Body dimensions and proportions in the differential diagnosis of child growth retardation[*]

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Abstract

This study was aimed at determining the similarities and differences with regard to body build traits between two groups of short-statured children: the first one including children with growth retardation related to the growth hormone deficiency and the second one comprising of children with normal secretion of the growth hormone. Subsequently the traits useful in the differential diagnostics of growth retardation were selected.

Anthropometric measurements were taken from 273 short-statured non-treated children aged from 3 to 17 years (73 girls and 200 boys). The children were divided into 6 clinical groups on the basis of the clinical picture and the results of stimulation tests assessing the pituitary reserve for growth hormone secretion. The clinical groups were differentiated using a specifically developed anthropometric test based on 9 calendar age traits (height, weight, BMI, length of upper and lower limbs, trunk length, shoulders breadth, hips breadth and chest breadth) and 4 developmental age traits (length and circumference of the head, chest circumference, thigh circumference) and the calculated value of arm fat content and the average stature of the parents.

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Introduction

Short stature may be caused by the growth hormone deficiency (*Idiopathic Growth Hormone Deficiency* (IGHD)) or other growth disorders [ROMER et al. 1990, ROMER 1993, RYMKIEWICZ-KLU-CZYŃSKA 1990a, 1990b]. The degree of growth retardation of the child under study in comparison with healthy children of the same age is one of the criteria for the analysis of the clinical picture of the disease. So far, the anthropological studies covering only a small number of features have shown significant differences in the body structure between the children affected with IGHD and the children whose growth retardation is related to other causes [BEVIS et al. 1997, BUUL-OFFERS AND BRANDE 1981, BURT AND KULIN 1977, KONFINO, PERTZELAN AND LARON 1975, LYSOŃ-WOJCIECHOWSKA et al. 1984, MARKUS et al. 1942, SCHARF AND LARON 1972, SORGO et al. 1982, SPIEGEL et al. 1971, TANNER et al. 1971, TROYER et al. 1980, ZACHMANN et al. 1980]. The attempts to use anthropometric measurements in the screening tests involving short-statured

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children in order to separate the children affected with IGHD were taken by SATINDER et al. 1981. His anthropometric test was based on selected clinical material and a restricted number of features. However, the test failed to differentiate the children with growth hormone deficiency (IGHD) from other ill children with a normal level of growth hormone when applied to a group of short-statured children formed without pre-selection. This study was aimed towards determining the similarities and differences with regard to body structure traits between two groups of short-statured children: the first one including children with growth retardation related to the growth hormone deficiency and the second one including children with normal secretion of the growth hormone. Subsequently the traits useful in the differential diagnostics of growth retardation were selected.

Material

One-time anthropological tests were conducted on 273 children affected with growth retardation (73 girls and 200 boys aged 3 to 17 years) examined in the Children's Memorial Institute. The short-statured children were divided into clinical groups on the basis of the results of stimulation tests assessing the pituitary reserve for growth hormone (GH) secretion. Additionally the thyroid hormones viz. T4, T3 and THS were determined as well as the level of somatomedin (Sm).

Division into clinical groups

Group I (n=49 children) – *Idiopathic Growth Hormone Deficiency* (IGHD).

Children whose maximum secretion level of GH was below 5 mg/ l in two stimulation tests.

Group II (n=15 children) – *Multihormonal Pituitary Deficiency* (MPD).

Children whose maximum secretion level of GH was below 5 mg/ l in two stimulation tests (similarly to IGHD) accompanied by below normal level of thyroid hormones. In both groups viz. IGHD and MPD a considerable deficiency of the growth hormone was noted together with considerable, yet smaller delay in skeletal age in relation to the stature age (the age at which the 50th centile of the standard body height corresponds to the actual growth of the examined child.

Group III (n=45 children) – *Partial Growth Hormone Deficiency* (PGHD).

Children whose maximum secretion level of GH ranged between 5 mg/ l and 10 mg/ l in two stimulation tests. In this group growth retardation and skeletal age delay are manifested to a lesser extent than in the case of IGHD.

