weight, Body Mass Index, triceps and subscapular skinfold thickness. The subjects with deficient sight were shorter and lighter and had greater trunk adiposity than their normally sighted peers. The degree of disability differentiated adiposity – blind children were markedly more obese ( $p < 0.001$ ) than partially sighted children. The weakest growth was observed in the subjects with deficient vision who had cranial surgery due to brain cancer or head injuries. These children were the shortest and most obese ( $p < 0.01$ ). The results obtained in the present study indicate that while evaluating physical growth in children, one ought to consider both the cause of vision impairment and therapies applied during the treatment.

**KEY WORDS** children, visual impairment, physical development, obesity

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### Introduction

A child's growth is not only controlled by genetic factors but is also under the influence of environmental factors. Among the latter, the incidence of infectious diseases is critical, especially in early and mid-childhood [MARTORELL

*et al.* 1994]. The American Academy of Pediatrics defines pediatric chronic diseases as illnesses that affect a person for an extended period of time, often for life, and require medical care and attention to a higher extent than in the case of other children [GEIST *et al.* 2003]. Numerous authors report that ca 10-20% of

children and youth are afflicted with chronic diseases [SEIN 2001, GEIST *et al.* 2003]. Among the most frequent are gastrointestinal, renal, respiratory, hematological diseases, endocrinopathies and eating disorders [GEIST *et al.* 2003]. The effect of a chronic disease on child's growth varies depending on the disease, age at its onset, its duration and severity and course of treatment [POZO and ARGENTE 2002]. Typical findings include reduced pubertal growth spurt, short final height, delay in bone maturation, delayed puberty and deficient body mass [SIMON 2002]. Diminished growth is mainly caused by chronic inflammation and malnutrition [PAGEZY and HAUSPIE 1989, POZO and ARGENTE 2002, SIMON 2002]. However, after the removal of the disease factor children demonstrate substantial catch-up growth if exposed to optimal environmental conditions [PREECE 1998].

Diseases of the special senses (sight, hearing) form a special kind of chronic diseases, yet the issue of their influence on physical growth is rarely considered in auxology [MALINA and GORZYCKI 1973, ŁUCZAK 1992, BUDAY and KAPOSÍ 1995, KALKA and CABAK 1997].

The objective of this study was to evaluate physical growth of children and youth with sight deficiency.

### Materials and methods

The study involved 288 subjects (126 girls and 162 boys) aged 6-19 years (mean 14.32; SD = 3.13), recruited from Centers for Blind and Partially Sighted Children in Wrocław and Cracow (Poland) (Table 1), where children and youngsters with sensory impairments

**Table 1.** Mean standardized values of somatic traits in children and adolescents with visual impairment, and comparison of the significance of the examined traits with the sample of healthy children.

| Measurements         | Subjects    |           | <i>p</i> |
|----------------------|-------------|-----------|----------|
|                      | <i>mean</i> | <i>SD</i> |          |
| body height          | -0.59       | 1.23      | < 0.01   |
| body weight          | -0.40       | 1.29      | < 0.01   |
| BMI                  | -0.11       | 1.20      | > 0.05   |
| triceps skinfold     | -0.03       | 1.26      | > 0.05   |
| subscapular skinfold | 0.26        | 1.11      | < 0.05   |

learn. Only children and youngsters afflicted with blindness or partial sight were considered. Those suffering from mental disorders were excluded. The material provides the following anthropological data: height and body weight, triceps and subscapular skinfold thickness. Unfortunately, data on midparental height were not available. Height and weight were measured according to the methods described by MARTIN and SALLER [1957-59]. Skinfold measurements were taken on the right side of the body with a Harpenden caliper and recorded to an accuracy of 0.1 mm. BMI (kg/m<sup>2</sup>) was used as an index of relative weight.

The children examined came mostly from big cities (having more than 100 thousand inhabitants) and villages (40% and 31% respectively), whereas 29% lived in small towns. The subjects with visual impairment formed quite a homogenous group with respect to their parents' education and number of children in the family – 69% of mothers and 74% of fathers ended their education at the level of primary school or basic vocational school, and only 2% of mothers and 6% of fathers graduated from institutions of tertiary education. In most

cases, i.e., 49%, the subjects were raised in families with many children (three or more children in a family), whereas single children constituted the smallest percentage (13%). An overwhelming majority, i.e., 75% of the subjects on the whole, was constituted by persons attending schools and living in the aforementioned Centers, spending only weekends and holidays in their family homes.

