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THE IMPLEMENTATION OF ADVANCED EXPLORATION TECHNIQUES IN THE EVALUATION OF THE YOUTH'S NUTRITIONAL STATUS

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The research was made on 95 pupils aged 13.1±0.04 years. There were held body mass and height measurements, and arm circumference and 4 skinfolds thickness. The BMI (kg/m^2), arm muscles circumference (AMC, cm), fat-free body mass (FFM, kg), fat mass (FM, kg) and fat mass percentage in the body (%FM, %) were counted. Moreover information characterizing life and nutrition style of the analyzed youth was gathered. From 12 anthropometrical parameters based on factor analysis main factors were separated, on the basis of which by means of cluster analysis homogeneous clusters were separated – grouping in them people characterized with similar nutritional status. The k-means clustering method was used to group objects.

On the basis of cluster analysis in boys group 3 clusters were separated that were characterized with: 1) small fattening and big FFM, AMC and body mass values – 22.7% of the subpopulation; 2) very big fattening and quite big FFM, AMC and body mass – 11.4% of the subpopulation; 3) small fattening and small FFM, AMC and body mass – 65.9% of the subpopulation. Among girls 4 clusters were separated that were characterized with: 1) moderate fattening and low height and small FFM values – 35.3% of the subpopulation; 2) small fattening and average height and average FFM values – 31.4% of the subpopulation; 3) big fattening and high height and big FFM values – 15.7% of the subpopulation; 4) big fattening and low height and small FFM values – 17.6% of the subpopulation. The correctness of conducted grouping in internally homogeneous clusters was confirmed by variance analysis. On the basis of 5 chosen anthropometrical parameters analysis no unequivocal examined youth nutritional status characteristic was received. The applied advanced statistical methods, *i.e.* factor and clusters analysis, enabled multi-featured evaluation of the examined youth nutritional status.

INTRODUCTION

Constant monitoring of the population nutritional status is an integral condition of trends research in health status and is one of the methods of gaining information about its background [Lloyd *et al.*, 1998; Middleman *et al.*, 1998; Molnar & Schutz, 1998; Ortega *et al.*, 1995; Twisk *et al.*, 1997]. In nutrition sciences, the standard of the nutritional status evaluation is the basic statistical parameters implementation, like *e.g.* mean value or median and their dispersion measures like *e.g.* standard deviation, standard error of mean, quartile range [Gawęcki & Wagner, 1984; Gibson, 1990; Molnar & Schutz, 1998; Parker *et al.*, 1997; Szponar & Rychlik, 1996a, b; Twisk *et al.*, 1997; Wądołowska & Cichon, 2000]. Very useful, in practical terms, is also application of terminal values as separation points, often appointed arbitrarily and determining the so-called outer evaluation criteria. Terminal values have become *e.g.* a basis for elaborating classification tables, and in reference to children and youth – percentile values tables [Ferro-Lucci *et al.*, 1992; Gibson, 1990; Palczewska & Niedźwiecka, 1999; WHO, 1995]. Applying them in the nutritional status evaluation allows getting information about the size of groups characterized with the analyzed parameters mean values and values too low or too high, enabling separating subpopulations threatened with pathology [Fogelholm, 1998; Ortega-Anta *et al.*, 1996; Szponar & Rychlik, 1996a, b; Wądołowska *et al.*, 2001]. Every time analysis most commonly includes one (more seldom two or more) nutritional status parameter, limiting this way evaluation range. Moreover results of evaluation held for each parameter separately may be different, which hampers formulating final conclusions.

Cluster analysis is one of interesting solutions, giving new evaluation possibilities [Mezzich & Solomon, 1980]. On the basis of optional number of features particular objects are attributed to groups, and the only inner division criterion is mathematical defined similarity among objects [Marek & Noworol, 1987]. The implementing of this procedure enables creating groups of people (clusters) characterized with high similarity inside the group and big differentiation between groups – considered for many features simultaneously. The final result is not so difficult to interpret, and in the case of nutritional status evaluation held on the basis of several parameters enables a penetrating multi-featured analysis.

The aim of the work was to apply advanced statistical analysis methods in the youth nutritional status evaluation and to separate homogeneous groups including many different anthropometrical parameters.