Group IV (n=62 children) – *Familial Growth Retardation* (FGR).

This group consisted of patients who a) had correct birth weight b) whose skeletal age constituted at least 80% of the calendar age, c) whose peak GH concentration during stimulation tests exceeded 10 ng/ml. Children aged from 2 to 9 years were classed into FGR group, if their body height was above the 25th centile on the TANNER'S [1970] grid taking account of the parents stature, and below the 3rd centile on the centile grid [KURNIEWICZ-WITCZAKOWA et al. 1983]. Children older than 9 years of age were classed into FGR group, if their body height expressed in standard deviations (*SD*) on average fell within the limits of a single deviation (± 1*SD*) from the average stature of the parents.

Group V (n=68 children) – *Constitu-*

tional Growth Retardation (CGR).

Also designated as constitutional delay of growth and pubescence. Covered the group of children of the parents (most often fathers) who had been short-statured for a long time due to late pubescence. Among such children a 2 to 4 years delay of developmental age was observed with the pubescence corresponding to the skeletal age. Normal birth weight and length. The growth curve was below or equalling the 3rd centile. The growth rate at the lower standard limit for the given age, correct secretion of GH, late pubertal spurt, the ultimate body height close to the lower limit of the standard.

Group VI (n=34) – *Intrauterine Growth Retardation* (IUGR)

Includes children with a variety of growth disorders, both in the generic program and as a result of intrauterine foetus injury with normal secretion of GH. The criterion was met by children with the birth length and weight deficiency (below 2500 g) born following the full-length pregnancy and children with birth length and weight deficiency below the 10th centile born pre-term (starting from the 30th week of pregnancy).

Method

The studies covered 16 traits, including 12 somatic measurements, one weight-height index (BMI) and 3 head features (length, breadth and circumference), used in the BODY program [ŁYSOŃ-WOJCIECHOWSKA et al. 1992] (Fig 1–6), and additionally the proportion between Mid Arm Fat Area (MAFA%) and Mid Arm Muscle Area (MAMA%) [SATINDER et al. 1981] used in the FAT program [ŁYSOŃ-WOJCIE-

CHOWSKA et al. 1992]. These traits being routine anthropometric measurements used in clinical diagnosis after standardisation according to the Warsaw standards [KURNIEWICZ-WITCZAKOWA et al. 1983] were used for statistical processing of the clinical material employing the method of variance analysis.

Results and discussion

Statistically significant differences between growth retarded children in six clinical groups and healthy children of the same calendar age concerned the somatic traits dimensions, head traits and weight-height index (BMI). A comparison with children of the same stature (the same stature age) showed differences in only certain dimensions. Children affected with growth hormone deficiency (IGHD and MPD) show growth retardation: -3.6 *SD* and -4.4 *SD* respectively. The degree of growth retardation is smaller in the case of Children with Familial, Constitutional and Intrauterine growth retardation as well as children affected with PGHD with the average value falling between -2.4 *SD* and -2.6 *SD*. Children with PGHD show stronger similarity of body structure to short-statured children with a normal level of growth hormone. The comparison of clinical groups with healthy children from the Polish population (according to the Warsaw norm [KURNIEWICZ-WIT-CZAKOWA et al. 1983]) with regard to anthropological features for a given stature age, expressed in *SD* units, is presented in diagrams (Fig. 1–6).

