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Usefulness of selected nutritional status indicators for body composition assessment in children with diagnosed autoimmune diseases and in healthy peers**

Użyteczność wybranych wskaźników stanu odżywienia do oceny składu ciała dzieci z rozpoznaną chorobą autoimmunizacyjną oraz dzieci zdrowych

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Słowa kluczowe

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S u m m a r y

Introduction. Nutritional status is an important predictor of treatment outcomes in children with chronic diseases and an instrument used in treatment monitoring. A choice of the adequate nutritional status indicator correlated with fat mass and fat free mass components enables effective diagnosis of a specific disorder and, consequently, makes it possible to start necessary interventions at the right time.

Aim. The aim of this study was to assess usefulness of selected nutritional status indicators in relation to body composition in children with newly diagnosed autoimmune diseases and in healthy peers.

Material and methods. Quantitative analysis designed to compare BMI, Cole Index and Książyk WMC in relation to fat mass (FM), and fat free mass (FFM) in 108 children newly diagnosed with autoimmune disease (type 1 diabetes – 63, coeliac disease – 15, ulcerative colitis – 16, Crohn's disease – 14), and in 108 healthy controls matched for age and sex.

Results. The most significant, positive correlations were found for BMI and fat mass (r = 0.878 sick children vs. r = 0.789 healthy children) and for WMC and fat free mass (r = 0.873 sick children vs. r = 0.894 healthy children) in both groups.

Conclusions. This research has shown that we should always take into account the condition of the specific components of body composition in children. The linear correlation of fat mass and fat free mass to BMI, WMC and COLE indexes identified separately for children with clinical conditions and for healthy peers, makes it possible to use optimal index.

S t r e s z c z e n i e

Wstęp. Stan odżywienia odgrywa znaczącą rolę w rokowaniu leczniczym u dzieci przewlekle chorych i stanowi instrument monitorowania leczenia. Dobór właściwego wskaźnika stanu odżywienia skorelowanego o komponent masy tłuszczowej i beztłuszczowej pozwala efektywnie zdiagnozować dane zaburzenie a następnie wprowadzić niezbędną interwencję we właściwym czasie.

Cel pracy. Ocena użyteczności wybranych wskaźników stanu odżywienia w odniesieniu do składu ciała dzieci w momencie rozpoznania choroby autoimmunizacyjnej oraz dzieci zdrowych.

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Materiał i metody. Ilościowa analiza porównawcza wskaźnika BMI, Cole'a oraz WMC Książyka w odniesieniu do masy tłuszczowej (FM) beztłuszczowej (FFM) u 108 dzieci z nowo rozpoznaną chorobą autoimmunizacyjną (type 1 diabetes 63, coeliac disease 15, ulcerative colitis 16, Crohn's disease 14), oraz 108 dzieci zdrowych dobranych pod względem płci i wieku (age and sex matched controls).

Wyniki. Wykazano najwyższą dodatnią korelację pomiędzy BMI a masą tłuszczową (r = 0.878 dzieci chore vs. r = 0,789 dzieci zdrowe) oraz WMC a masą beztłuszczową (r = 0.873 dzieci chore vs. r = 0,894 dzieci zdrowe) w obu badanych grupach.

Wnioski. Przedstawione wyniki badań wykazały, że zawsze należy mieć na uwadze stan poszczególnych komponentów składu ciała dziecka. Korelacja liniowa masy tłuszczowej i beztłuszczowej do wskaźników BMI, WMC oraz Cole'a, odrębnie dla dzieci chorych i dzieci zdrowych, daje możliwość zastosowania optymalnego wskaźnika.

INTRODUCTION

Nutritional status is an important predictor of treatment outcomes in children with chronic diseases and an instrument used in treatment monitoring (1). Body composition, represented by components of fat and fat-free mass, is significantly linked with survival rate, quality of life and duration of comorbidities (2).

