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SOME METHODOLOGICAL CONSIDERATIONS ON BODY COMPOSITION

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Abstract: ***The aim of this study was to compare five variables indicating fatness: the triceps skinfold thickness, the sum of four skinfold thicknesses, the body fat percent assessed by skinfold thicknesses, the BMI and the body fat percent assessed by near infrared interactance (NIR) method. The sample was 5076 healthy 3–18 year old Budapest boys and girls.***

Results show that there is some similarity between these methods assessing fatness, but there are remarkable differences as well. The strongest connection is among methods based on skinfold thicknesses. Relatively strong connection is between BMI and NIR-method too. Conclusion is that the assessing equations of NIR-method are not enough exact, improvement of this method is necessary.

Keywords: *Body composition; Fatness; Skinfold thicknesses; Body fat percent; BMI; NIR-method.*

Introduction

Body composition and especially fatness and obesity are in the interest of many humanbiologists and medical scientists, because excessive fatness is an increasing health problem among both children an adults in the developed countries. It is well established fact, that obesity is a risk factor for several serious diseases such as diabetes, hypertension, cardiovascular diseases (Ducimetičre et al. 1986, Hubert et al. 1983, Stern and Hoffner 1986). This issue, which is closely associated with nutrition, is very important in Hungary as well, where obesity is a widespread health problem for the whole population (Blatniczky et al. 1989/90, Bodzsár et al. 1998, Gyenis 1994, Gyenis et al. 1994). Intervention is necessary and it should start in childhood for successful prevention.

The first step for it is to establish the nutritional status and within this the percent of body fat. Assessment of body fat percent in children and youth is not easy because the tissues develop differently, and the chemical composition of these change during growth and maturation (Forbes 1978). There are many methods for assessing the body composition of children (Roche et al. 1991, Roche 1993). Some of these can be used only in laboratories as well as they are complicated and expensive methods. They are, however, very exact procedures, so can be reference for other methods. These others are used for epidemiological researches, because they are cheap, simple, and non-invasive ones. In this study these latters are examined.

The best known and most used methods are based on skinfold thickness measurements. Several prediction equations have been elaborated (for adults and also for children and youth) to estimate body density and body fat percentage from these measurements (Pařízková 1961, Siri 1961, Durnin and Womersley 1974, Deurenberg et al. 1990). Though this approach is based on several assumptions and has low interobserver reliability (Lukaski 1987), it has been very popular for decades, because of the above mentioned advantages. Nevertheless the validity and practical utility of these equations have been proved (Lohman 1981, Himes and Bouchard 1989).

Body fatness can be inferred directly from either the sum of skinfold thicknesses or from a single skinfold (Marshall et al. 1991). Tanner et al. (1969) recommended the triceps and subscapular skinfolds as the most informative of the skinfold thicknesses.

In recent years, body mass index (BMI, which is calculated from height and weight) has become very popular of assessing obesity (Garrow 1981, Rolland-Cachera et al. 1982) particularly in medical practice, because it can be identified very simply. Nevertheless there is controversy among researchers concerning its validity in identifying obesity (Ross et al. 1996).

One of the newer methods of body composition analysis is the near infrared analysis (NIR-method). It has been used to assess fat content of the human body since the 1980s. There are several studies which compare this method to others. Opinions on its validity differ (Conway et al. 1984, Conway and Norris 1986, Israel et al. 1989, Davis et al. 1988, Brodie and Eston 1992, Cassady et al. 1993). Infrared interactance is based on the principles of light absorption, reflection and near infrared spectroscopy. Adipose tissue absorbs infrared radiation at a wavelength different from tissues that contain more water (Rosenthal 1991). Body fat percent can be calculated from these data using a complicated mathematical procedure.

The aim of this study is to compare some methods assessing body fatness, which are elaborated for children and adolescents, using a large sample in wide age-interval.

Results

Tests of independence were significant for each pairing of the variables (Table 1.).

Table 1. Contingency coefficients of different fatness indicator pairs.