Body weight, weight/ height index (BMI), body composition and circumference values

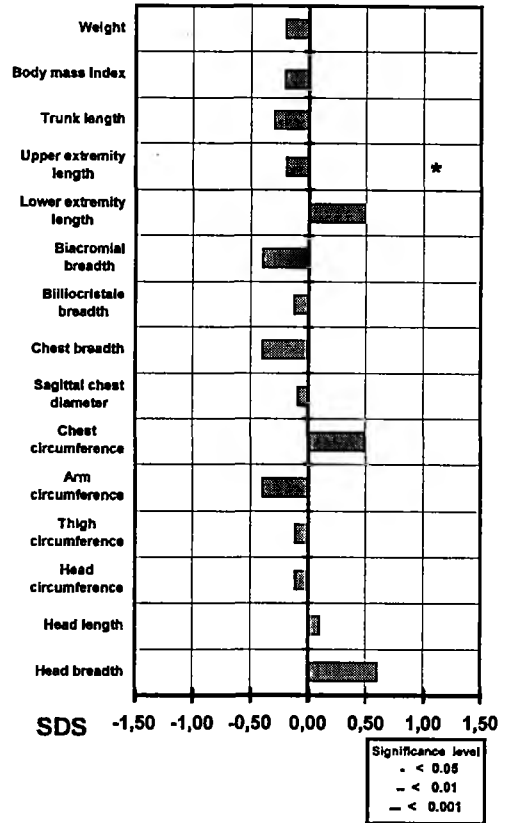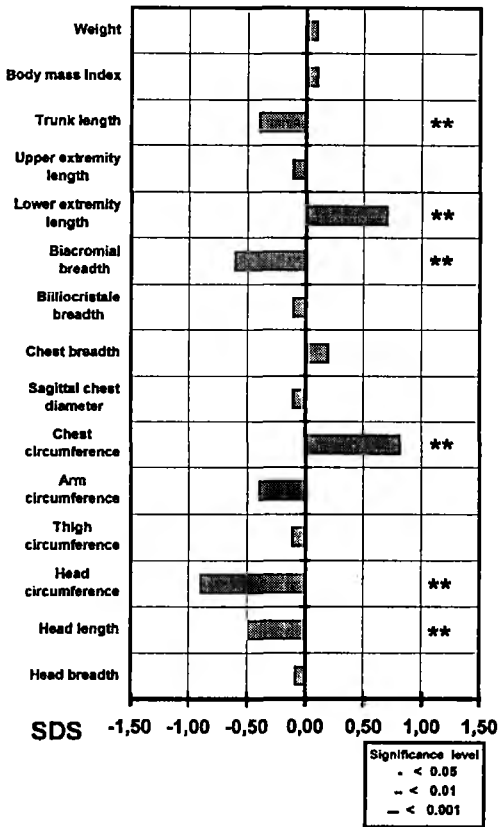In comparison to the healthy children

Fig. 1. Diagram of the standard deviation (*SD*) of anthropometric measurements of children with idiopathic growth hormone deficiency (IGHD) in relation to normal values for children of the same stature

Fig. 2. Diagram of the standard deviation (*SD*) of anthropometric measurements of children with multihormonal pituitary deficiency (MHPD) in relation to normal values for children of the same stature

of the same height, the children with the IGHD and MPD have normal weight and BMI value as well as arm and thigh circumferences. When compared with children from other clinical groups the children show statistically significant differences of Mid Arm Fat Area, which exceeds the normal value (100%) and equals 105.7% and 101.9% respectively. The Mid Arm Muscle Area value is correct.

Children with Familial, Constitutional and Intrauterine Growth Retardation as well as with PGHD show significantly

lower body weight, BMI values and arm and thigh circumferences in comparison with healthy children of the same stature. These four clinical groups have also smaller values of Mid Arm Fat Area ranging between 58.3% do 74.3%, with normal Mid Arm Muscle Area value.