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MATERIAL AND METHODS

The research was made on 95 pupils aged 13.1±0.04 years, attending 4 classes from 2 secondary schools in Olsztyn and Barczewo. The examined persons were drawn stratifyingly, by drawing schools, and then classes, two from each school.

On the basis of body mass and height measurements BMI (kg/m^2) was assigned. On the basis of arm circumference measurements and 4 skinfolds thickness: triceps (TSF, mm), biceps (BSF, mm), subscapular (SCSF, mm), and supra-iliac (SISF, mm) were counted: arm muscles circumference (AMC, cm) and fat-free body mass (FFM, kg), fat mass (FM, kg) and fat mass percentage in the body (%FM, %) [Gibson, 1990; Heymsfield & Williams, 1988]. Moreover information characterizing analyzed youth life and nutrition style was gathered.

From 12 anthropometrical parameters on the basis of factor analysis the main factors were separated, on the basis of which homogeneous clusters were found – grouping people characterized with similar nutritional status. For grouping objects k-mean clustering method was used [Marek & Noworol, 1987]. The differentiation of people included to particular clusters was verified on the basis of one-factor variance analysis, with significance level of $p \leq 0.05$. The statistical analysis was held with the use of computer program STATISTICA PL v.6.0.

RESULTS

On the basis of the conducted factor analysis it was established that of the 12 analyzed anthropometrical parameters 2 created factors of each group had fundamental impact on the examined girls and boys nutritional status (Table 1). Among girls factor 1 co-created 2 parameters: %FM (correlation coefficient r=0.95) and TSF (r=0.93), factor 2: height (r=0.89) and FFM (r=0.80), among boys – factor 1: %FM (r=0.96) and BSF (r=0.94), and factor 2: FFM (r=0.97), body mass (r=0.89) and AMC (r=0.88).

TABLE 1. Correlation coefficients values between analyzed anthropometrical parameters and separated factors.

Parameter	Girls		Boys	
	Factor 1	Factor 2	Factor 1	Factor 2
Height	0.04	0.89	-0.15	0.77
Body mass	0.70	0.71	0.42	0.89
Arm circumference	0.79	0.54	0.56	0.78
TSF	0.93	0.12	0.89	0.10
BSF	0.86	0.30	0.94	-0.07
SCSF	0.82	0.39	0.81	0.39
SISF	0.86	0.33	0.90	0.29
BMI	0.83	0.46	0.64	0.69
FM	0.81	0.57	0.83	0.53
FFM	0.58	0.80	0.18	0.97
% FM	0.95	0.25	0.96	0.19
AMC	0.54	0.70	0.23	0.88

TSF – triceps skinfold; BSF – biceps skinfold; SCSF – subscapular skinfold; SISF – supra-iliac skinfold; BMI – body mass index; FM – fat mass in the body; FFM – fat-free body mass; %FM – fat mass percentage; AMC – arm muscles circumference.

On the basis of cluster analysis in boys group 3 clusters were separated that were characterized with: 1) small body fattening and high FFM values, AMC and body mass – 22.7% of the subpopulation; 2) very high fattening and quite big FFM values, AMC and body mass – 11.4% of the subpopulation; 3) small fattening and small FFM values, AMC and body mass – 65.9% subpopulation (Table 2, Figure 1).

TABLE 2. Separated clusters characteristic in boys subpopulation.

Sex/ cluster	Parameter	Parameter size	Cluster characteristic	% N
Boys 1	BSF	small	small fattening	22.7
	%FM	small	and big muscles mass	
	FFM	big	and big body mass	
	AMC	big		
	body mass	big		
Boys 2	BSF	very big	very big fattening and	11.4
	%FM	very big	quite big muscles mass	
	FFM	quite big	and quite big body mass	
	AMC	quite big		
	body mass	quite big		
Boys 3	BSF	small	small fattening,	65.9
	%FM	small	small muscles mass	
	FFM	small	and small body mass	
	AMC	small		
	body mass	small		

% N – subpopulation percentage; BSF – biceps skinfold; FFM – fat-free body mass; %FM – fat mass percentage in the body; AMC – arm muscles circumference.