Variable-pairs	Contingency coefficients*	
	Boys	Girls
%BF – SSF	0.752	0.744
TR – %BF	0.743	0.727
TR – SSF	0.736	0.738
NIR-%BF – BMI	0.676	0.636
NIR-%BF – SSF	0.668	0.575
NIR-%BF – %BF	0.635	0.569
NIR-%BF – TR	0.632	0.542
BMI – SSF	0.604	0.573
%BF – BMI	0.585	0.547
TR – BMI	0.554	0.524

*All coefficients are significant ($p < 0.05$)

Abbr.: %BF: percent of body fat estimated by skinfold thicknesses, SSF: sum of four skinfold thicknesses, TR: triceps skinfold thickness, NIR-%BF: percent of body fat estimated by NIR-method.

Contingency coefficients between %BF and SSF were the lowest ones for both the boys and the girls (0.197 in boys, 0.202 in girls, respectively). The highest contingencies were found between %BF and SSF for both genders (0.752 in boys, 0.744 in girls, respectively).

Cluster analysis of the four variables for the total sample shows that TR, SSF and %BF formed one cluster with BMI on its own (Figs. 1 and 2). On the restricted sample for five variables NIR-%BF was clustered with BMI and not with skinfold thicknesses, though distances are bigger in these clusters than in that of skinfold thicknesses. These results refer to both the boys and the girls (Figs. 3 and 4).

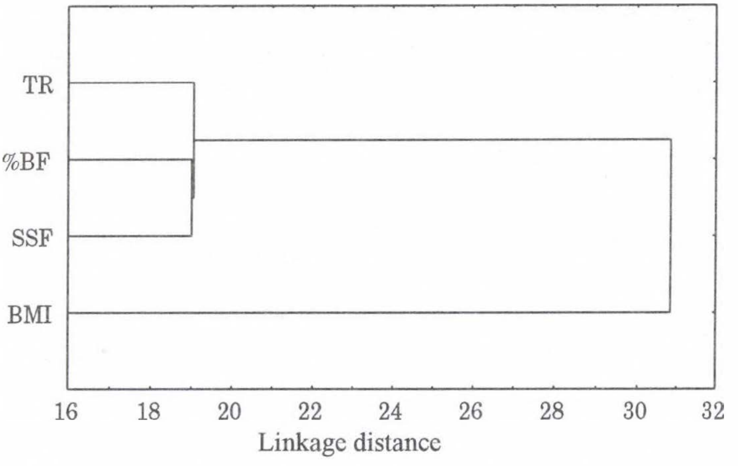

Fig. 1: Tree diagram for four methods of fatness assessment in 3–18 year-old Budapest boys.

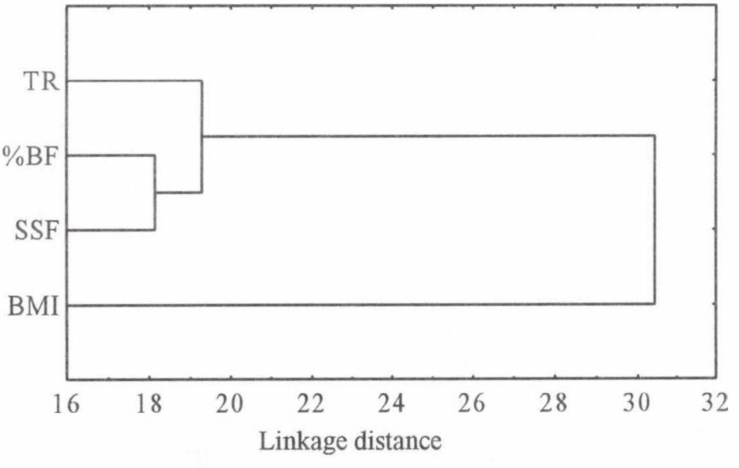

Fig. 2: Tree diagram for four methods of fatness assessment in 3–18 year-old Budapest girls.

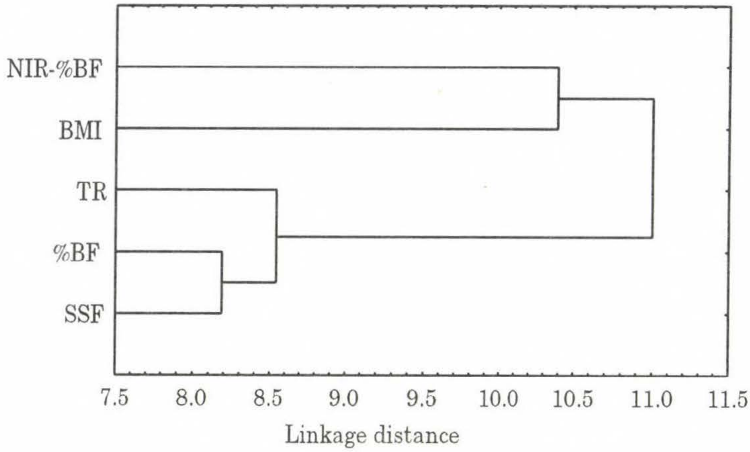

Fig. 3: Tree diagram for five methods of fatness assessment in 5–18 year old Budapest boys.