We were able to define the degree of defect and etiology by means of a questionnaire and information received from the subjects' medical histories. The medical records, however, provided no detailed information on the therapies received during hospital treatment. The data informed on cranio-cerebral injuries, preterm birth, cancer or cranial surgery.

The majority of the subjects (65%,  $n = 186$ ) had a high degree of sight defects, while the remaining 35% ( $n = 102$ ) were blind – with or without light perception. Following the etiology of visual impairment, the subjects were divided into three categories. The first category was the most frequent and included subjects with prenatally acquired congenital defects. Indeed, 48% of the subjects' sight defects were observed upon birth or in early childhood, and ophthalmologic anamnesis excluded the occurrence of defective vision in the closest family. The most frequent prenatal congenital defects were optic atrophy, cataract and retinal degeneration. The second group comprised 27% of subjects with defects acquired postnatally due to the eyeball traumas, retinopathy of prematurity or cancer. The third group (26%) involved subjects

with hereditary defects, such as retinal degeneration, cataract or optic atrophy. In the majority of children and youths, the sensory defect originated either during the prenatal period, upon birth or in early childhood.

Due to the variability in the levels of all values of measurements by age among children, the anthropometric data on the Wroclaw children and youth, as elaborated by HULANICKA *et al.* [1990], were used to convert these values into sex- and age-specific Z-scores. Standardization was done on the basis of the LMS method described by COLE [1988]. This method of fitting anthropometric data allows for the departure from normality while, at the same time, the centiles can be calculated from the mean and SD [COLE 1989]. Furthermore, the method allows for the estimation of each tabulated age and sex L, M and S smoothed curves, which represent a power of Box-Cox conversion to normality, the mean and the coefficient of variation, respectively. The Z scores for each subject were calculated by use of the formula:

$$Z = \frac{(X/M)^L - 1}{LS}$$

where  $X$  is the anthropometric measurement;  $M$  is a value obtained by mixing the arithmetic, geometric and harmonic means;  $S$  is a generalized coefficient of variation, and  $L$  is a value defined as "power of transformation" which stretches one-tail of the distribution and shrinks the other, removing the skewness.

In order to implement the method, the FORTRAN program developed by COLE and GREEN [1992] was applied.

The effect of the degree of visual impairment and defect etiology on somatic traits was assessed by two-way analysis of variance. The differences in means between two groups were tested by the Student's *t*-test for two samples with equal variance. Statistical significance was considered at  $p < 0.05$ . The analyses were carried out by means of the STATISTICA 6.0 package.

## Results

The subjects with visual impairment grew considerably less than their sighted peers, with respect to body height and body weight, where the most significant negative deviations were noted for body weight. Despite the fact that the subjects differed negatively with respect to body weight and Body Mass Index, they were characterized by relatively higher adiposity. The standardized values of triceps skinfold thickness were the same as for the control group, whereas the subscapular skinfold was thicker (Table 1).

The girls examined were characterized by more thickset body structure than boys and, as a consequence, revealed higher values of Body Mass Index (Table 2).

The subjects with visual impairment constituted a relatively homogeneous group with regard to socio-economic

conditions, particularly due to a relatively low level of parent education. By means of a two-way analysis of variance, the potential influence of the urban factor and the size of the family on the values of somatic traits were assessed. This analysis did not prove any significant influence of the factors mentioned on the level of physical development of the examined children and youths with sight deficiency (Table 2).

We evaluated physical growth of the subjects with respect to the degree of disability and its cause. To this end a two-way analysis of variance was performed and the following factors were included: degree of visual impairment (partially sighted or blind) and defect etiology (hereditary, congenital or acquired). The analysis of variance revealed no standardized differentiation between somatic trait values in respect of the etiology of sight illness; however, the degree of disability remarkably differentiated two of the traits analyzed - the skinfold thickness on the triceps and subscapular areas (Table 3). Blind children manifested higher standardized values of the subscapular and triceps skinfolds than partially sighted children (0.38, and  $-0.26$  SD and 0.70 and 0.02 SD, respectively), which indicated higher adiposity (Fig. 1).

