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THE RELATIONS BETWEEN CHILDREN'S BODY MASS INDEX AND SELECTED HEMODYNAMIC PARAMETERS OF CIRCULATORY SYSTEM DURING PHYSICAL EFFORT

ABSTRACT: The authors indicate that body mass is the factor which can have influence on physical efficiency. Bad diet and lack of physical activity can be the reasons of overweight which can cause diseases of the circulatory system. This problem refers to children and youths too. WHO suggests using body mass index (BMI) to estimate state of nutrition and health connected with efficiency. The lack of univocal works concerning the problem of relations between BMI and hemodynamic parameters connected with physical efficiency determine the authors to undertaking the problem. The aim of the work was the estimation of connections between relative body mass of children and hemodynamic parameters of circulatory system as heart rates and blood pressure in rest and after effort. Research was carried out in autumn in 1998 and 1999 in some villages and town Polkowice in south-west Poland, where 293 pupils were examined. There were measured such parameters as: body mass and body height, relative body mass index (BMI), heart rates and systoles in rest, after 1 and 5 minutes after step-test, efficiency index (FI) and heart work index (HWI). Next the groups with lower BMI were compared to groups with higher BMI to estimate influence of relative body mass on physical efficiency. The t-Student test was used to estimate statistically significant differences between groups. Authors suppose that the factor analysed in work affects strongly on all parameters used in the analysis.

KEY WORDS: Children's BMI – Physical effort – Efficiency – Hemodynamic parameters – Poland

INTRODUCTION

The growth of civilisation diseases has been observed in high-level industrialised countries for recent years. Among the most important and most frequent health problems are circulatory system diseases, first of all blood overpressure, sclerosis or heart diseases. There are a lot of reasons of these problems. But it can be said that the major reasons are first of all hypokinesis and bad diet causing overweight or obesity.

The problem of the health and biological condition of young generation is a main aim in researches of the children (Hulanicka *et al.* 1990, Rywik *et al.* 1995, Malarecki 1979, Bielicki *et al.* 2001, Kozieł *et al.* 2000). The authorities say that metabolism troubles connected with bad nutrition and lack of physical activity appear earlier and earlier – nowadays in the second decade of life – and they are a very serious danger of diseases in adult life (Blair *et al.* 1988, Beunen 1994). World Health Organisation (WHO) recommend using body mass index (BMI) to estimate state of nutrition and health connected with efficiency. According to Malarecki (1979), physical fitness is based on high level of circulatory system, respiratory system, nervous system and metabolism. So, the scientists say that physical activity is one of the most important factors for proper development of all human organism's functions.

So, if we accept that circulatory system efficiency is connected with BMI in early age of life and it can be a

reason of diseases of that system in adult life, research of the relations between body mass and circulatory system parameters should be provided in early phases of ontogenesis.

Physical efficiency, as a significant component of physical fitness, is very important with reference to population of children and youth. Its higher level in childhood not only testifies to correctness in progressive development, but during the onset of adulthood has an effect on adult health, retards involution and reduces the risk of civilisation illnesses. It is also physiological component of endurance which allows to working hard without tiredness (Osiński 1994, Szopa *et al.* 1996). In this case control and estimation of physical efficiency is an important aspect of the care about biological quality of each population.

There are a lot of population tests indirectly measuring physical efficiency. One of them is Harvard step-test. It permits to estimate the adaptation of circulatory system to physical effort (Goncarzewicz *et al.* 1979). As mentioned in many works, physical efficiency depends on internal as well as external (environmental) factors (e.g. training). Physical efficiency is understood as a component of endurance ability. It depends on aerobic energy processes which allow long physical efforts. Physical efficiency depends on body composition (muscle mass first of all) and somatic type too (Ignasiak *et al.* 1997). Probably physical efficiency depends on sex too. Higher level of it was observed in boys than in girls in a lot of works (Osiński 1988, Mleczko 1991).

TABLE 1. Statistics of hemodynamic parameters in all boys and girls from A($\overline{x}$ – S) and B($\overline{x}$ + S) groups of BMI (joined places of living).