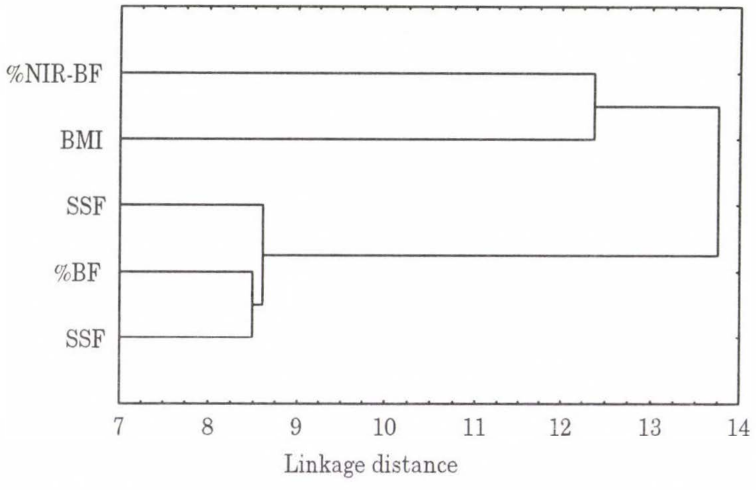

Fig. 4: Tree diagram for five methods of fatness assessment in 5–18 year old Budapest girls.

Based on the above results, linear regression analysis was performed by using NIR-%BF versus %BF, BMI, WT, and RHT^2. This analysis provided different results for boys and girls. Regression equations corroborated the inferences drawn from the cluster analysis in the girls, but not in the boys. The NIR-%BF are in relatively strong linear association with BMI and WT (R^2 values are between 0.70 and 0.80, Figs. 8 and 10). Relationship between NIR-%BF and %BF is weaker, or probably not linear (R^2=0.5568, Fig. 6). This is more true for the NIR-%BF and RHT^2 pair (R^2=0.3678, Fig. 12) and this association is negative.

Practically no relationships were found between NIR-%BF and BMI, WT and RHT^2 in the boys: (R^2 values are not bigger than 0.15, Figs. 7, 9 and 11). Associations with %BF is at similar level to that in the girls (R^2=0.5472, Fig. 5).

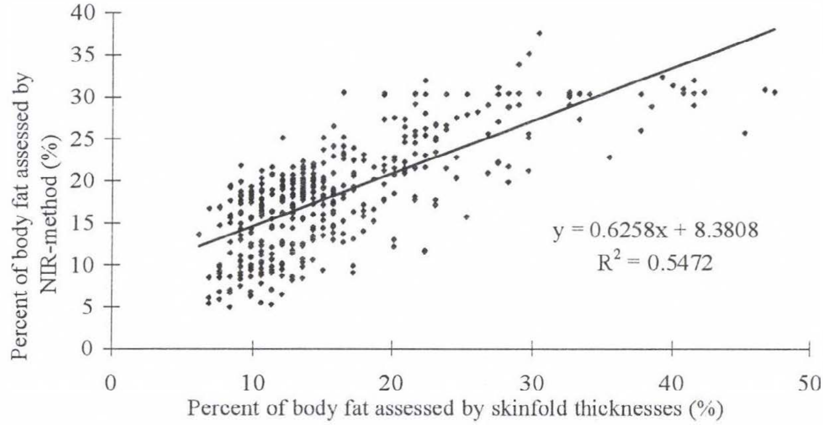

Fig. 5: Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and %BF (percent of body fat assessed by skinfold thicknesses) in 5–18 year old Budapest boys.