**Table 2.** Comparison of standardized values of somatic traits in girls and boys (*t*-Student test)

| Measurements         | Girls       |             | Boys         |             | <i>t</i> -test |
|----------------------|-------------|-------------|--------------|-------------|----------------|
|                      | <i>mean</i> | <i>SD</i>   | <i>mean</i>  | <i>SD</i>   |                |
| body height          | -0.70       | 1.20        | -0.50        | 1.24        | 1.41           |
| body weight          | -0.26       | 1.34        | -0.51        | 1.20        | 1.66           |
| BMI                  | <b>0.17</b> | <b>1.16</b> | <b>-0.33</b> | <b>1.19</b> | 3.59**         |
| triceps skinfold     | 0.02        | 1.24        | -0.08        | 1.08        | 0.80           |
| subscapular skinfold | 0.20        | 1.07        | 0.31         | 1.16        | 0.70           |

\*\*  $p < 0.01$

**Table 3.** Results of two-way analysis of variance

| Factors considered         | <i>df</i> | Body height<br><i>F</i> | Body mass<br><i>F</i> | BMI<br><i>F</i> | Triceps skinfold<br><i>F</i> | Subscapular skinfold<br><i>F</i> |
|----------------------------|-----------|-------------------------|-----------------------|-----------------|------------------------------|----------------------------------|
| Urbanization               | 2         | 0.14                    | 1.86                  | 2.54            | 0.26                         | 2.05                             |
| Family size                | 2         | 1.56                    | 2.01                  | 2.00            | 0.35                         | 1.31                             |
| Urbanization x Family size | 4         | 0.40                    | 0.84                  | 1.21            | 1.52                         | 0.88                             |

**Table 4.** Results of two-way analysis of variance

| Factors considered   | <i>df</i> | Body height<br><i>F</i> | Body mass<br><i>F</i> | BMI<br><i>F</i> | Triceps skinfold<br><i>F</i> | Subscapular skinfold<br><i>F</i> |
|--|-----------|-------------------------|-----------------------|-----------------|------------------------------|----------------------------------|
| Degree of visual impairment                                    | 1         | 1.47                    | 0.05                  | 0.05            | 16.77***                     | 20.23***                         |
| Etiology of visual impairment                                  | 2         | 0.52                    | 0.49                  | 2.59            | 0.67                         | 0.92                             |
| Degree of visual impairment<br>x Etiology of visual impairment | 1         | 2.88                    | 5.54**                | 5.82**          | 4.78*                        | 0.82                             |

\*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

The group of blind children comprised mostly subjects with postnatally acquired sight defects (50%) ensuing from retinopathy of prematurity (ROP), cancer or trauma. A medical questionnaire provided information that 13% ( $n = 13$ ) of blind children in their early childhood underwent brachycranial surgery because of retinoblastoma (7 cases), cancer of the central nervous system (3 cases) and congenital hydrocephalus (3 cases). In case of cancer, surgery was combined

with chemo- or radiation therapy, yet no details on the administered doses of cytostatic agents and irradiation were given.

Among the partially sighted children, those with congenital but nonhereditary defects prevailed (51%), and only in 2% of them ( $n = 3$ ) brachycranial surgery was performed, due to hydrocephalus or traumas. The time elapsed after the surgery in each of the 16 cases was at least 5 years. Parameters of the physical

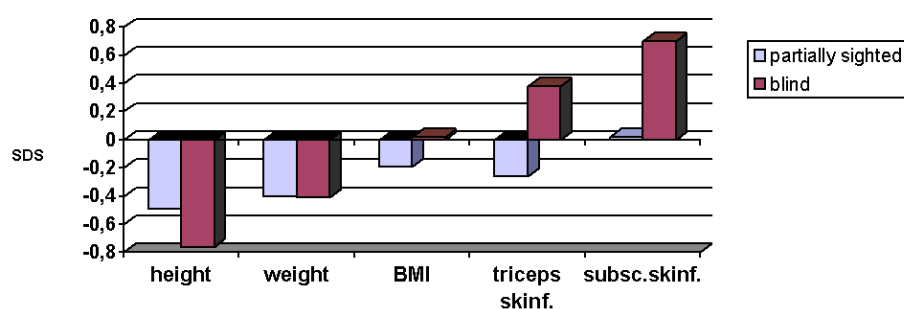


Fig. 1. Standardized values of somatic traits depending on the level of visual impairment.