Parameter	Statistic	Boys		t	Girls		t
		A (N=64)	B (N=85)		A (N=64)	B (N=80)	
BMI	$\overline{x}$	14.32	22.92	–24.34	13.95	22.80	–26.90
	s	0.93	2.71		0.53	2.59	
	v	6.49	11.82		3.79	11.35	
HR in rest	$\overline{x}$	77.92	85.38	–2.84	83.57	88.97	–2.02
	s	14.99	15.29		16.42	14.76	
	v	19.24	17.91		19.65	16.59	
HR in 1' after effort	$\overline{x}$	98.08	113.69	–5.46	110.47	124.13	–3.52
	s	13.63	17.98		20.23	22.00	
	v	13.90	15.81		18.31	17.72	
HR in 5' after effort	$\overline{x}$	86.87	94.97	–3.25	93.12	101.01	–2.13
	s	12.93	14.95		20.31	20.19	
	v	14.88	15.74		21.81	19.99	
Systols in rest	$\overline{x}$	96.95	108.75	–5.12	93.44	106.98	–4.64
	s	11.47	12.65		13.71	16.74	
	v	11.83	11.63		14.67	15.65	
Systols in 1' after effort	$\overline{x}$	103.64	121.26	–7.21	102.26	119.59	–5.19
	s	11.42	13.27		19.99	13.60	
	v	11.02	10.94		19.55	11.37	
Systols in 5' after effort	$\overline{x}$	97.33	111.77	–5.72	95.15	106.34	–4.42
	s	13.79	11.29		14.04	11.50	
	v	14.17	10.10		14.76	10.81	

TABLE 2. Statistics of relative indicators in all boys and girls from A($\overline{x}$ – S) and B($\overline{x}$ + S) groups of BMI (joined places of living).

Indicator	Statistic	Boys		t	Girls		t
		$\overline{x}$ – S (N=64)	$\overline{x}$ + S (N=85)		$\overline{x}$ – S (N=64)	$\overline{x}$ + S (N=80)	
FI	$\overline{x}$	63.59	56.98	2.64	50.49	42.87	3.41
	s	16.85	11.56		11.22	8.11	
	v	26.50	20.29		22.22	18.92	
HWI in rest	$\overline{x}$	0.84	1.02	–4.00	0.84	1.05	–3.99
	s	0.21	0.26		0.24	0.30	
	v	25.00	25.49		28.57	28.57	
HWI in 1' after effort	$\overline{x}$	1.13	1.56	–6.94	1.27	1.67	–4.98
	s	0.24	0.36		0.39	0.42	
	v	21.24	23.08		30.71	25.15	
HWI in 5' after effort	$\overline{x}$	0.92	1.15	–5.11	0.94	1.15	–2.95
	s	0.22	0.23		0.28	0.40	
	v	23.91	20.00		29.79	34.78	

Physical efficiency, as positive health index, is an important biological value not only for contemporary men. It is also a social value which allows effective work and daily activity.

The main aim of our work is the estimation of connections between relative body mass of children (BMI) and hemodynamic parameters of circulatory system, as heart rates and blood pressure in rest and after effort.

MATERIAL AND METHODS

The material was obtained in 1998 and 1999 during complex research of school children (8.5–11.5 years old) from villages Kotla, Kromolin, Rosochata, Rzeszotary, Brzeg Głogowski, Nielubia and small town Polkowice situated in industrial south-west region of Poland called Coppermine District. The basic somatic traits were measured: body height and body mass. On its basis body mass index (BMI) was calculated. On the basis of BMI values all children were divided into two groups: A. with low BMI values (mean–1S)–64> and 64+; B. high BMI values (mean+1S)–85> and 80+. The basic hemodynamic parameters of circulatory system such as heart rate (HR) and blood-pressure (systols) in three kinds of situations: before Harvard step-test and in the 1st and 5th minutes after step-test were analysed in both groups. Additionally efficiency index (FI) and heart work index (HWI) were

TABLE 3. Statistics of hemodynamic parameters in rural boys and girls from A($\bar{x}$ – S) and B($\bar{x}$ + S) groups of BMI.