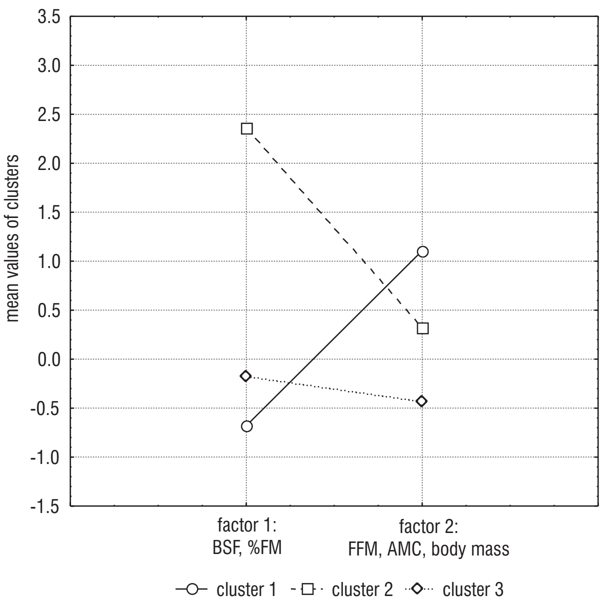

FIGURE 1. Diagram of separated clusters mean values in boys group. BSF – biceps skinfold, %FM – fat mass percentage in the body, FFM – fat-free body mass, AMC – arm muscles circumference.

Among girls 4 clusters were separated that were characterized with: 1) moderate body fattening and low height and small FFM values – 35.3% of the subpopulation; 2) small fattening and average height and average FFM values – 31.4% of the subpopulation; 3) big fattening and high height and big FFM values – 15.7% of the subpopulation; 4) big fattening and low height and small FFM values – 17.6% of the subpopulation (Table 3, Figure 2).

TABLE 3. Separated clusters characteristic in girls subpopulation.

Sex/ cluster	Parameter	Parameter size	Cluster characteristic	% N
Girls 1	TSF %FM height FFM	moderate moderate small small	moderate fattening and small size and small muscles mass	35.3
Girls 2	TSF %FM height FFM	small small average average	small fattening and average size and average muscles mass	31.4
Girls 3	TSF %FM height FFM	big big big big	big fattening, big size and big muscles mass	15.7
Girls 4	TSF %FM height FFM	big big small small	big fattening and small size and small muscles mass	17.6

% N – subpopulation percentage; TSF – triceps skinfold; FFM – fat-free body mass; %FM – fat mass percentage in the body.

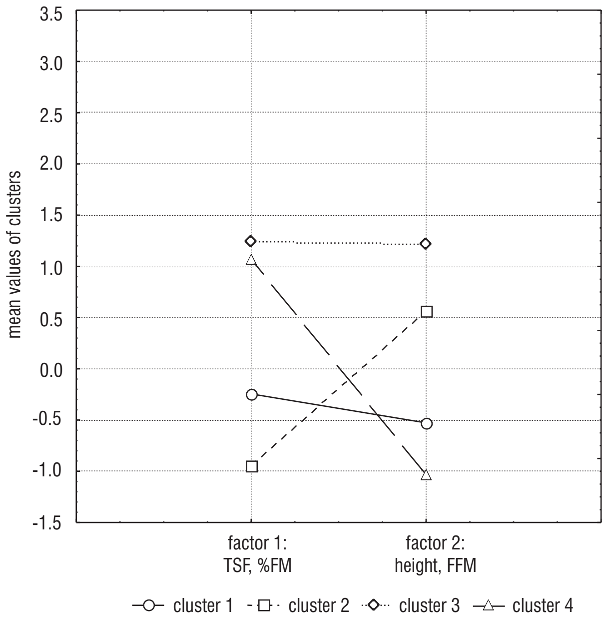

FIGURE 2. Diagram of separated clusters mean values in girls group. TSF – triceps skinfold, %FM – fat mass percentage in the body, FFM – fat-free body mass.

The correctness of the executed grouping into inwardly homogenous clusters was confirmed by variance analysis. A significant differentiation (p≤0.05) between separated clusters of all analyzed anthropometrical parameters was displayed (Tables 4 and 5).

