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HEIGHT, WEIGHT, BODY FAT, STATIC STRENGTH AND EXPLOSIVE POWER OF GIRLS AGED 10-14 TESTED WITH "EUROFIT" TEST

VIŠINA, TEŽA, TELESNA MAŠČOBA, STATIČNA IN EKSPLOZIVNA MOČ DEKLET MED 10. IN 14. LETOM STAROSTI IZMERJENO Z "EUROFIT" TESTOM

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Abstract

The aim of the study is a multifaceted analysis of the relationsships between height, weight and body fat with static strength and explosive power, determined in accordance with the Eurofit test. The subject sample consisted of 1,574 girls 10 – 14 years of age.

Body height, weight, the thickness of five skinfolds, static strength and explosive power were measured. The logarithm of the sum of five skinfolds was computed and accepted as a measure of fatness. The subjects were divided into three groups on the basis of this measure: lean, average and fat. Pearson correlation, partial correlation, linear, non–linear regression, analysis of variances and student's t-test were used for statistical analysis.

Body fat is the only parameter, which significantly affects both static strength and explosive power in every age. Body fat determined explosive power (r = -0.33 to r = -0.45) more than static strength (r = 0.17 to r = 0.30). The relations are linear in some age groups and non-linear in others. Curvilinear relationships between body fat and both static strength (14-year-olds) and explosive power (11- and 14-year-olds) were observed. In this instance, the explosive power is determined by body fat to a greater extent (D = 21.3% and 17.4%) than static strength (D = 6.0%), as indicated by higher values of the coefficient of determination. Analysis of variance showed a high level of significance (p≤0.01) of the differences in all age groups. This means that body fat is a factor, which differentiates between levels of static strength and explosive power. The above observations confirm earlier results indicating the need for using multifaceted methods of data analysis to study the relations between somatic parameters and physical fitness.

Key words: physical fitness, somatic parameters, girls, Eurofit

Izvleček

Namen študije je kompleksna analiza odnosov med telesno višino, težo, maščobo in statično ter eksplozivno močjo, opredeljenimi v skladu z Eurofit testom. Vzorec je sestavljalo 1.574 deklet med 10. in 14. letom starosti.

Izmerjene so bile telesna višina, teža, debeline petih kožnih gub, statična in eksplozivna moč. Mero debelosti predstavlja logaritem vsote petih kožnih gub. Na osnovi te mere so bila dekleta razdeljena v tri skupine: suhe, povprečne in debele. Za analizo podatkov so bile uporabljene korelacijska analiza, parcialna korelacija, linearne in ne-linearne regresija, analiza variance in t-test.

Telesna maščoba je edini parameter, ki statistično značilno vpliva na statično in eksplozivno moč v vsaki starosti. Telesna maščoba je bolje opredeljevala eksplozivno moč (r = -0.33 do r = -0.45) kot statično moč (r = 0,17 do r = 0,30). Odnosi so linearni v nekaterih starostih in ne-linearni v drugih – med telesno maščobo in statično močjo pri 14. letnicah ter med telesno maščobo in eksplozivno močjo pri 11. in 14. letnicah. V tem primeru je bila eksplozivna moč bolj opredeljena s telesno maščobo (D = 21.3% in 17.4%) kot statična moč (D = 6.0%), na kar kaže višji koeficient determinacije. Analiza variance je pokazala visoko statistično značilnost (p≤0,01) razlik med skupinami, kar kaže, da je telesna maščoba dejavnik, ki razlikuje ravni razvitosti statične in eksplozivne moči. Dobljeni rezultati kažejo na potrebo po uporabi več metod analize podatkov za ugotavljanje odnosov med morfološkimi parametri in telesno pripravljenostjo.