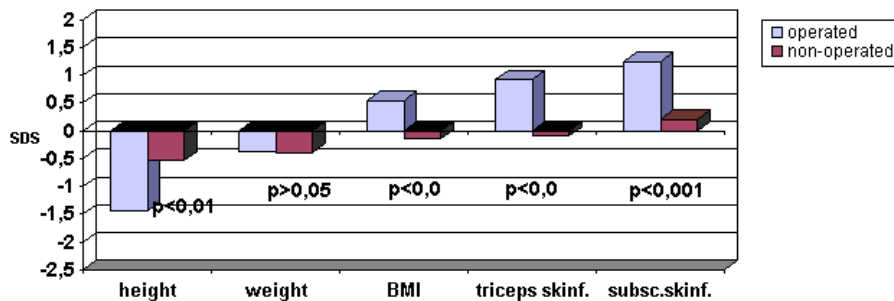


Fig. 2. Comparison of physical growth in children after cranial surgery with those not undergoing surgical treatment (*t*-Student test).

growth of these children are provided in Figure 2. The results indicate a marked statural deficiency and significantly higher adiposity on the trunk and extremities in children after cranial surgery when compared with controls.

### Discussion

The children and adolescents examined were significantly stunted compared with their sighted peers in regard to body height and body weight, and at the same time they revealed relatively higher adiposity, as shown by subscapular skinfold measurements (Table 1). Similar results for physical growth in children with visual impairment were also obtained by ŁUCZAK [1992], BUDAY and KAPOSI [1995], as well as KALKA and CABAK [1997]. In the studies carried out by the aforementioned authors, boys were characterized by lower values of somatic traits than girls, which proved greater eco-sensitivity of the male sex to the effects of pathology. In these studies, significant statistical intersex differences were found only in relation to Body Mass Index – the girls were characterized by a more thickset body

structure than boys.

In studies carried out by ŁUCZAK [1992], blind children were characterized by a lower level of physical growth in comparison with partially sighted children. Entirely blind children were characterized by significant deficiency in body height and weight. In this study, the level of visual impairment statistically significantly differentiated two of the somatic traits analyzed: triceps and subscapular skinfold thickness. Blind subjects were characterized by higher accumulation of adipose tissue on the triceps and subscapular areas than partially sighted children (Fig. 1).

It is believed that blind children have an in-born need of having a more robust body build; furthermore, they even idealize such body structure. In their studies on body self-evaluation, WALSH and WARDLE [1996] showed that 3/4 of the subjects believed that sturdy or even obese persons, did much better in team games and sport.

In work by ROEBOTHAN [1999] and MONTERO [2005], greater accumulation of adipose tissue in persons with visual impairment, leading to overweight or even obesity, was described. The afore-

mentioned studies concentrated on the nutritional habits observed in blind patients and on their body structure. While studying the diet of adults, ROEBOTHAN [1999] noted a lower daily calorie consumption (73.5% of the recommended value) on average, but the percentage of subjects with overweightness or obesity, measured by means of BMI values, was significant and amounted to 12% and 52%, respectively. The obtained results were interpreted by the author as an effect of lower physical activity of these subjects and the more sedentary lifestyle of blind people. Similar results were obtained by MONTERO [2005] while studying children and adolescents with visual impairment. Fat consumption dominated in the subjects' diet and only 12% of children ate healthily, according to norms appropriate for their age. The percentage of overweight or obese children was higher than among the sample of healthy children without sight deficiency, and amounted to 25.8% and 11.8%, respectively. In this study, 3/4 of the children examined ate their meals in the canteens of the Centers, yet accurate information on the daily calorie consumption by these subjects is not available. It should also be mentioned that the subjects, independently of the level of visual impairment, regularly attend gymnastics or posture defects' corrective classes regularly, 2-3 times a week, as well as swimming classes.

Limitation of physical activity in blind children probably plays a vital role but is not the sole reason for their higher adiposity. The obtained results revealed significantly higher standardized values of the BMI and measurements of adipose tissue in children after cranial surgery

(Fig. 2). Excessive increments in body mass leading to obesity are observed in people after surgery, in particular in those with structural hypothalamic damage (PINKNEY *et al.* [2002]). A broader interpretation of the possible reasons for the greater adiposity in persons with visual impairment can be found in the paper by UMLAWSKA [2006].