Parameter	Statistic	Boys A (N=32)	Boys B (N=42)	t	Girls A (N=33)	Girls B (N=35)	t
BMI	$\bar{x}$	14.52	22.59	–15.73	13.89	22.51	–20.56
	s	1.08	2.74		0.56	2.34	
	v	7.45	12.14		4.04	10.42	
HR in rest	$\bar{x}$	75.66	79.97	–1.34	81.00	84.68	–0.97
	s	12.89	13.86		16.18	13.68	
	v	17.04	17.33		19.98	16.15	
HR in 1' after effort	$\bar{x}$	98.09	108.20	–2.72	108.24	118.18	–2.05
	s	12.47	17.26		20.88	15.22	
	v	12.71	15.95		19.29	12.88	
HR in 5' after effort	$\bar{x}$	86.69	92.53	–2.00	90.90	101.89	–2.34
	s	10.24	13.50		21.54	12.73	
	v	11.82	14.59		23.70	12.50	
Systols in rest	$\bar{x}$	96.32	106.58	–3.58	94.07	107.81	–3.51
	s	10.58	12.78		13.84	16.52	
	v	10.99	11.99		14.72	15.33	
Systols in 1' after effort	$\bar{x}$	105.81	122.83	–5.94	104.74	120.71	–4.14
	s	10.49	12.54		15.03	13.59	
	v	9.91	10.21		14.35	11.26	
Systols in 5' after effort	$\bar{x}$	98.06	111.94	–5.17	98.41	109.32	–3.34
	s	11.19	10.62		12.63	11.59	
	v	11.41	9.49		12.83	10.60	

TABLE 4. Statistics of relative indicators in rural boys and girls from A($\bar{x}$ – S) and B($\bar{x}$ + S) groups of BMI.

Indicator	Statistic	Boys $\bar{x}$ – S (N=32)	Boys $\bar{x}$ + S (N=42)	t	Girls $\bar{x}$ – S (N=33)	Girls $\bar{x}$ + S (N=35)	t
FI	$\bar{x}$	56.45	51.75	2.38	52.15	46.94	2.31
	s	6.90	8.83		10.21	6.35	
	v	12.23	17.06		19.57	13.54	
HWI in rest	$\bar{x}$	0.83	0.97	–2.50	0.86	1.05	–2.72
	s	0.21	0.23		0.27	0.30	
	v	25.11	23.92		31.24	28.49	
HWI in 1' after effort	$\bar{x}$	1.17	1.59	–4.92	1.32	1.69	–3.59
	s	0.23	0.37		0.39	0.37	
	v	19.51	23.44		29.89	22.14	
HWI in 5' after effort	$\bar{x}$	0.94	1.18	–4.16	1.00	1.27	–3.80
	s	0.19	0.24		0.27	0.26	
	v	20.41	20.19		26.65	20.85	

calculated (Goncarzewicz *et al.* 1979). The Harvard step-test was used as physical efficiency test. T-Student test was used to estimate statistical significance of differences between mean values.

RESULTS

All statistics are shown in *Tables 1–6*. Statistically significant differences on p≤0.05 level were marked by bold type and asterisks.

Physical efficiency of human organism is an ability poligenetically conditioned, so besides genetic factors the environmental factors have an influence on its level, first of all physical activity. The basis of physical efficiency is the ability of circulatory system, which decides about adaptation possibilities of the organism. The basic parameters estimating circulatory system's performance are heart rates and blood pressure.

The girl's heart rates in rest are in normotonic border reaction and do not indicate higher emotional stimulation. In both groups of sex children with lower BMI have better and statistically significant level of heart rates in rest (*Figures 1, 2*). We observed the same direction of differences in heart rates in 1 and 5 minutes after effort. The children with higher BMI had worse values of that parameter, and all differences were statistically significant.

TABLE 5. Statistics of hemodynamic parameters in urban boys and girls from A($\bar{x}$ – S) and B($\bar{x}$ + S) groups of BMI.

Parameter	Statistic	Boys A (N=32)	Boys B (N=43)	t	Girls A (N=31)	Girls B (N=45)	t
BMI	$\bar{x}$	14.13	23.25	–18.84	14.00	23.02	–17.91
	s	0.71	2.66		0.51	2.76	
	v	5.02	11.45		3.63	12.01	
HR in rest	$\bar{x}$	81.29	90.86	–2.39	87.79	91.80	–1.03
	s	17.10	15.09		17.94	14.94	
	v	21.04	16.61		20.44	16.27	
HR in 1' after effort	$\bar{x}$	98.07	119.55	–5.06	113.17	128.20	–2.53
	s	15.09	17.31		19.51	24.99	
	v	15.39	14.48		17.24	19.50	
HR in 5' after effort	$\bar{x}$	87.07	97.81	–2.58	95.91	100.41	–0.77
	s	15.64	16.24		18.75	24.13	
	v	17.96	16.60		19.55	24.03	
Systols in rest	$\bar{x}$	97.75	113.59	–4.12	92.59	106.10	–3.02
	s	12.72	11.24		13.81	17.22	
	v	13.01	9.89		14.92	16.23	
Systols in 1' after effort	$\bar{x}$	100.83	116.67	–3.42	98.74	118.46	–3.43
	s	12.18	14.81		25.50	13.76	
	v	12.07	12.69		25.82	11.61	
Systols in 5' after effort	$\bar{x}$	96.38	111.25	–2.66	90.53	103.36	–3.42
	s	16.78	13.55		14.96	10.80	
	v	17.41	12.18		16.52	10.45	

TABLE 6. Statistics of relative indicators in urban boys and girls from A($\bar{x}$ – S) and B($\bar{x}$ + S) groups of BMI.