Ključne besede: telesna pripravljenost, morfološki parametri, dekleta, Eurofit

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INTRODUCTION

The problem of the effect of somatic features on static strength and explosive power of humans has been touched upon, among others, in the works of Beunen et al. (1983), Osiński (1988), Malina et al. (1995), Oja and Jürimäe (1997). Beunen et al. (1983), while studying Belgian boys, proved a similar, negative effect of body fat on static strength (hand grip) and explosive power (vertical jump). The similarity between the effect of body fat on static strength and explosive power was particularly visible after the elimination of the effect of height and weight. A study of girls carried out by Malina et al. (1995) indicated stronger, negative relations between body fat and explosive power (vertical jump) than between body fat and static strength (hand grip). In the work of Osiński (1996) the values of coefficient of determination for the relation between body fat and explosive power (vertical jump) were three times higher than the respective values for the relation between body fat and static strength (trial on the leg-back dynamometer). Oja and Jürimäe (1997), who determined explosive power on the basis of the standing broad jump, noted a significantly higher coefficient of variation in groups of girls than in groups of boys. Malina and Reyes (1994) observed that the differences in static strength and explosive power between the lean body mass and the fat (calculated per unit of weight) vary significantly, depending on the age of the subjects.

Among studies one can find works in which no significant relations between static strength and explosive power and height, weight and body fat were found (Raudsepp, & Jürimäe, 1996b). In other works no significant correlation was found between functional strength, determined on the basis of the time of hanging on a bar, and body fat (Raudsepp, & Jürimäe, 1996a). A study by Copley (1987) did not prove a relation between static strength measured using a dynamometer and body weight. Results of other studies indicate significant straight-line relations between explosive power (standing broad jump) and static strength (hand grip) with somatic features (Malina et al., 1995; Benefice, & Malina, 1996; Raudsepp, & Jürimäe, 1998). In the majority of the studies the analyses of relations between body fat and strength are based on straight-line methods. The partial correlation method and in particular non-linear regression analysis are seldom applied. Belgian studies indicate that the level of strength does not always change proportionally to the increase in body fat (Beunen et al., 1983). It has been proven that these relations are often non-linear (Osiński, 1996; Bober, 1996; Maciaszek, 1999). Thus, it is difficult to determine clearly the relations between strength and body fat.

The aim of the study is a multifaceted analysis of the significance of height, weight and body fat for static strength and explosive power determined in accordance with the Eurofit test (1993).

METHODS

Subjects

The sample consisted of girls from primary schools in Poznań 10, 11, 12, 13 and 14 years of age. The age categories were made according to the recommendations of Malina and Bouchard (1991) and Eurofit (1993). In total 1,574 girls were studied. Detailed information is presented in Table 1.

Procedures

Anthropometric measures were taken in a standing, straight position, except the skinfold on the calf, which was measured while sitting. Body height, weight and the thicknesses of five skinfolds (biceps skinfold, triceps skinfold, subscapular skinfold, calf skinfold and suprailiac skinfold) were measured. Then the logarithm of the sum of five skinfolds was computed and used as a measure of body fat.

The subjects were divided into three groups on the basis of this body fat measure: a) the level of 15 centiles was the top limit for lean individuals, b) the range from 25 to 75 centiles was used for individuals with medium, c) the level of 85 centiles was the lowest value for the group of the fat. The individuals with body fat 15 - 25 and 75 - 85 centiles were excluded from the analysis. The aim of the exclusion was to obtain groups of distinctly different individuals. The method of division presented, was used earlier in the studies of Garn and Clark (1976) and Chrzanowska (1992, 1993).

Hand-grip and standing broad jump (from the Eurofit test) were used to determine the static strength and explosive power. The relationship between height, weight, body fat, static strength and explosive power was calculated by zero order correlation, partial correlation and non-linear regression analysis. Differences between the groups classified as lean, medium and fat were analysed with analysis of variance and post-hoc two-group differences with student's t-test.

Table 1. The number of studied girls by age groups

Age	10 years	11 years	12 years	13 years	14 years	Total
Num-ber	255	334	302	326	357	1,574

RESULTS

The analysis of the relations between somatic parameters and static strength started with determining the value of correlation coefficient (Table 2). The strongest relations are between static strength and height. The correlation coefficients have values from r = 0.36 to r = 0.48. Weight has a similar effect on static strength (from r = 0.35 to r = 0.55). The lowest (statistically significant) values of correlation coefficients were noted for the relations between the thickness of skinfolds and static strength (from r = 0.17 to r = 0.30).