Apart from higher accumulation of adipose tissue, the subjects revealed high statural deficiency. It has been assumed that over 70% of patients treated for cancer of the central nervous system (CNS) suffer consequently from a variety of endocrinopathies, the most frequent being GH deficiency [SPOUDEAS 2002, COHEN 2003]. GH deficiency is usually caused by loss of growth hormone-releasing hormone neurons located in the arcuate nucleus of the hypothalamus or by impairment of GH by the pituitary gland [MERCHANT *et al.* 2002]. The group of shorter children and with higher adiposity involved not only subjects treated for cancer, but also those who experienced cranial trauma in early childhood. As shown by clinical research, early childhood cranial trauma underlies numerous neurological disturbances, particularly in the hypothalamo-pituitary axis [RYMKIEWICZ-KLUCZYŃSKA 1995]. Examinations carried out on people who suffered from severe head injuries in childhood showed that 60% of them had hormonal disturbances, mostly somatotropin (GH) hypoactivity of the pituitary gland [RUSZCZYŃSKA-WOLSKA *et al.* 1990]. Moreover, in these adult subjects the pituitary gland was abnormally small or sometimes had involution of its frontal section only, as seen from autopsy conducted at various times after the trauma.

Interestingly, not every child with GH deficiency has a slower growth rate or shorter stature. TIULPAKOV *et al.* [1999] observed this phenomenon in children treated for craniopharyngioma, some of whom attained height for age, despite lack of GH. However, this has been proven mostly for obese children. In such cases it is supposed that excessive secretion of insulin stimulates secretion of IGF-I, thus allowing the child to develop correctly. In our material, the children who had undergone cranial surgery manifested significant statural deficiency, despite their higher adiposity.

The examined group of children and youth with sight deficiency differed from the reference group in respect of their social status. It is quite difficult to estimate whether, and potentially to what extent, the relatively lower social status of the subjects as compared with the control group contributed to their lower level of physical development. While the smaller body height can be attributed, to some degree, to lower SES, the reason for greater adiposity of the subjects is not clear. In countries with a high level of economic development, a reverse correlation between level of adiposity and socio-economic situation can be observed – higher frequency of overweight and obese individuals can be found in the “lowest” social classes [SOBAL and STUNKARD 1989, DE SPIEGELAERE *et al.* 1998]. Similar dependencies could be observed among adults in Poland [WELON *et al.* 2001], but among children and youths fundamental differences were found compared to western countries. In studies by LIPOWICZ [1999], and KOZIEL and KOŁODZIEJ [1999], greater adipo-

sity measured by the thickness of skin-folds and BMI index values were observed in children from the upper social classes (high level of parent education and small number of children in the family). Similar results were obtained by KOZIEL *et al.* [2004] in studies of Polish conscripts. In the study by KOZIEL *et al.* [2000] concerning the assessment of the degree of obesity of the children examined between 1987 and 1997, the highest increase was observed in the percentage of obese children from families with the lowest level of parent education. These authors are of the opinion that currently in Poland there is a slow change of dependency between the social status and obesity, making Poland similar to western countries in this respect. In light of the above data, it is difficult to decide whether the greater adiposity of the children with visual impairment is an effect of their socio-economic status. It seems more likely that visual impairments and their consequences are responsible for this.

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## Streszczenie

Celem pracy była ocena poziomu rozwoju fizycznego dzieci i młodzieży ze schorzeniami narządu wzroku w zależności od płci oraz stopnia upośledzenia widzenia. Badania dotyczyły 288 osób (126 dziewcząt i 162 chłopców) w wieku od 6-19 lat będących uczniami Ośrodków Szkolno-Wychowawczych Dzieci Niewidomych we Wrocławiu i w Krakowie. Pośród badanych 35% stanowiły osoby niewidome, a 35% osoby niedowidzące. Wykonano pomiary wysokości i masy ciała, grubości fałdów skórno-tłuszczowych na ramieniu i pod łopatką oraz obliczono wskaźnik masy ciała BMI. Dane pomiarowe poddano zabiegowi standaryzacji metodą LMS względem grupy kontrolnej.

Badani z deficytem wzroku byli istotnie statystycznie niżsi, lżejsi niż ich widzący rówieśnicy oraz charakteryzowali się większym otluszczeniem na tułowi. Stopień upośledzenia widzenia różnicował poziom otluszczenia ciała – dzieci niewidome cechowały się znacznie większymi ( $p < 0,001$ ) wartościami pomiarów fałdów skórno-tłuszczowych. Największy poziom otluszczenia ciała i jednocześnie największy niedobór wysokości ciała dotyczył badanych z deficytem widzenia, u których przeprowadzono w dzieciństwie zabiegi chirurgiczne w obrębie czaszki spowodowane leczeniem nowotworów ośrodkowego układu nerwowego, wodogłowia oraz urazów głowy. Poziom rozwoju fizycznego dzieci z wadami wzroku powinien być rozpatrywany nie tylko w zależności od stopnia upośledzenia wzroku, ale również w zależności od zastosowanych terapii leczniczych.