Body length

Abnormal proportions of longitudinal dimensions resulting from significantly increased lower extremity length coinciding with normal or below normal length
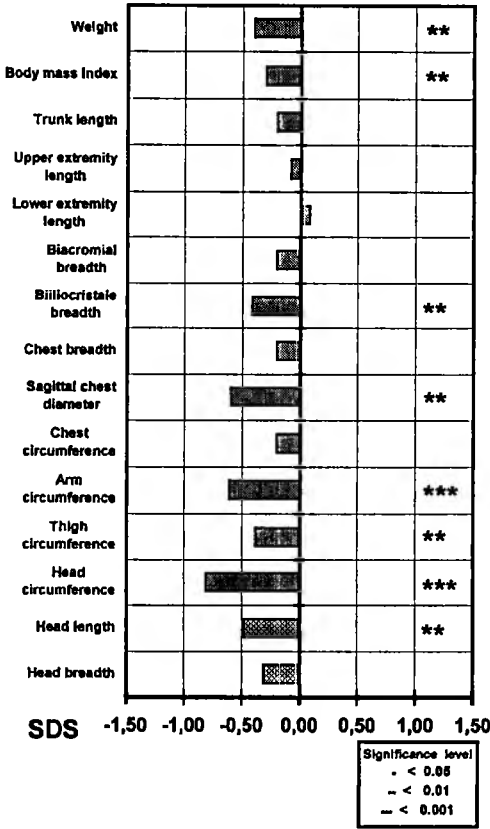
Measurement	SDS	Significance
Weight		**
Body mass index		**
Trunk length		
Upper extremity length		
Lower extremity length		
Biacromial breadth		
Biiliocristale breadth		**
Chest breadth		
Sagittal chest diameter		**
Chest circumference		
Arm circumference		***
Thigh circumference		**
Head circumference		***
Head length		**
Head breadth		

SDS -1,50 -1,00 -0,50 0,00 0,50 1,00 1,50

Significance level
• < 0.05
•• < 0.01
••• < 0.001

Fig. 3. Diagram of the standard deviation (*SD*) of anthropometric measurements of children with partial growth hormone deficiency (PGHD) in relation to normal values for children of the same stature

Measurement	SDS	Significance
Weight		**
Body mass index		***
Trunk length		*
Upper extremity length		
Lower extremity length		***
Biacromial breadth		
Biiliocristale breadth		***
Chest breadth		*
Sagittal chest diameter		***
Chest circumference		**
Arm circumference		***
Thigh circumference		***
Head circumference		***
Head length		***
Head breadth		

SDS -1,50 -1,00 -0,50 0,00 0,50 1,00 1,50

Significance level
• < 0.05
•• < 0.01
••• < 0.001

Fig. 4. Diagram of the standard deviation (*SD*) of anthropometric measurements of children with familial growth retardation (FGR) in relation to normal values for children of the same stature

of the trunk were noted in three groups of children: those with IGHD, those with MPD and those with FGR. A correct length of lower extremities coinciding with shorter trunk was observed among children with IUGR. Children with PGHD and children with CGR have normal proportions of longitudinal body dimensions. Shorter upper limbs are characteristic of children with CGR and IUGR while short-statured children belonging to the other groups have normal dimensions of upper limbs.
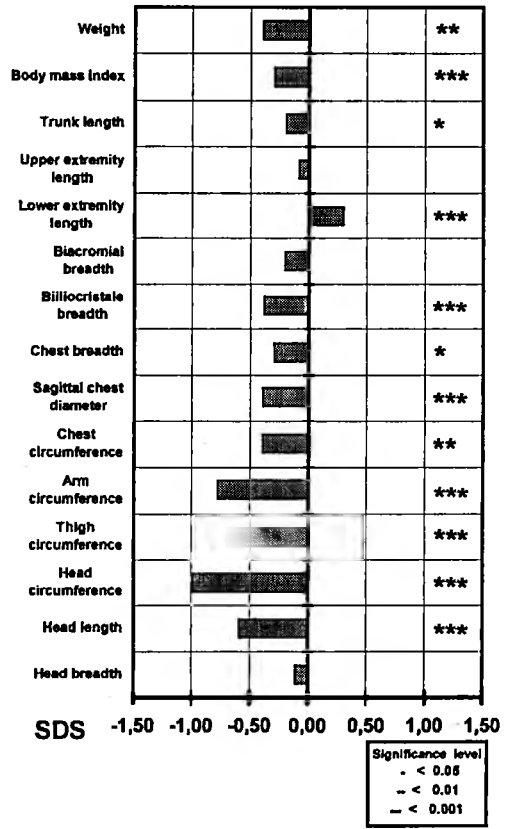
Body breadth