The cases of relation between somatic parameters and explosive power are also frequent (Table 3). The relations between the height and explosive power are significant at the ages 10, 11 and 14 years, but the values of correlation coefficients are low (from r = 0.13 to r = 0.15). Weight defines explosive power to a stronger degree but negatively (from r = –0.15 to r = –0.22). The effect of weight on the results of long jump isn't statistically significant only for 12 year-old girls. The effect of the thickness of fat on the explosive power is the strongest. In every age group the increase in body fat results in a decrease in explosive power. The values of the correlation coefficient range from r = –0.33 to r = –0.45.

Table 4 presents the relations between static strength and the thickness of the skinfolds, where the effect of height and weight (individually and simultaneously) has been eliminated. The picture of linear relations between static strength and the thickness of skinfold, presented above, changes when height or weight are partialised. After the elimination of the effect of height the relation between the thickness of fat tissue and static strength, with the exception of 11 year-old girls, is significant, but the values of correlation are lower (from r = 0.13 to r = 0.25). After the elimination of weight, the relation (except in the group of 10 year olds) is negative and ranges from r = –0.17 to r = –0.34 (p≤0.01). Thus, with the same weight, the increase in body fat results in a decrease in static strength.

Interesting results were obtained when the relations between body fat and static strength were studied, after the elimination of the effects of both height and

Table 2. Correlation between static strength and height, weight, body fat

Variables/Age	10 years	11 years	12 years	13 years	14 years
Height	0.48**	0.36**	0.47**	0.46**	0.40**
Weight	0.44**	0.35**	0.55**	0.48**	0.46**
Body fat	0.30**	0.17**	0.24**	0.20**	0.21**

** - p≤0.01 * - p≤0.05

Table 3. Correlation between explosive power and height, weight, body fat

Variables/Age	10 years	11 years	12 years	13 years	14 years
Height	0.13*	0.15**	0.12	0.03	0.13**
Weight	-0.15*	-0.18**	-0.09	-0.21**	-0.22**
Body fat	-0.45**	-0.43**	-0.33**	-0.40**	-0.40**

** - p≤0.01 * - p≤0.05

Table 4. Second order partial correlation between body fat and static strength

Age	10 years	11 years	12 years	13 years	14 years
Height constant	0.18**	0.10	0.13*	0.13*	0.25**
Weight constant	-0.08	-0.17**	-0.34**	-0.30**	-0.23**
Both variables constant	0.07	-0.08	-0.30**	-0.21**	-0.10

** - p≤0.01 * - p≤0.05

Table 5. Second order partial correlation between body fat and explosive power

Age	10 years	11 years	12 years	13 years	14 years
Height constant	-0.52**	-0.49**	-0.39**	-0.41**	-0.41**
Weight constant	-0.54**	-0.48**	-0.43**	-0.38**	-0.38**
Both variables constant	-0.46**	-0.35**	-0.36**	-0.34**	-0.30**

** - p≤0.01 * - p≤0.05

weight. In four age groups the correlation coefficient has a negative value, whereas this value is statistically significant for 12 and 13 year-old girls (r = -0.30 and r = -0.21). Thus, the positive effect of body fat on static strength, proved on the basis of correlation, is only apparent.

Then the relations of explosive power were analysed in a similar way, i.e. using the partial correlation method (Table 5). In each case the relation between body-fat and explosive power was negative ($p \leq 0.01$), that is with an increase of thickness of fat tissue the standing broad jump result decreases. The highest values of the partial correlation coefficient were noted after the elimination of weight (from r = -0.38 to r = –0.54), therefore an increase of body fat with the same weight affects the level of explosive power very negatively.

The elimination of the effects of weight, height or both variables at the same time, in the study of the relations in question, did not affect significantly the values of correlation coefficients. The values of partial correlation coefficients ranged from r = -0.30 to r = –0.54.

Another step of the analysis of relations of body fat with static strength and explosive power was determining the regression equations and a graphic presentation of this relation. For groups of girls 10 to 13 years old, the significant relations between body fat and static strength are sufficiently well described by a straight line (Fig.). The increase in thickness of skinfolds is related to increased static strength. In a group of the oldest of the studied girls (14 year-old), in the range of high body fat values, the curve is broken and with a further increase in thickness of skinfolds there is a drop of static strength (D = 6.0%). The value of coefficient of determination for the analysed regression equations ranges from D = 2.7% to D = 8.9%.