Based on the analysis of distribution of 5 selected anthropometrical parameters no unequivocal characteristics of the examined youth nutritional status was obtained. On the basis of body mass, undernutrition (body mass <10 percentile) was stated among 6.8% of boys, while based on BMI (BMI<10 percentile) – among 4.5% of subpopulation (Table 6). Depending on implemented parameter, obesity was revealed among 8.8% of boys (body mass >90 percentiles), 9.1% (BMI>90 percentile), 6.8% (SCSF>90 percentile) and 4.5% (arm circumference >90 percentile). Bigger variances in evaluation were found among girls. Undernutrition based on body mass was displayed among 7.8% of girls (body mass <10 percentile) and 13.7%, if the criterion was BMI (BMI<10 percentile). Obesity was stated among 19.6% of girls (body mass >90 percentile), 23.5% (BMI>90 percentile), 15.7% (SCSF>90 percentile) and 11.8% (arm circumference >90 percentile). Among girls a high height above 75 percentile of the value for Warsaw youth population [Palczewska & Niedźwiecka, 1999] was stated for 25.5% of the subpopulation, while very high (height>90 percentile) for 9.8%.

DISCUSSION

The analyzed youth population was characterized with average anthropometrical parameters values, very similar to

TABLE 4. The comparison of anthropometrical parameters of separated clusters in boys population.

Parameter	Cluster 1		Cluster 2		Cluster 3		Boys total		p
	N=10		N=5		N=29		N=44		
	x	SEM	x	SEM	x	SEM	x	SEM	
Height, cm	169.0	1.33	159.2	3.99	158.4	0.92	160.9	1.03	<0.0001
Body mass, kg	56.7	2.46	62.8	7.45	45.3	0.87	49.8	1.49	<0.0001
Arm circumference, cm	23.2	0.56	25.6	1.49	21.1	0.27	22.1	0.35	<0.0001
TSF, mm	8.5	0.56	15.8	1.04	9.0	0.41	9.7	0.46	<0.0001
BSF, mm	5.7	0.36	17.6	1.28	7.8	0.45	8.4	0.61	<0.0001
SCSF, mm	7.1	0.34	15.4	2.80	6.7	0.27	7.8	0.54	<0.0001
SISF, mm	7.7	0.65	21.1	2.29	7.6	0.51	9.1	0.78	<0.0001
BMI, kg/m^2	19.8	0.66	24.5	1.91	18.0	0.29	19.2	0.44	<0.0001
FM, kg	7.2	0.49	14.7	2.03	6.0	0.35	7.3	0.53	<0.0001
FFM, kg	49.5	2.05	48.1	5.45	39.2	0.59	42.6	1.08	<0.0001
% FM, %	12.6	0.52	23.2	0.69	13.1	0.55	14.2	0.63	<0.0001
AMC, cm	20.5	0.47	20.7	1.66	18.3	0.21	19.1	0.29	0.0004

TSF – triceps skinfold; BSF - biceps skinfold; SCSF – subscapular skinfold; SISF – supra-iliac skinfold; BMI – body mass index; FM – fat mass in the body; FFM – fat-free body mass; %FM – fat mass percentage; AMC – arm muscles circumference; N – sample size; p – significance level for single-factor variance analysis; x – mean value; SEM – standard error of mean.

TABLE 5. The comparison of anthropometrical parameters of separated clusters in girls population.