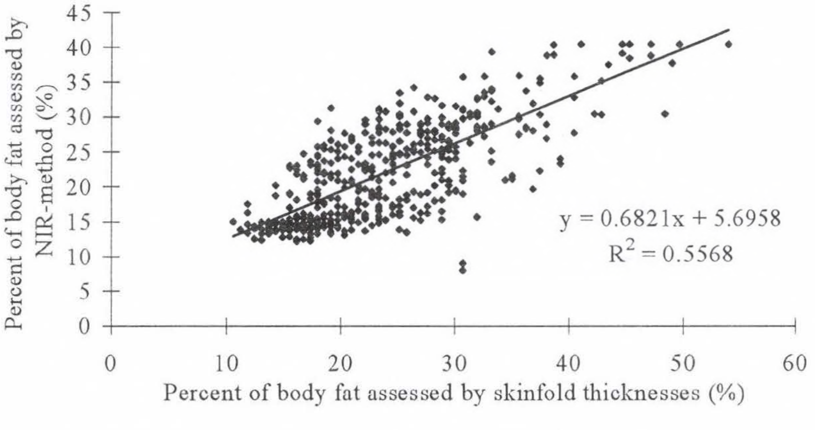

Fig. 6: Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and %BF (percent of body fat assessed by skinfold thicknesses) in 5–18 year old Budapest girls.

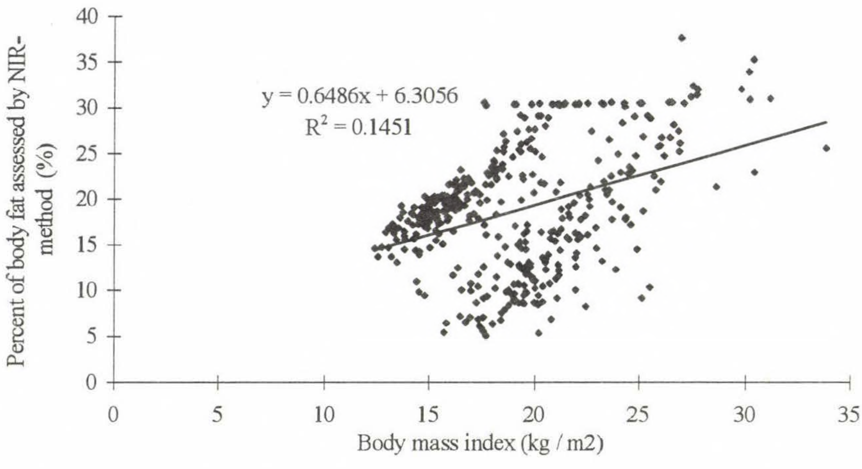

Fig. 7: Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and BMI (body mass index) in 5–18 year old Budapest boys.

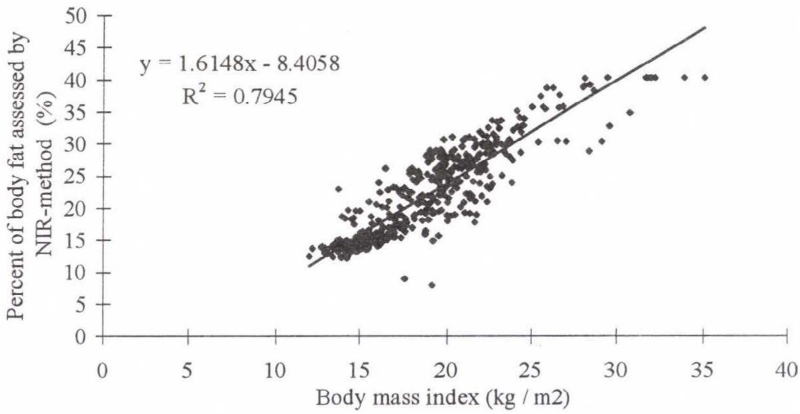

Fig. 8: Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and BMI (body mass index) in 5–18 year old Budapest girls.