Figure 2 shows regression lines, which present the changes in the explosive power (standing broad jump), depending on the body fat in individual age groups. At the ages of 10, 12 and 13 years the relation is described by straight lines which show a systematic decrease of explosive power with an increase in skinfold thickness. Coefficient of determination amounts here to D = 20.5%, D = 11.4% and D =

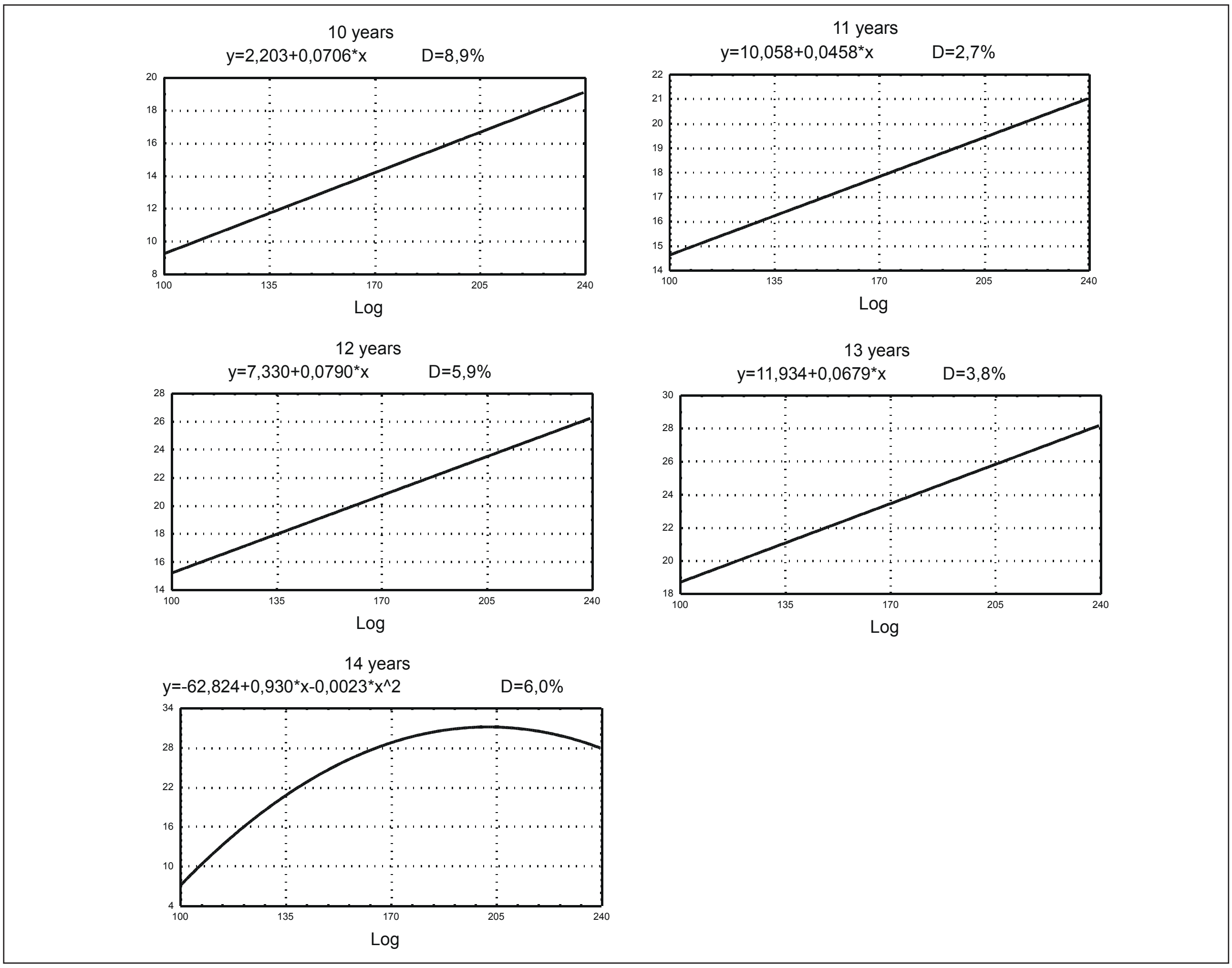

Fig. 1. Regression curves for the relations between static strength measured by hand grip (kg) with the fatness in girls aged 10–14.