Parameter	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Girls total		p
	N=18		N=16		N=8		N=9		N=51		
	x	SEM	x	SEM	x	SEM	x	SEM	x	SEM	
Height, cm	154.6	1.27	161.8	1.03	166.0	2.47	153.5	1.26	158.5	0.95	<0.0001
Body mass, kg	44.6	1.51	47.8	1.83	71.7	4.43	51.4	2.63	51.0	1.71	<0.0001
Arm circumference, cm	21.1	0.41	21.1	0.56	27.6	0.46	23.1	0.63	22.5	0.42	<0.0001
TSF, mm	12.3	0.56	10.3	0.71	19.1	0.83	18.1	0.55	13.7	0.60	<0.0001
BSF, mm	10.2	0.52	9.4	0.44	19.7	1.71	15.2	0.69	12.3	0.64	<0.0001
SCSF, mm	8.8	0.59	7.8	0.51	16.8	1.62	12.6	1.08	10.4	0.60	<0.0001
SISF, mm	10.3	0.74	9.4	0.79	19.3	2.14	14.7	0.98	12.2	0.71	<0.0001
BMI, kg/m2	18.6	0.49	18.3	0.69	25.9	0.96	21.7	0.90	20.2	0.52	<0.0001
FM, kg	10.6	0.60	10.6	0.76	22.7	2.13	14.8	0.95	13.2	0.78	<0.0001
FFM, kg	34.0	0.93	37.2	1.09	49.0	2.36	36.6	1.73	37.8	0.96	<0.0001
% FM, %	23.4	0.64	21.7	0.78	31.4	1.00	28.6	0.57	25.0	0.63	<0.0001
AMC, cm	17.2	0.32	17.8	0.42	21.6	0.31	17.5	0.56	18.1	0.29	<0.0001

TSF – triceps skinfold; BSF – biceps skinfold; SCSF – subscapular skinfold; SISF – supra-iliac skinfold; BMI – body mass index; FM – fat mass in the body; FFM – fat-free body mass; %FM – fat mass percentage; AMC – arm muscles circumference; N – sample size; p – significance level for single-factor variance analysis; x – mean value; SEM – standard error of mean.

the values (corresponding age group) given by Palczewska and Niedźwiecka [1999] for Warsaw youth, acknowledged as population comparative in the children and youth nutritional status evaluation in Poland. On the other hand, Szponar and Rychlik [1996 a, b] revealed among 13-year old youngsters living across whole country smaller body mass and height and the BMI values, correspondingly for about 5 kg, 2–5 cm and 1–2 kg/m^2 in comparison to the values gathered in this work.

Girls accepted to cluster 1, which were described as characterized with medium body fattening and low height and small FFM values, had body height and arm circumference corresponding with 25th percentile of the compared population [Palczewska & Niedźwiecka, 1999], body mass located between 25th and 50th percentile, and supra-iliac skinfold thickness and the BMI corresponding with 50th percentile of 13-year old Warsaw girls (Table 5). Girls accepted to cluster 2 had arm circumference corresponding with the value of Warsaw girls 25th percentile, the BMI and subscapular skinfold – between 25th and 50th percentile and body height located between 50th and 75th percentile, which confirms that this cluster was characterized with small fattening and average height and average fat-free body mass content. The highest mean body height was stated for girls from the 3rd cluster – 166.0 cm, which corresponded with body height for 90th percentile of 13-year old Warsaw girls [Palczewska & Niedźwiecka, 1999]. The arm circumference for girls from this cluster corresponded with the value for 90th percentile of Warsaw girls, subscapular skinfold thickness exceeded the value for 90th percentile, while body mass amounted to as much as 71.7 kg and exceeded the value for 97th Warsaw girls percentile. It means that girls from the 3rd cluster were high and much fatty. A big fat tissue content was reported also for girls accepted to cluster 4, however their body height (amounting approximately 153.5cm) did not exceed the value of 25th percentile for Warsaw girls. But the body mass, the arm circumference and subscapular skinfold thickness for girls from the 4th cluster were approximately big values – they were located between 50th and 75th percentile. Girls from cluster 4 ("low and fatty") in comparison to girls from cluster 3 ("high and fatty") had however smaller fat content in the body, 28.6% vs. 31.4% respectively, but both numbers are the evidence for big fat tissue content. In total, girls with big fat tissue content (cluster 3 and 4) constituted 33.3% of the subpopulation, and girls moderately fatted (cluster 1) – 35.3%.