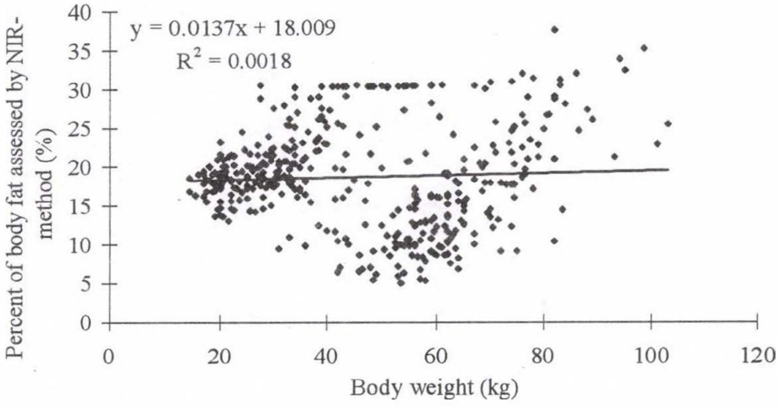

Fig. 9: Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and WT (body weight) in 5–18 year old Budapest boys.

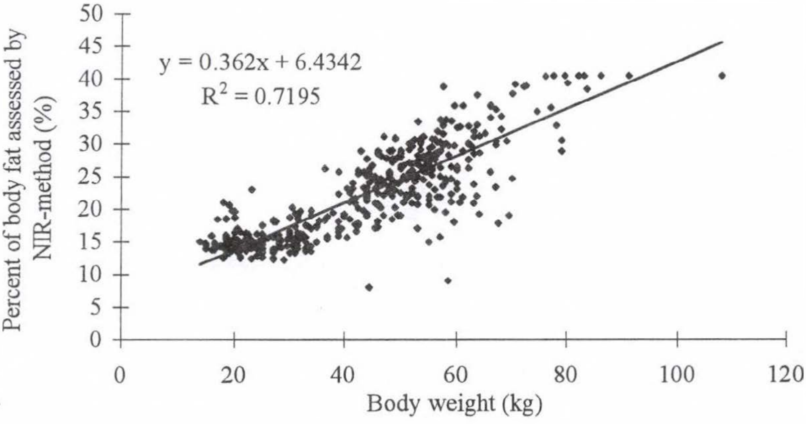

Fig. 10: Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and WT (body weight) in 5–18 year old Budapest girls.

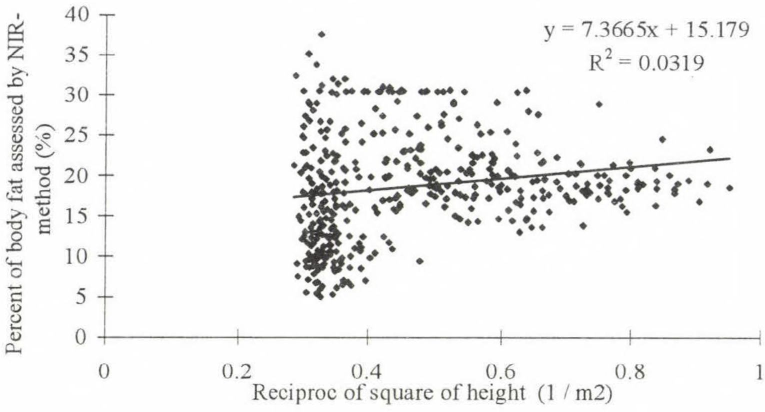

Fig. 11: Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and RHT^2 (reciproc of square of height) in 5–18 year old Budapest boys.

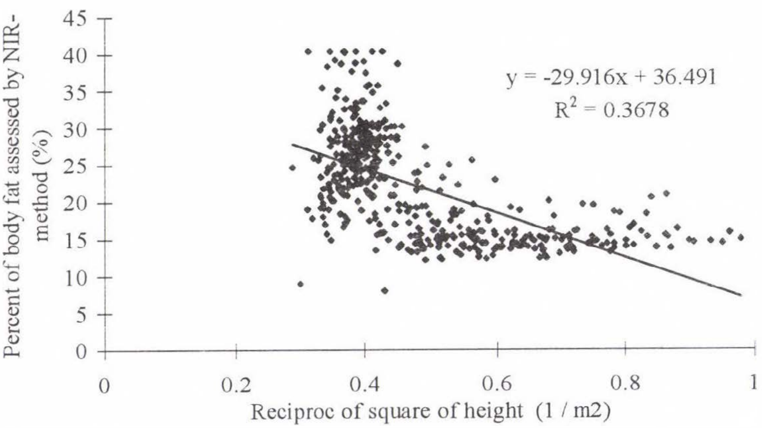

Fig. 12. Linear regression equation and predicted line for NIR-%BF (percent of body fat assessed by near infrared interactance method) and RHT^2 (reciproc of square of height) in 5–18 year old Budapest girls.