16.3%, respectively. In the groups of 11 and 14 year olds, the curve, which best describes the relations is a parabola (D = 21.3% and D = 17.4%). From this analysis a conclusion can be made that the optimal body fat to be able to perform an effective standing broad jump is average to close to medium.

Then the level of static strength and explosive power of girls in groups with different degree of body fat was analysed. The basic statistical description is presented in Table 6. As a result of the analysis of variance it was found that the value of the F test has a high level of relevance ($p \le 0.01$) in all age groups. This means that body fat is a factor, which does differentiate the levels of static strength and explosive power.

For static strength, the largest differentiation is noted between lean and fat girls (t-test from 3.4 to 4.6, $p \le 0.01$). Lean and medium girls differ in terms of static strength at the age of 12, 13 and 14 (t-test from 2.0 to 3.5, $p \le 0.01$ or $p \le 0.05$). The smallest differences were noted between medium and fat girls (for 10 and 13 year old, $p \le 0.05$).

The variation of the level of explosive power, due to the level of body fat is, even greater than in the case of static strength (from F = 11.40 to F = 27.53, $p \le 0.01$). The differences were noted in all the age groups between the fat and lean girls (t-test from 16.5 to 28.7, $p \le 0.01$) and between the fat and medium. Only for girls aged 11 and 14 no differences in the explosive power are noted between lean and medium. The variation of the explosive power between lean and fat girls aged 10, 13 and 14 is 28.7 cm, 28.2 cm and 28.1 cm, respectively, which is over 16%.

The graphic picture of the variation expressed in centiles of the level of static strength (Figure 3) and explosive power (Figure 4) of girls in different fractions of body fat indicates how well groups of the lean and fat girls are distinguished. Fat girls have better results in static strength than lean or medium girls. The differen-