In boys subpopulation the most numerous was cluster 3 (65.9%), characterized with small fat and muscles tissue content. The arm circumference for boys of this cluster corresponded with the value for 25th percentile of 13-year old Warsaw boys [Palczewska & Niedźwiecka, 1999], body mass and the BMI – were located between 25th a 50th percentile, and subscapular skinfold thickness – the value for 50th percentile (Table 4). Boys accepted to cluster 1 were characterized as a group with small fattening, but counted arm circumference mean values corresponded with the values for 50th percentile of 13-year old Warsaw boys, the BMI and subscapular skinfold thickness were located between 50th and 75th percentile, and body mass exceeded the value for 75th percentile of Warsaw boys [Palczewska & Niedźwiecka, 1999]. Boys from cluster 1 had body height amounting approximately 169.0 cm, which corresponded with the value for 90th percentile of Warsaw boys, and body fat percentage for this cluster boys was the lowest and amounted to 12.6%. It confirms the correctness of cluster 1 separation as a group with low fat tissue content, and big – muscles content. In total, boys with small fattening and big or small fat-free tissue content (cluster 1 and 3) constituted 88.6% of the subpopulation. The least numerous group was separated of boys from cluster 2. The mean boys skinfold thickness from this cluster was twice higher than this skinfold thickness of boys from cluster 1 and 3 (correspondingly 15.4 cm vs. 7.1 cm and 6.7 cm) and exceeded the value for 90th percentile of Warsaw boys [Palczewska & Niedźwiecka, 1999]. Similarly high value (over 90th percentile) was stated for the BMI, however the arm circumference corresponded with the value for 75th percentile, and body fat percentage amounted to 23.2% and was twice higher than for boys from cluster 1 and 3. It confirms that boys from cluster 2 were characterized with very big fattening and quite big fat-free tissue content.

TABLE 6. The selected anthropometrical parameters distribution in ranges separated after percentiles values of Warsaw youth population [Palczewska & Niedźwiecka, 1999].

Parameter/range	Population percentage [%]		
	In total N=95	Girls N=51	Boys N=44
Body mass			
<10 percentile	7.4	7.8	6.8
<25 percentile	18.9	25.5	11.4
in the norm 25–75 percentile	54.7	37.3	75.0
>75 percentile	26.3	37.3	13.6
>90 percentile	13.7	19.6	6.8
Height			
<10 percentile	7.4	7.8	6.8
<25 percentile	23.2	25.5	20.5
in the norm 25–75 percentile	52.6	49.0	56.8
>75 percentile	24.2	25.5	22.7
>90 percentile	8.4	9.8	6.8
BMI			
<10 percentile	9.5	13.7	4.5
<25 percentile	17.9	19.6	15.9
in the norm 25–75 percentile	54.7	39.2	72.7
>75 percentile	27.4	41.2	11.4
>90 percentile	16.8	23.5	9.1
SCSF			
<10 percentile	2.1	3.9	0.0
<25 percentile	12.6	15.7	9.1
in the norm 25–75 percentile	61.1	49.0	75.0
>75 percentile	26.3	35.3	15.9
>90 percentile	11.6	15.7	6.8
Arm circumference			
<10 percentile	12.6	15.7	9.1
<25 percentile	36.8	35.3	38.6
in the norm 25–75 percentile	48.4	43.1	54.5
>75 percentile	14.7	21.6	6.8
>90 percentile	8.4	11.8	4.5

SCSF – subscapular skinfold; BMI – body mass index.

The comparison of anthropometrical parameters distribution results and cluster analysis results indicates differences in the youth nutritional status evaluation. Moreover, which seems to be particularly important, the evaluation held on the basis of features distribution analysis was limited only to those features for which standards were elaborated and as a result only 5 parameters were analyzed [Palczewska & Niedźwiecka, 1999]. In the cluster analysis it was stated that the most numerous group (65.9% of the subpopulation – cluster 3) constituted of boys with small fattening and small muscles and body mass; in the factors distribution analysis the small body mass (<10 percentile) was revealed almost among 10-time smaller boys group – 6.8%. The size of boys subpopulation with small arm circumference (<10 percentile) accounted to 9.1%, and for no boy the small subscapular skinfold thickness (SCSF<10 percentile) was stated. From single parameters distribution analysis it does not appear if boys with small body mass had also small fattening and small muscles mass. Analogically such variations in evaluation appeared among girls. Girls with big fat tissue in total content constituted 33.3% of the subpopulation (cluster 3 and 4). Based on factors distribution analysis obesity was stated in smaller girls group: 19.6% if the criterion was the body mass (>90 percentile), 23.5% if the criterion was BMI (>90 percentile) and 15.7%, if the criterion was subscapular skinfold thickness (SCSF>90 percentile).