Five methods of fatness assessment were compared. The question was how similarly or differently these indicators identified children on the basis of their body fat mass. The question was whether these indicators identify equivalently the children based on their body composition.

Tests of independence have shown that the distributions of five variables are not independent, that is there is a significant relationship among these fatness indicators. These different methods classified the children into the categories ("overweighted", "normal" and "thin") which was chosen by the authors arbitrarily, in a very similar way. Contingency coefficients show, however, that the strength of the relationships between variable-pairs is different. The greatest contingency coefficients can be seen for the pairs of skinfold thickness variables in both sexes. It is not surprising, since these are calculated from each other.

The characteristics of connections among these variables can be refined by cluster analysis. It is obvious again, that skinfold thicknesses would range children in alike manner to the calculated body fat percentage, because the latter is calculated from skinfold thicknesses. However, the fact that the distance between %BF and TR was bigger than that between %BF and SSF was surprising, because %BF was calculated from TR and subscapular skinfold thickness. This result suggests that body fatness can be assessed more precisely by skinfold thicknesses when measurement sites are chosen from both the trunk and from the extremities. Marshall et al. (1991) have also found that the sum of skinfold thicknesses is more sensitive indicator of obesity than a single skinfold over the triceps in both genders.

The BMI-method ranges children differently to the skinfold thickness methods. Weight and height are used in calculating BMI, and it is well known that BMI is maximally correlated with weight and minimally with height in adults (Ross et al. 1988). Since weight is determined by many components and body fat is only one of them, it is evident that BMI does not indicate fatness in the same way as skinfold thicknesses do. This is particularly so in children and adolescents, because they undergo profound changes in body composition during the growth process. The amount of body fat and fat free mass change differently, thus their proportions change as well. Bodzsár (1991) and Ramirez (1993) stated that while body fat percent and subcutaneous fat change significantly during adolescence (the body fat percent decreases and increases too during the puberty), BMI stays relatively constant. [It is not connected closely to this study, thus we mentioned it only in brackets, that mathematical-statistical analysis showed in this sample, that body fat percent changes more rapidly with age than BMI does (unpublished data)].

When the five variables in the smaller sample were analysed by cluster analysis it was found that NIR-%BF stands nearest to BMI, though their distance is larger than those of the other three variables. This result occurs in both sexes. Based of this, linear regression analysis performed to compare NIR-%BF with the other variables. The results for boys and girls were different. Girls' data support the findings of cluster analysis. Since connection between NIR-%BF and BMI is strong it is not a surprise that there is strong connection between NIR-%BF and WT as well, and weak connection between NIR-%BF and RHT^2. It is well-known that the correlation coefficient for BMI and weight is high and for BMI and height is low. Bodzsár (1996) found these values 0.8 and 0.2, respectively. Based on these results we can conclude that body weight has too big role (bigger than it would be real) in the equation of NIR-method. Thus the value of

NIR-%BF depends on the weight to higher degree than the real body fat percent. Weaker relationship between NIR-%BF and body fat percent estimated by skinfold thicknesses (which are associated strongerly with the fat content of the body than the weight is) indicate that NIR-%BF is not enough precise for assessing body fat percent.

This last sentence is true for boys as well, but in the boys NIR-%BF values show very slight, if any connection with BMI and do not show any relationship with height and weight. The estimation of NIR-%BF does not seem to be more precise here than in the girls, but we cannot find any connection with other variables. The reason for this may be that there are remarkable gender differences in the changes of body composition during childhood and adolescence which fact was not properly considered during the development of these prediction equations.

The validity of the NIR-method is a controversial issue (Israel et al. 1989). Brodie and Eston (1992) stated that the assumption cannot be sustained that interactance value has little contribution to the estimation of fat percentage. This may be so for adults, but concerning children there are too few results. Cassady et al. (1993) have found this method to be reliable in children and adolescents, but correlations with the criterion methods were moderate.

Based on the results of the current and previous studies the authors consider that NIR-method cannot be used safely for assessing children's and adolescents' body fat percent. Developing of the estimating equations is necessary.

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