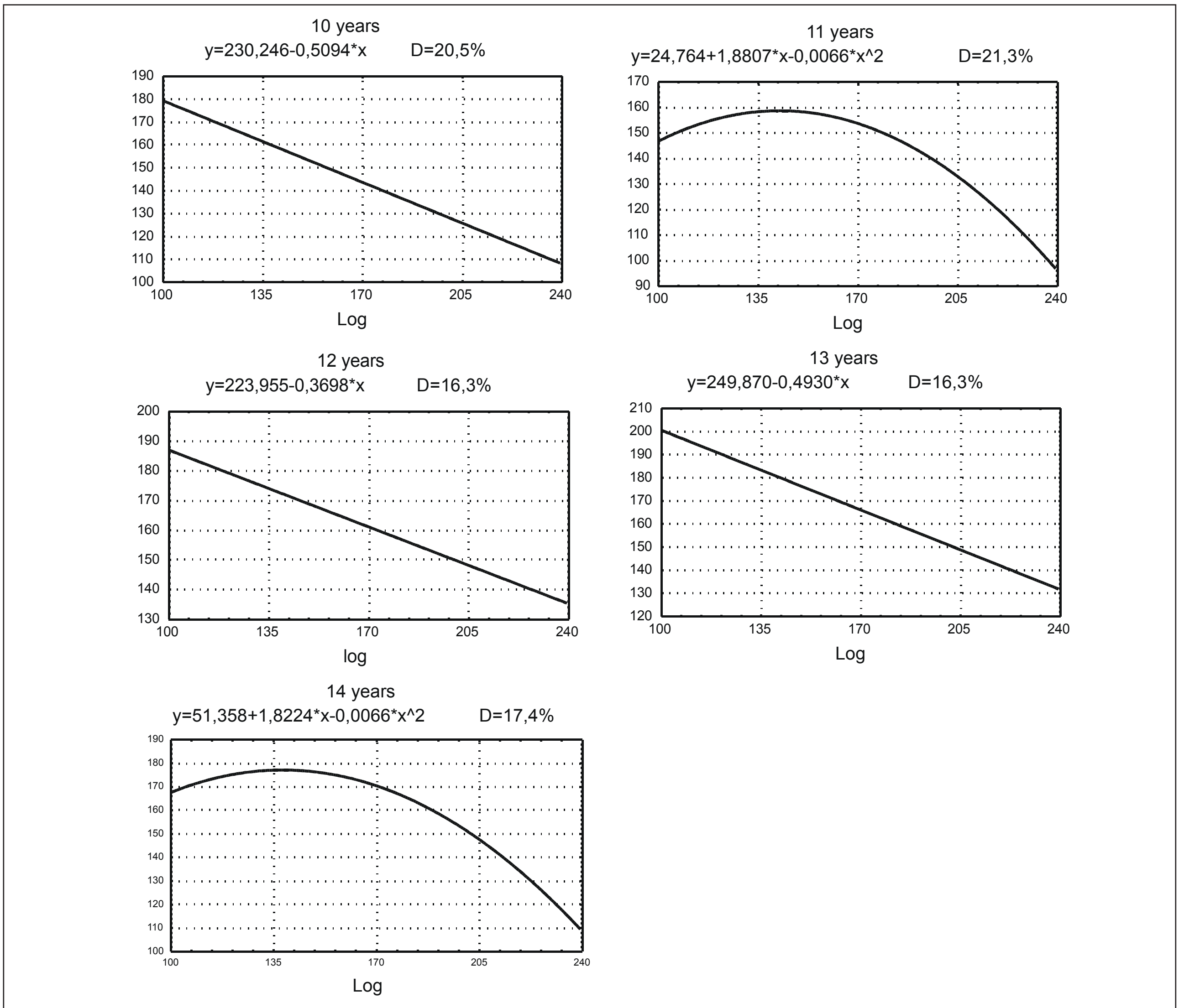

Fig. 2. Regression curves for the relations between explosive power measured by standing broad jump (cm) with the fatness in girls aged 10–14.

Table 6. Level of hang grip (kg) and standing broad jump (cm) in individual groups of body fat with the assessment of relevance of differences between lean, medium and fat girls

Age (years)	Lean (L)			Average (A)			Fat (F)			Value of F test	Values of t-test		
	N	$\bar{\chi}$	SD	N	$\bar{\chi}$	SD	N	$\bar{\chi}$	SD		L-A	A-F	L-F
HAND GRIP													
10	33	12.6	3.5	102	13.7	4.2	34	16.2	4.1	7.4**	1.1	2.5*	3.6**
11	34	16.0	4.2	137	17.6	5.6	46	19.6	4.5	4.8**	1.6	2.0	3.6**
12	35	17.9	5.5	116	21.4	5.5	37	22.5	4.8	7.1**	3.5**	1.1	4.6**
13	43	21.8	4.7	125	23.8	5.8	45	26.4	6.3	6.9**	2.0*	2.6*	4.6**
14	38	23.9	5.6	116	27.3	5.5	37	27.3	5.2	5.3**	3.4**	0.0	3.4**
STANDING BROAD JUMP													
10	35	154.1	19.1	106	145.2	17.1	38	125.4	27.2	19.2**	8.9**	19.8**	28.7**
11	38	152.2	30.7	149	154.7	16.6	51	135.7	14.8	27.5**	2.5	19.0**	16.5**
12	35	168.3	16.3	116	162.0	16.5	37	149.2	21.4	11.4**	6.3*	12.8**	19.1**
13	43	174.8	21.7	125	163.2	17.9	45	146.6	28.6	18.8**	11.6**	16.6**	28.2**
14	38	172.6	16.9	116	168.9	19.9	37	144.5	30.3	19.0**	3.7	24.4**	28.1**