Children with IGHD and children with Intrauterine and Constitutional Growth Retardation have narrower shoulder span. Children with IGHD and IGR have normal hip breadth while groups with Intrauterine, Constitutional and Familial Growth Retardation as well as children with PGHD have narrower hips than the healthy children of the same developmental age. The children with IGR, FGR and CGR have also lower values of the chest breadth, depth and circumference.
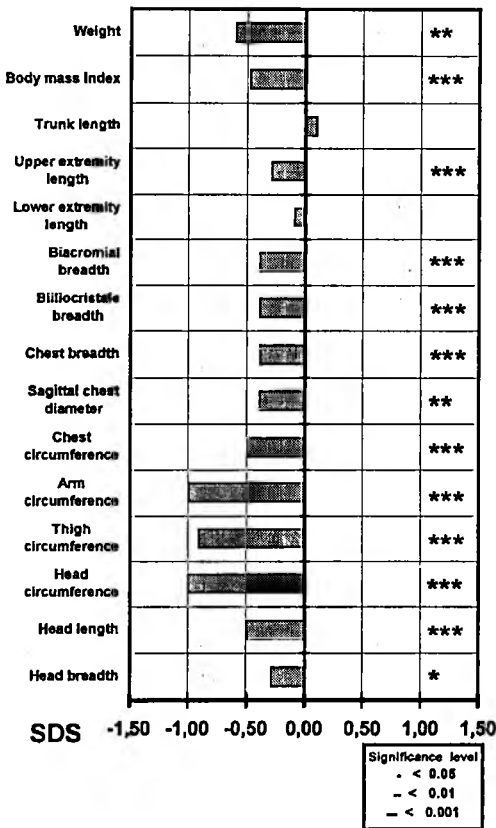
Fig. 5. Diagram of the standard deviation (*SD*) of anthropometric measurements of children with constitutional delay of growth and development (CDGD) in relation to normal values for children of the same stature
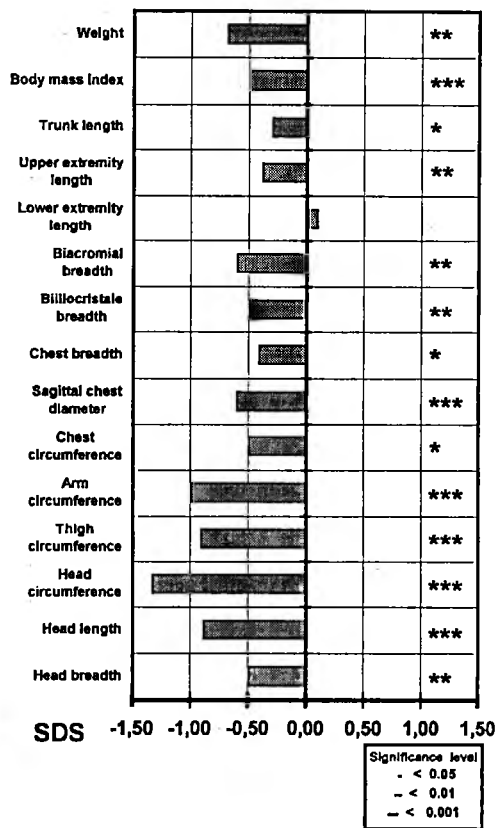
Fig. 6. Diagram of the standard deviation (*SD*) of anthropometric measurements of children with intrauterine growth retardation (IUGR) in relation to normal values for children of the same stature

Similarly lower were the values of chest depth among children with PGHD. On the other hand children with IGHD have higher value of the chest circumference in comparison to healthy children of the same body height. Children with MPD have normal values of the chest breadth, depth and circumference.