In current clinical practice identification of impaired nutritional status relies closely on anthropometric measurements carried out in children. The recommended screening methods of assessing nutritional status in children include the simplest, non-invasive and the least costly anthropometric measurements (3, 4). The identified values should be compared to age and sex related norms in accordance with centile grids verified for a given population. Some difficulties result from the variety of recommended reference norms for the measurement values. Given this, to interpret such results we must explicitly define cut-off values, below/above which a given disorder is diagnosed (4, 5).

The most popular indicator assessing nutritional status in children is the body mass index (BMI) representing the quotient of body weight and height (BMI = body weight [kg]/body height [m^2]) (6) and waist-hip ratio (WHR) (7). The calculated result is transferred onto centile grids representative for a given population, relative to the child's sex and age (5, 8). At present it is believed that BMI highly correlates with in-depth nutritional status measures, such as skinfold thickness, bioimpedance and DXA (9). Unfortunately, numerous studies have questioned usefulness of the BMI for children with medical conditions (2, 10-14).

Widely accepted methods of anthropometric assessment of nutritional status also include Cole index, which is a transformed BMI, calculated as a quotient of the child's actual BMI and 50^{th} centile of BMI, multiplied by 100% [(BMI act./BMI 50^{th} cent) x 100%]. The respective cut-off values are: > 120% (obesity), 110-119% (overweight), 90-109% (standard), 85-89% (slight malnutrition), 75-84% (modest malnutrition), < 75% (emaciation) (8).

One more, index examined here, is the body weight index (pol. *współczynnik masy ciała* – WMC) proposed by J. Książyk. WMC is a transformation of Body Mass Index (BMI) and the formula for body surface area proposed by DuBois (WMC = M1.425 x 71.84/L1.275, where M = body mass [kg], L = body length [cm]). The delineated WMC centile grids for boys and girls are a recommended tool in assessing nutritional status of children with medical conditions (15).

Methods of in-depth anthropometric assessment include, e.g. skinfold thickness measurement (3, 16) bioelectrical impedance analysis (BIA) (3, 16, 17) and dual-energy X-ray absorptiometry (DEXA) (3, 18). Other researchers worldwide have also suggested a number of indicators derived from components of body composition which can be useful in assessing nutritional status; these include: fat mass index (FMI) (19, 20), fat free mass index (FFMI) (19, 20), body cell mass index (BCMI) (2, 21) and phase angle (PA) (22, 23). In nutritional status assessments some importance can also be attributed to bioelectrical impedance vector analysis (BIVA) (22).

The present study was designed to examine selected indexes used in nutritional status assessment and to analyze their relationship to components of human body. This was an attempt to answer the following question: "Which of the indexes recommended for assessing nutritional status presents the highest correlation with changes in fat mass and fat free mass in sick and healthy children". The present findings may provide a valuable tool for identifying a highly accurate nutritional status indicator, and consequently enable more effective identification of the existing impairment.

AIM

The aim of the study was to assess usefulness of selected nutritional status indicators in relation to body composition in children with newly diagnosed autoimmune diseases and in healthy peers.

MATERIAL AND METHODS

Design and settings

The study was conducted from 2013 to 2015, at the Clinical Department of Paediatrics with Paediatric Neurology Unit, Regional Hospital No. 2 in Rzeszów, and Children's Outpatient Clinic, Regional Hospital No. 2 in Rzeszów as well as in randomly selected primary, middle and secondary schools in rural and urban areas of the Podkarpackie Region, Poland. The examinations were performed in three stages, which were preceded by a month-long pilot study. Comparative analyses focused on BMI, Cole index and Książyk WMC, which were examined in relation to fat mass (FM) and fat free mass (FFM) in 108 children with newly diagnosed autoimmune diseases (type 1 diabetes – 63, coeliac disease – 15, ulcerative colitis – 16, Crohn's disease – 14), and in 108 healthy controls matched for age and sex.