** - p≤0.01 * - p≤0.05

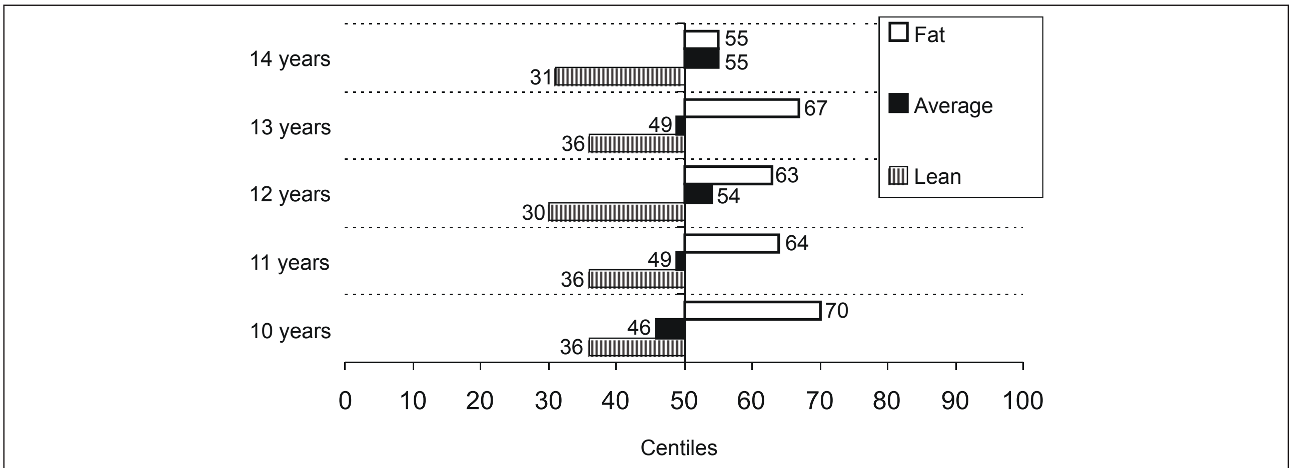

Figure 3. Level of hand grip (static strength) of girls by age groups qualified for different body fat groups

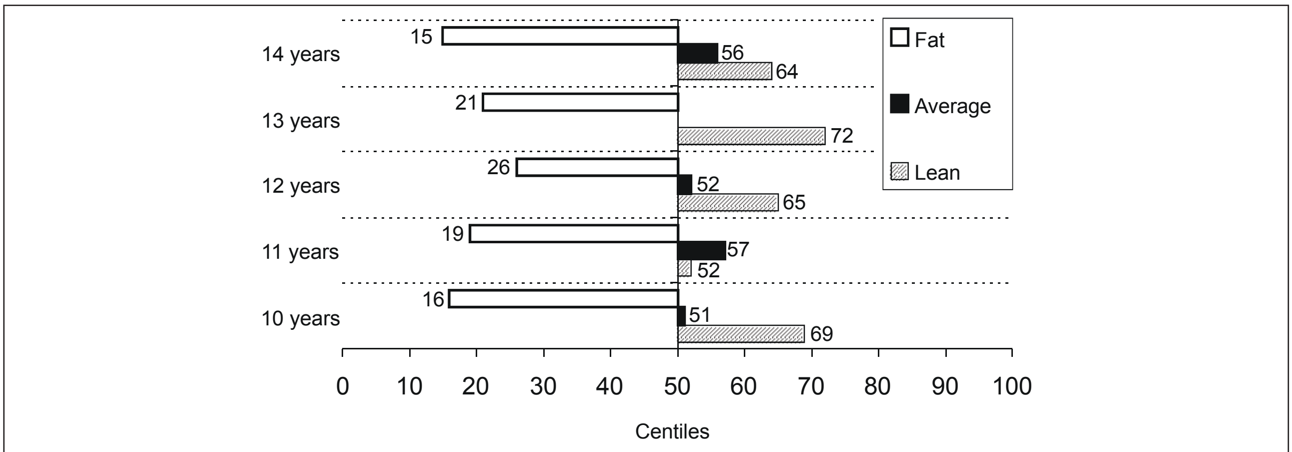

Figure 4. Level of standing broad jump (explosive power) of girls by age groups qualified for different body fat groups

ces noted, however, are not as large as in the case of variation in explosive power, where the group of fat girls have much lower results than girls from the lean group or from the medium group.

DISCUSSION

The study, in particular the application of correlation, partial correlation, non-linear regression analysis, and analysis of variance, as well as determining the centile level of factors of physical fitness; made it possible to determine relations between the level of static strength and explosive power and height, weight and the thickness of skinfolds.