The executed statistical analysis with the use of factors and cluster analysis enabled executing of very wide nutritional status evaluation, based on many body content evaluation parameters applied simultaneously. Because of applied mathematical procedures it was stated, which of nutritional status and with what value occurred simultaneously, giving a full view and detailed characteristic of nutritional status, in view of analyzed anthropometrical parameters. The obtained results were unequivocal, in contrast to results of single anthropometrical parameters distribution analysis.

CONCLUSIONS

1. The applied statistical methods, *i.e.* factor and cluster analysis, enabled multi-featured evaluation of the examined youth nutritional status.

2. A big differentiation in nutritional status among girls was revealed, while among boys the most numerous group was that with boys with small fat and muscles tissue content.

REFERENCES

1. Ferro-Lucci A., Sette S., Franklin M., James W.P.T., A simplified approach to assessing adult chronic energy deficiency. Eur. J. Clin. Nutr., 1992, 46, 173–186.
2. Fogelholm M., Diet, physical activity and health in Finnish adolescents in the 1990s. Scand. J. Nutr., 1998, 42, 10-20.
3. Gawęcki J., Wagner W., 1984, Podstawy metodologii badań doświadczalnych w nauce o żywieniu i żywności. PWN, Warszawa (in Polish).
4. Gibson R., 1990, Principles of nutritional assessment. Oxford University Press, New York, Oxford.
5. Heymsfield S.B., Williams P.J., Nutritional assessment by clinical and biochemical methods, 1988, *In*: Modern nutrition in health and disease (ed. Shils M.E., Young V.R. Lea Febiger), Philadelphia, Ed. 7th, Ch. 45, 817–860.
6. Lloyd T., Chinchilli V.M., Rollings N., Kieselhorst K., Tregea D.F., Henderson N.A., Sinoway L.I., Fruit consumption, fitness, and cardiovascular health in female adolescents: the Pen State Young Women's Health Study. Am. J. Clin. Nutr., 1998, 67, 624–630.
7. Marek T., Noworol Cz., 1987, Zarys analizy skupień – niehierarchiczne i hierarchiczne techniki skupiania. W.J. Brzeziński (ed.). Wielozmiennowe modele statystyczne w badaniach psychologicznych. PWN. Poznań (in Polish).
8. Mezzich J.E., Solomon H., 1980, Taxonomy and Behavioral Science, Academic Press, New York.
9. Middleman A.B. Vazquez I., Durant R.H., Eating patterns, physical activity and attempts to change weight among adolescents. J. Adolesc. Health, 1998, 22, 37–42.
10. Molnar D., Schutz Y., Fat oxidation in nonobese and obese adolescents: effect of body composition and pubertal development. J. Pediatr., 1998, 132, 98–104.

11. Ortega R.M., Requejo A.M., Andres P., Lopez-Sobaler A.M., Redondo R., Gonzalez-Fernandez M., Relationship between diet composition and body mass index in a group of Spanish adolescents. Brit. J. Nutr., 1995, 74, 765–773.
12. Ortega-Anta R.M., Andres-Carvajales P., Requejo--Marcos A.M., Lopez-Sobaler A.M., Redondo-Sobrado M.R., Gonzalez-Fernandez M., The food habits and energy and nutrient intake in overweight adolescents compared to those with normal weight. An. Esp. Pedriatr., 1996, 44, 203–208.
13. Palczewska I., Niedźwiecka Z., Tabele charakterystyk liczbowych i wskaźników antropometrycznych dzieci i młodzieży warszawskiej. Zakład Rozwoju Dzieci i Młodzieży, Instytut Matki i Dziecka, Warszawa, 1999 (unpublished) (in Polish).
14. Parker D.R., Gonzalez S., Derby C.A., Gans K.M., Lasater T.M., Carleton R.A., Dietary factors in relation to weight change among men and women from two southeastern New England communities. Int. J. Obes., 1997, 21, 103–109.
15. Szponar L., Rychlik E., Nutrition mode and nutritional status of boys and men in Poland. Żyw. Człow. Met., 1996a, 23, Supl. 2, 3-37.
16. Szponar L., Rychlik E., Nutrition mode and nutritional status of girls and women in Poland. Żyw. Człow. Met., 1996b, 23, Supl. 2, 38–70.
17. Twisk J.W., Van Mechelen W., Kemper H.C., Post G.B., The relation between “long-term exposure” to lifestyle during youth and young adulthood and risk factors for cardiovascular disease at adult age. J. Adolesc. Health, 1997, 20, 309–319.
18. Wądołowska L., Cichon R., Aktywność fizyczna a masa ciała i jej skład u młodzieży w wieku od 16 do 19 lat. Nowa Medycyna. Medycyna w Sporcie IV, 2000, 108, 12, 45–48 (in Polish).
19. Wądołowska L., Słowińska M.A., Cichon R., Diety odchudzające a stan odżywienia, spożycie energii i aktywność fizyczna młodzieży. Nowiny Lekarskie, 2001 (accepted for publication) (in Polish).
20. WHO. Physical status: the use and interpretation of anthropometry. Technical Report Series 854. Genewa, 1995.