Sample

At the first stage the examinations involved a group of 256 children aged 4-18, diagnosed with medical conditions (type 1 diabetes – 138, coeliac disease – 55, ulcerative colitis – 34, Crohn's disease – 29), including 108 children with newly diagnosed conditions linked with abnormal immune response and 148 children subjected to assessment of nutritional status and body composition parameters at various stages of treatment. The control group consisted of 243 healthy children attending randomly selected primary, middle and secondary schools in rural and urban areas of the Podkarpackie region.

Those qualified for the second stage included 108 children with newly diagnosed autoimmune diseases (type 1 diabetes – 63, coeliac disease – 15, ulcerative colitis – 16, Crohn's disease – 14), and 108 healthy controls matched for age and sex. The study group consisted of 59 boys and 49 girls. Arithmetic mean age of the boys was 11.34 years ± 4.08 years, and girls 11.85 years ± 3.53 years.

Procedures

The subjects were measured for body mass and height (SECA 799 scale with telescopic height rod). The results provided data for calculating body mass index (BMI), body weight index (Książyk WMC) and Cole's Index.

Measurement of body composition was performed using BIA-101 impedance analyzer from AKERN, Italy. The measurement was performed with tetrapolar system in a contralateral arrangement (amplitude of the measuring current 800 uA, sinusoidal, 50 kHz). Disposable electrodes were placed on the dorsal surface of the right upper limb (above the cavity of the wrist joint), and the right lower limb (ankle joint).

Variables

The measurement results were transferred to specialized software (Bodygram1_31 from AKERN) in order to compute fat mass (FM) and fat free mass (FFM). The equations used by the software to assess the specific parameters are restricted property of the company, but to a significant degree they are based on computing algorithms developed by Sun et al. (24). Subsequently the selected nutritional status indicators (BMI, Cole Index and Książyk WMC) were examined for correlations with fat mass (FM) and fat free mass (FFM) in the sick children and the healthy controls.

Bias

The examination of the study group was split into two stages, and the healthy controls participating in the second stage were matched for sex and age, in order to reduce estimation error resulting from potential effects of the applied treatment in the nutritional status and body composition, and to obtain a uniform group of children. Each subject from the study group was matched with a control subject by means of stratified sampling without replacement. During the first phase both groups were divided according to sex and age, and then in course of sampling without replacement a person was drawn from the control group, and assigned to a subject from the study group, with the use of random number generator – random ordering of elements with the use of "random" feature.

Additionally, to ensure high reliability of the measurements, examinations of body composition were carried out strictly following the manufacturer's instructions for BIA analyzer (two cycles of measurements one after the other, measurement during morning hours – 7.00-12.00, in supine position, with abduction of upper (30°) and lower limbs (45°), after night fasting, after 5-minute rest).

Study size

During the two-year study data were obtained from the total of 256 children, aged 4-18, with medical conditions (type 1 diabetes – 138, coeliac disease – 55, ulcerative colitis – 34, Crohn's disease – 29), yet in order to ensure reliable findings, quantitative comparative analyses took into account results from 108 children with newly diagnosed autoimmune diseases (type 1 diabetes – 63, coeliac disease – 15, ulcerative colitis – 16, Crohn's disease – 14). Additionally, with the adopted 95% confidence level, the maximum estimation error in conclusions related to the entire population was of marginal value.

Statistical analysis

Statistical analyses were carried out, at the first stage for 256 sick children and at the second stage for 108 sick children and 108 healthy controls matched for age and sex. Sample matching was based on the assumption that each subject from the study group was matched with a control subject by means of stratified sampling without replacement. During the first phase both groups were divided according to sex and age, and then in course of sampling without replacement a person was drawn from the control group, and assigned to a subject from the study group, with the use of random number generator – random ordering of elements with the use of "random" feature. Statistical analyses took into account only those children whose measurements met the criteria of reliability and completeness, described above in the section related to methodology.