The analyses of relations have shown how big a mistake can be made in drawing premature conclusions only on the basis of the correlation coefficient. Correlation coefficients indicate that the increase in height, weight and thickness of skinfolds positively affects static strength of girls 10 to 14 years of age ($p \leq 0.01$). However, the thickness of skinfolds is not the main and direct determinant of the level of static strength. A high level of body fat usually coincides with high total weight, and the weight in turn depends to a large extent on the mass of muscle tissue, which plays a basic part in static strength trials (Raudsepp, & Jürimäe, 1997). Strong positive relations between static strength and body fat were also observed in other studies (¯ak, 1991; Benefice, & Malina; 1996; Kim, & Tanaka, 1997). However, as a result of our own studies, we found that the „pure« effect of body fat on static strength, after the elimination of height and weight variables, is negative. Thus, in the study of relations between the thickness of skinfolds and the level of static strength, elimination of the effect of weight is a significant condition of an adequate analysis. Other scholars have also pointed out a similar mechanism (Beunen et al. 1983; Malina et al., 1995).

Explosive power is determined by somatic parameters even to a larger extent. The strongest parameter with a negative effect ($p \leq 0.01$) is the thickness of body fat. Osiński (1996) has indicated the significance of body fat for the level of explosive power. In the study of young people in the city of Kraków it was also found that the strongest relations are those between the amount of body fat and explosive power and that they are always negative (Żak, 1991). In the adopted method of assessment of explosive power, due to the need to move the whole body in space, body fat is only an unnecessary burden (Oja, & Jürimäe, 1997).

This study not only confirms the observations made in other works (Osiński, 1988; 1995; 1996; Pate, Slentz, & Katz, 1989), but also extends the knowledge on the linear and non-linear relations shown by the results of the assessment of static strength and explosive power measured in accordance with the instructions of the popular Eurofit test. The relations between the thickness of the skinfolds and elements of physical fitness are not always clear, uniform and independent of age. The relations in question are linear in some age groups and non-linear in others. In spite of additional complications resulting from the introduction of quadratic equations, the precision of matching the regression curve to empirical data is multiplied, thus the reasoning becomes more reliable (Ambrožič, 1999). As a result of such statistical analyses one can say that low body fat is not always the factor, which facilitates carrying out a physical exercise. Claessens et al. (1998) observed that body fat correlates with the distinguished factors of fitness related to health only in the area of average fitness results. However, body fat does not affect results on the high (>P75) or low (<P25) levels. Thus, the level of fitness may be a factor differentiating the relations between body fat and static strength or explosive power. The reasons for a very small layer of adipose tissue could explain a lot. Certainly, sometimes we may encounter cases of emaciation, which may result from chronic diseases, malnutrition, bad diet, stress or other factors which lower the biological value of an individual, determining at the same time his or her physical fitness (Wolański, 1986).

In our study a negative effect of significant leanness or obesity on both static strength (in the group of 14-year-olds) and explosive power (in the groups of 11- and 14-year-olds) was observed. The explosive power is determined by body fat to a larger extent (D = 21.3% and 17.4%) than static strength (D = 6.0%), which is indicated by the higher values of the coefficient of determination. Similar observations were also made by Osiński (1988). Pate et al. (1989) on the other hand, observed that relations between the thickness of skinfolds and some motor parameters are linear for boys and non-linear for girls. The picture of the centile level of static strength of the studied girls should be considered taking into account the observations related to the effect of weight on relations between static strength and body fat. Higher centile level of static strength of fat girls is probably related to their higher weight. Determining the centile level of explosive power has indicated that this level for any age group of fat girls is not as high as for girls with medium fat and lean girls.

One must not, however, forget that the obtained results are also influenced significantly by different maturation levels of the examined girls (problem of biological versus chronological age) and that this is connected with different level of body fatness. We were unfortunately unable to determine biological age in our study, future studies should take this also into account, but this fact does not invalidate the findings obtained. The above observations confirm earlier results, indicating the need for using multifaceted methods of statistical analysis to discuss the relations between somatic parameters and human motor activity (Osiński, 1988; Maciaszek, 1999).

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