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ZASTOSOWANIE ZAAWANSOWANYCH TECHNIK EKSPLORACYJNYCH W OCENIE STANU ODŻYWIENIA MŁODZIEŻY

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Celem pracy było zastosowanie zaawansowanych metod analizy statystycznej w ocenie stanu odżywienia młodzieży i wyodrębnienie jednorodnych grup uwzględniających wiele różnych parametrów antropometrycznych. Badaniami objęto 95 uczniów w wieku 13.1±0.04 lat. Przeprowadzono pomiary masy i wysokości ciała, obwodu ramienia oraz grubości 4 fałdów skórno-tłuszczowych. Obliczono: BMI (kg/m^2), obwód mięśni ramienia (AMC, cm), beztłuszczową masę ciała (FFM, kg), masę tłuszczu (FM, kg) i odsetek tłuszczu w ciele (%FM, %). Ponadto zebrano informacje charakteryzujące styl życia i sposób żywienia badanej młodzieży. Spośród 12 parametrów antropometrycznych na podstawie analizy czynnikowej wyodrębniono czynniki główne (tab. 1), w oparciu o które na podstawie analizy skupień utworzono jednorodne skupienia – grupując w nich osoby charakteryzujące się podobnym stanem odżywienia (rys. 1, 2). Do grupowania obiektów zastosowano metodę k-średnich.

Na podstawie analizy skupień w grupie chłopców wyodrębniono 3 skupienia charakteryzujące się: 1) małym otłuszczeniem ciała oraz dużymi wartościami FFM, AMC i masy ciała – 22.7% subpopulacji; 2) bardzo dużym otłuszczeniem oraz względnie dużymi wartościami FFM, AMC i masy ciała – 11.4% subpopulacji; 3) małym otłuszczeniem oraz małymi wartościami FFM, AMC i masy ciała – 65.9% subpopulacji (tab. 2). Wśród dziewcząt wyróżniono 4 skupienia charakteryzujące się: 1) umiarkowanym otłuszczeniem ciała oraz małą wysokością i małymi wartościami FFM – 35.3% subpopulacji; 2) małym otłuszczeniem oraz przeciętną wysokością i przeciętnymi wartościami FFM – 31.4% subpopulacji; 3) dużym otłuszczeniem oraz dużą wysokością i dużymi wartościami FFM – 15.7% subpopulacji; 4) dużym otłuszczeniem oraz małą wysokością i małymi wartościami FFM – 17.6% subpopulacji (tab. 3). Poprawność przeprowadzonego grupowania w jednorodne wewnętrznie skupienia potwierdzono analizą wariancji (tab. 4, 5). Na podstawie analizy rozkładów 5 wybranych parametrów antropometrycznych nie uzyskano jednoznacznej charakterystyki stanu odżywienia badanej młodzieży (tab. 6). Zastosowane zaawansowane metody statystyczne, tj. analiza czynnikowa oraz skupień, umożliwiły wieloaspektową ocenę stanu odżywienia badanej młodzieży.