Parametric and non-parametric tests of significance were used for statistical analysis of the data. Kolmogorov-Smirnov test was applied to verify normal distributions of quantitative variables. Subsequently equality of variances was examined with Levene's test, and equipotency of variables distributions was verified with χ^2 test. Meeting the conditions for application of parametric tests allowed to use t-test for independent samples, one-way analysis of variance (ANOVA) and Pearson's correlation (25). The calculations were computed with IBM SPSS Statistics 20 software.

Ethical considerations

The study was approved by the Bioethical Commission of the Faculty of Medicine, University of Rzeszów (No.5/02/2012). The study was conducted in accordance with the Declaration of Helsinki.

RESULTS

The present study shows the most highly significant relationship between FM value and BMI in both groups. The value of Spearman's correlation coefficient was positive (r = 0.832) showing that higher BMI corresponded with higher FM among the subjects. In the group of sick children the correlation value of r = 0.878 was higher than in the group of healthy children (r = 0.789). Both groups were found with a clearly linear correlation between FM and BMI. It was also observed that values of FM increased with BMI more rapidly in the group of children with medical conditions than in the healthy controls (fig. 1).

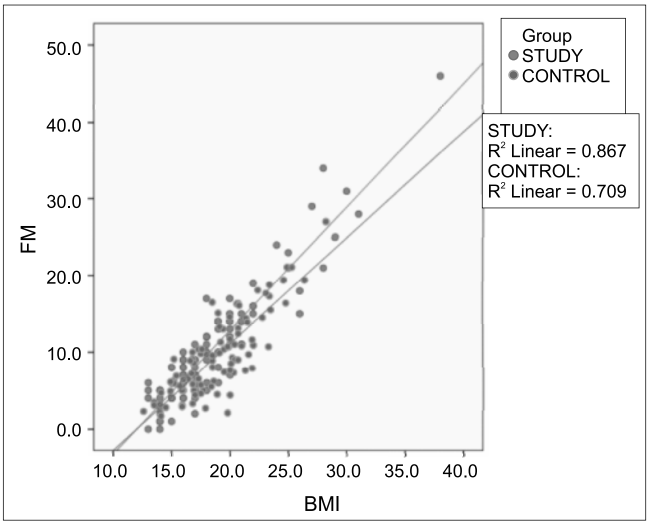

Fig. 1. Relationship between FM and BMI in the study group and in the controls
FM – fat mass; BMI – body mass index

Highly significant correlation was found for the values of FM and WMC in the examined children. Spearman's correlation coefficient was positive (r = 0.762) reflecting the fact that higher WMC corresponded with higher FM. The children with medical conditions were found with far greater correlation (r = 0.837) than the controls (r = 0.669). There was a linear relationship between FM and WMC in the study and in the control groups, while FM values increased with WMC more rapidly in the group of children with medical conditions than in the healthy controls (fig. 2).

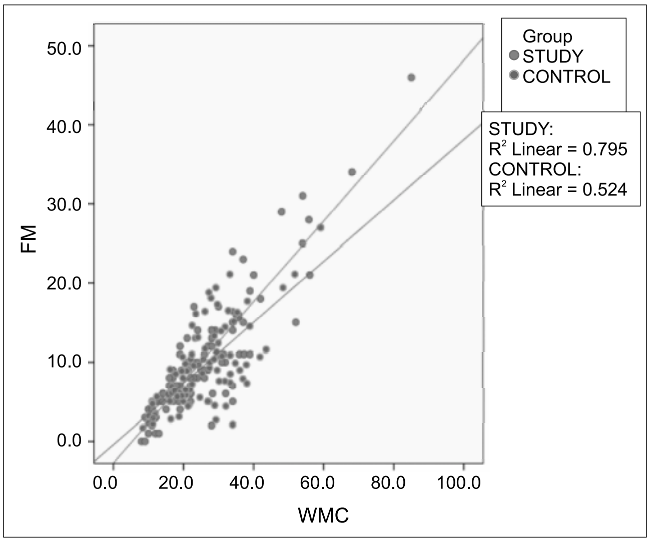

Fig. 2. Relationship between FM and WMC in the study group and in the controls
FM – fat mass; WMC – body weight index proposed by Książyk

Extremely significant correlation was observed between FM values and COLE index in the group of the examined children. Spearman's correlation coefficient was positive (r = 0.654), showing that higher COLE index values corresponded with higher FM. The value of this correlation in the study group (r = 0.673) did not differ significantly from the value in the control group (r = 0.626). In the sick children there was a linear relationship between FM and COLE index, and in the group of healthy children the linear relationship had lower strength. It was also observed that FM grew with the increasing COLE index more rapidly in the group of children with medical conditions than in the healthy controls.