Head dimensions

A statistically significant reduction in the head circumference in relation to the stature was observed among children with Idiopathic and Partial Growth Hormone Deficiency as well as in children with Intrauterine, Constitutional and Intrauterine Growth Hormone Deficiency mainly as a result of the head length reduction. Children with MPD have normal length, breadth and circumference of the head. A preliminary anthropological analysis showed similar level of differences in body structure, proportions and composition between children with GH deficiency belonging to the groups of IGHD and MPD in comparison with

healthy children of the same stature. Moreover, differences were found between the former two groups and the group of children with PGHD. Despite a partial deficiency of growth hormone with respect to body dimensions and composition the children belonging to the just mentioned clinical group show stronger affinity with children from clinical groups with a normal level of growth hormone and show similar degree of differences with healthy children of the same height.

Statistical processing of the material

Differential diagnostics of growth retardation in children classed into 6 clinical groups was carried out using the variance analysis method [OKTABA 1971]. At subsequent stages of the study the strongest similarities and differences for the standardised somatic traits (and the head characteristics) of short-statured children were determined. The results obtained were used for developing an anthropometric test. The greatest differences and the highest number of characteristics differentiating the children belonging to the clinical groups subject to examination were observed in the case of the following traits: body height and weight, BMI, upper limbs length, lower limbs length, the trunk length, shoulders breadth, hips breadth, the chest breadth, standardised skeletal age in relation to the calendar age and the difference of standardised height of a child in relation to standardised height of parents (mother's and father's height values were related to the Warsaw standards for 18 years of age [KURNIEWICZ-WITCZAKOWA et al. 1983]). These traits were included in the anthropometric test. For the developmental age the most substantial differences among

the clinical groups concerned a smaller number of traits (the head length, head circumference, chest circumference, thigh circumference and Mid Arm Fat Area proportion); also these traits were included in the anthropometric test. Similarly to the developmental age also in the case of skeletal age the number of differentiating traits was small. Therefore, the traits standardised for the calendar age were taken as a differentiating criterion for short-statured children in six clinical groups.

It is problem of clinical nature how to identify short-statured children who should undergo hormonal tests. The classification into clinical groups on the basis of the anthropometric test was compared with the classification according to the clinical diagnosis. In the case of children with Idiopathic Growth Hormone Deficiency and Multihormonal Pituitary Deficiency the conformity between clinical classification and classification with anthropometric test reached 64.0%, when all the clinical groups were taken into account. The conformity index would increase to 65.6% if children with Partial Growth Hormone Deficiency showing strong similarity with regard to the studied features to clinical groups of children with normal level of the growth hormone were excluded from the test. With the anthropometric test some of these children were classified to groups of a normal secretion of the growth hormone. A large spread of the traits entailed moving of some children from the Idiopathic Growth Hormone Deficiency to the group of Multihormonal Pituitary Deficiency (classification skewness). The anthropometric test was used in developing a computer program for the differential diagnosis of growth retardation (Tab. 1).