Highly significant relationship was found between FFM and BMI values in the examined children. Spearman's correlation coefficient was positive (r = 0.685), so higher FFM values coincided with higher BMI values. In the group of children with medical conditions Spearman's correlation coefficient was higher (r = 0.724) than in the control group (r = 0.593). Analysis of FFM and BMI showed that FFM value increased in the group of healthy children more rapidly (fig. 3).

The present study showed highly significant relationship between FFM and WMC in the children. Pearson's correlation was positive (r = 0.876) which means that higher values of WMC corresponded with greater FFM. In the group of sick children the strength of correlation between FFM and WMC was similar (r = 0.873) to the correlation in the controls (r = 0.894). In both cases the correlation was linear. The study found the group of healthy children with more rapid increase in FFM values than the group of sick children (fig. 4).

Statistically significant relationship was identified between FFM and COLE index. Value of Spearman's correlation coefficient was positive (r = 0.182), and the level of significance was slightly higher than the adopted threshold value ($p < 0.05$). In the subjects with medical conditions the value of Spearman's correlation

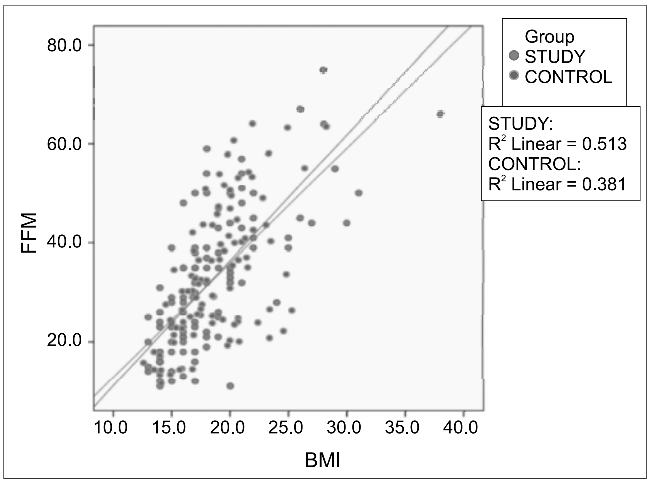

Fig. 3. Relationship between FFM and BMI in the study group and in the controls
FFM – fat free mass; BMI – body mass index

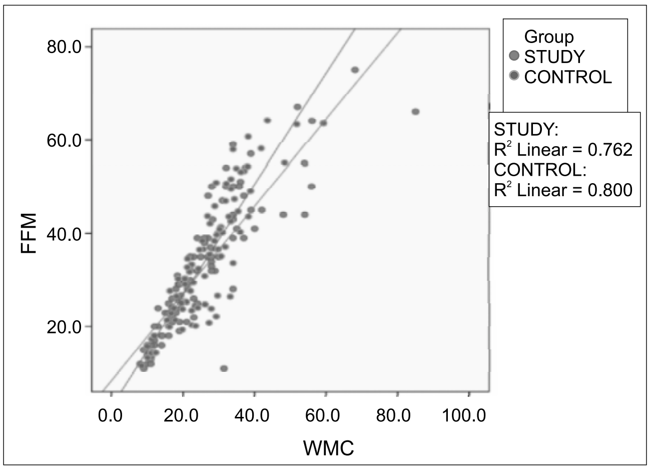

Fig. 4. Relationship between FFM and WMC in the study group and in the controls
FFM – fat free mass; WMC – body weight index proposed by Książyk

coefficient was positive (r = 0.229). In the control group Spearman's correlation coefficient (r = 0.068) was statistically insignificant ($p > 0.05$). Correlation of FFM and COLE showed that higher FFM values corresponded with higher COLE values. This relationship, however, was not strongly linear. In the control group the relationship between FFM and COLE was not linear.

DISCUSSION

Analysis of the present findings related to children with medical conditions showed the highest positive correlation between fat mass FM and BMI (r = 0.878). Slightly lower correlation was observed for FM and WMC (r = 0.837). In the relevant group the value of fat free mass FFM was found to correlate best with WMC index (r = 0.873). In the group of healthy children (control group) the most visible relationships were observed for FM vs BMI (r = 0.789) and FFM vs WMC (r = 0.894). There are some differences between the presented correlations observed in the study group and in the controls. This suggests that the values representing specific components of body composition grow more rapidly in children with newly diagnosed autoimmune diseases than in their healthy peers, hence their correlation to recommended nutritional status indicators is more pronounced. Analysis of the correlations also showed certain tendencies visible for fat mass and fat free mass parameters. Both in the sick children and in the healthy controls the parameter of fat mass correlated best with BMI. On the other hand Książyk WMC seems to be the best indicator for fat free mass.

Analysis of the present findings and those reported by other researchers with respect to changes in fat free mass in children with newly diagnosed autoimmune diseases (listed above), leads to a conclusion that WMC index is found with the highest level of correlations in nutritional status assessments in the relevant group. The authors of the present study made an attempt to analyse current research investigating the relationship of fat mass and fat free mass to nutritional status indicators, other than BMI, in the relevant group of children, yet a search of major medical databases (PubMed, Science Direct, Ebsco) did not produce desired results.

A study by Freedman et al. examining the relationship between BMI and body fatness in children demonstrated that BMI was an effective measure of excess adipose tissue represented by FM component. On the other hand the differences in the parameters of fat free mass and BMI in slim children are so significant that the usefulness of this index is highly limited in relation to FFM (26). Similar findings reported by Boeke et al. showed correlation of fat mass in 1,110 healthy children at the level of r = 0.83 (27). Moreover, Srdić et al. investigated correlation of BMI and fat mass in 2,284 Serbian children and found higher correlation in girls (r = 0.83 vs. 0.57) (28). The same conclusions were reached by Japanese researchers who estimated correlation of BMI and fat mass in 3,750 children (girls r = 0.97 vs. boys r = 0.74) (29). This trend has also been observed in an adult population (30). Yet, some researchers argue that estimation of body fat content from BMI is significantly biased (31). This opinion is for instance supported by findings published by Pereira-da-Silva et al. where correlation of FM and BMI was extremely low (r = 0.12) (32). A study by Murphy et al., who investigated nutritional status in children with cancer, Crohn's disease, cystic fibrosis and anorexia nervosa, demonstrated differences in active cell mass BCM, regardless of any changes in BMI. Moreover, such differences were observed in the specific clinical conditions in comparison to healthy children constituting a control group in this study (2).

CONCLUSIONS

To sum up the discussion focusing on the usefulness of selected nutritional status indicators, this research has shown that we should always take into account the condition of the specific components of body composition in children. Further research involving greater populations of children and conducted over a longer period of time may provide adequate amount of data which will make it possible to more accurately specify potential risks of disorders both in healthy children and in those with medical conditions.

LIMITATIONS

This study was limited by the disproportionate size of the study group (type 1 diabetes – 63, celiac disease – 15, ulcerative colitis – 16, Crohn's disease – 14). The attempt to reduce the potential estimate error was taken by applying a comparable control group of healthy children matched for age and sex. In addition, another limitation is the relatively small numer of children with celiac disease (15 children), ulcerative colitis (16 children) and Crohn's disease (14 children). However, considering the inclusion criterion which limits the group only to children with a new diagnosis, the given number is a valuable source of information to infer.

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