Table 1. Differential diagnosis of growth retardation

```
            DIFFERENTIAL   DIAGNOSIS
    of G R O W T H   R E T A R D A T I O N

        Department of Endocrinology
        Laboratory of Clinical Anthropology

        Merits:                Grace Lyson
        Statistical analysis: W.Skawinski
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```
Patient's record No:   18971/93
Patients' Name:        XXXX
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      Antropometric test for diagnosis of growth retardation
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PATIENT'S DATA                        100 | Record No: 18971/93
                                          | Patient:   XXXX
calendar age              10.48        90 | Diagnosis:   MHPD
bone age                   5.50           | Probability=  42.9%
height          [SDS]     -3.11        80 |
body mass       [SDS]     -2.75           |
BMI             [SDS]     -1.23        70 |
upper extr.length [SDS]   -2.67           |
trunk length    [SDS]     -3.90        60 |
lower extr.length [SDS]   -2.84           |
biacromial bredth [SDS]   -2.94        50 |
chest breadth   [SDS]     -1.64           |
biiliocrist.breadth[SDS]  -2.19        40 |
head length*    [SDS]     -1.45           |
head circumfer.* [SDS]    -2.12        30 |
chest circumfer.* [SDS]   -0.38           |
thight circumfer.*[SDS]   -2.10        20 |
arm circumfer.  [mm]     160.00           |
triceps skinfold [mm]      6.00        10 |
mother height   [mm]    1529.00           |
father height   [mm]    1721.00         0 |
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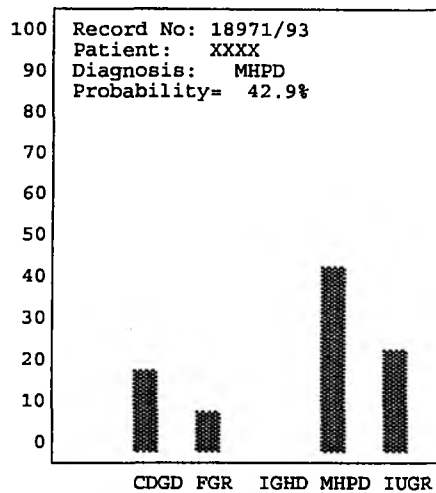
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* - according to the growth age            CDGD FGR  IGHD MHPD IUGR
NOTATION
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CDGD  - constitutional delay of growth and development
FGR   - familial growth retardation
IGHD  - idiopathic growth hormone deficiency
MHPD  - multihormonal pituitary defficiency
IUGR  - intrauterine growth retardation
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Conclusions

On the basis of 9 features of calendar age (height, body weight, BMI, upper limbs length, lower limbs length, trunk length, shoulders breadth, hips breadth, chest breadth) and 4 traits of the developmental age (the head length and circumference, chest circumference, thigh circumference) as well as based on the calculated value of Mid Arm Fat Weight and the parents' mean stature an anthropometric test was developed with the purpose of differentiating short-statured children. The test differentiates two clinical groups of children with growth hor-

mone deficiency: the first one including children with Idiopathic Growth Hormone Deficiency and the second one including children with Multihormonal Pituitary Deficiency from the groups of short-statured children with normal secretion of the growth hormone. The test fails to distinguish the children with Partial Growth Hormone Deficiency from the children with a normal level of the growth hormone. The correctness of diagnosis in the case of children with growth hormone deficiency (Idiopathic Growth Hormone Deficiency and Multihormonal Pituitary Deficiency) with the application of the anthropometric test reaches 65.6%.

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Streszczenie

Celem pracy było ustalenie podobieństw i różnic w cechach budowy ciała u dzieci niskorosłych w dwóch grupach: w wyniku niedoboru hormonu wzrostu i u dzieci z prawidłowym wydzielaniem hormonu wzrostu oraz wybór cech przydatnych w diagnostyce różnicowania niedoboru wzrostu. Pomiary antropologiczne obejmujące 12 cech budowy ciała, 3 cechy głowy, BMI oraz pomiary masy tłuszczowej i beztłuszczowej ramienia wykonano u 273 dzieci nieleczonych z niedoborem wzrostu, w wieku od 3 do 17 lat (73 dziewczynki i 200 chłopców), badanych w Instytucie „Pomnik-Centrum Zdrowia Dziecka". Dzieci niskorosłe zostały podzielone na 6 grup klinicznych w oparciu o obraz kliniczny i testy stymulacyjne oceniające rezerwę przysadkową w zakresie wydzielania hormonu wzrostu. Opracowano test antropometryczny różnicujący wspomniane grupy kliniczne w oparciu o 9 cech dla wieku kalendarzowego (wysokość, masę ciała, BMI, długość kończyn górnych i kończyn dolnych, długość tułowia, szerokość barków, szerokość bioder, szerokość klatki piersiowej) i 4 cechy dla wieku wzrostowego (długość i obwód głowy, obwód klatki piersiowej, obwód uda) oraz obliczoną masę tłuszczową ramienia i średnią wysokość ciała rodziców. Prawdopodobieństwo poprawnego oszacowania rozpoznania testem antropometrycznym dzieci z niedoborem hormonu wzrostu (SNP i WNP) wynosi 65,6%.