Indicator	Statistic	Boys $\bar{x}$ – S (N=32)	Boys $\bar{x}$ + S (N=43)	t	Girls $\bar{x}$ – S (N=31)	Girls $\bar{x}$ + S (N=45)	t
FI	$\bar{x}$	71.79	62.06	2.35	40.86	34.10	1.86
	s	20.89	11.73		13.13	2.55	
	v	29.11	18.90		32.13	7.49	
HWI in rest	$\bar{x}$	0.85	1.14	–3.79	0.83	1.06	–2.92
	s	0.22	0.28		0.21	0.31	
	v	25.45	24.38		25.44	29.26	
HWI in 1' after effort	$\bar{x}$	1.08	1.47	–4.11	1.21	1.66	–3.49
	s	0.24	0.33		0.39	0.46	
	v	21.87	22.37		32.11	28.01	
HWI in 5' after effort	$\bar{x}$	0.90	1.06	–2.12	0.87	1.03	–1.38
	s	0.25	0.15		0.29	0.47	
	v	27.71	14.34		33.46	45.47	

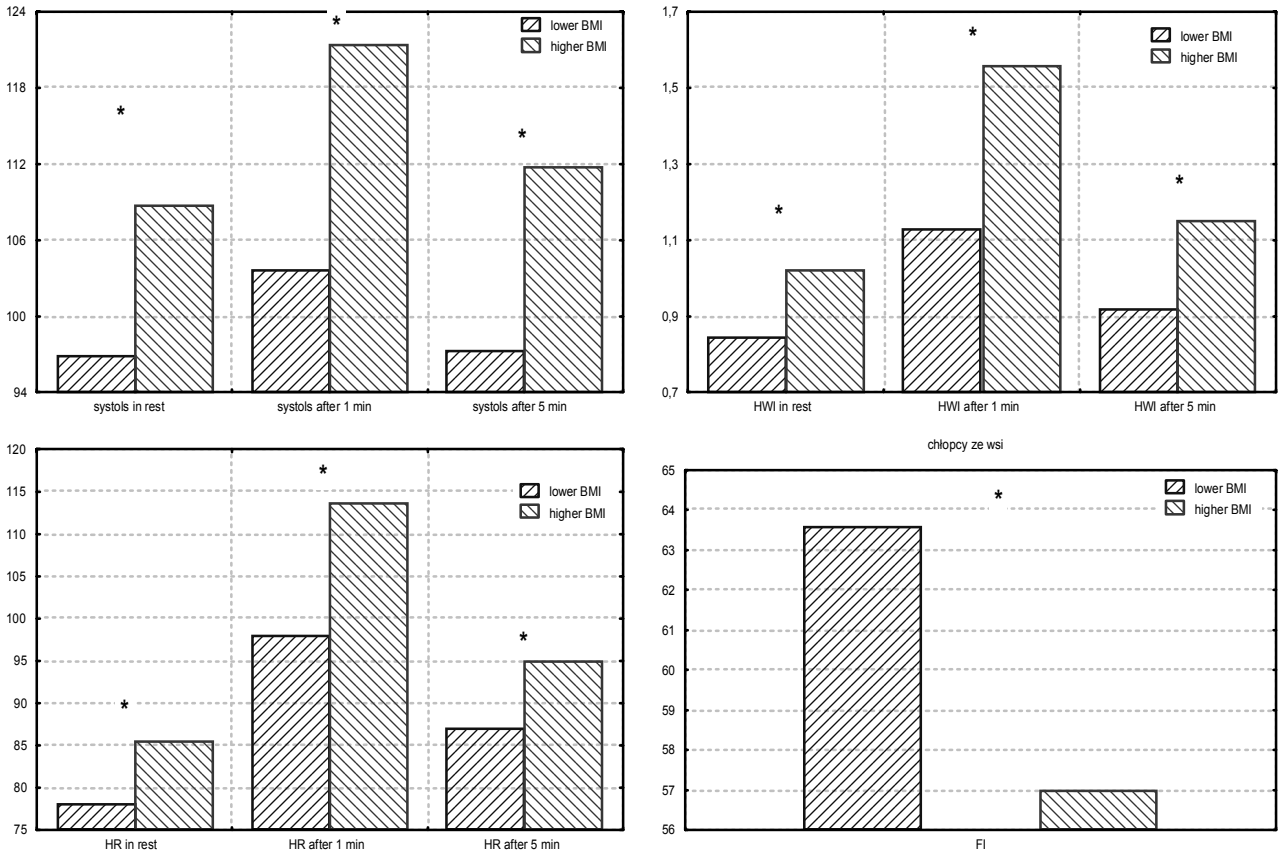

FIGURE 1. Mean values of HR, blood pressure, FI and HWI in rest, in 1' and 5' after effort in boys' groups.

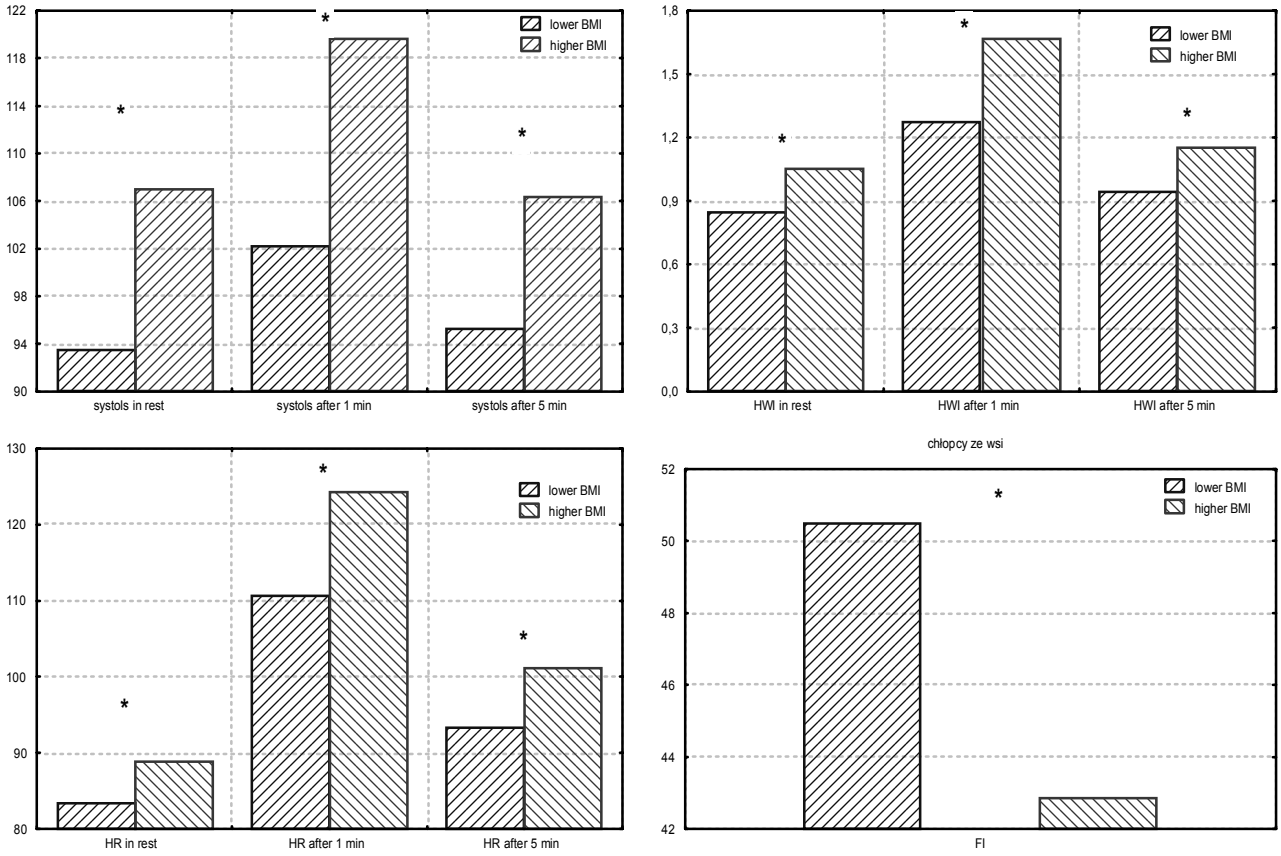

FIGURE 2. Mean values of HR, blood pressure, FI and HWI in rest, in 1' and 5' after effort in girls' groups.

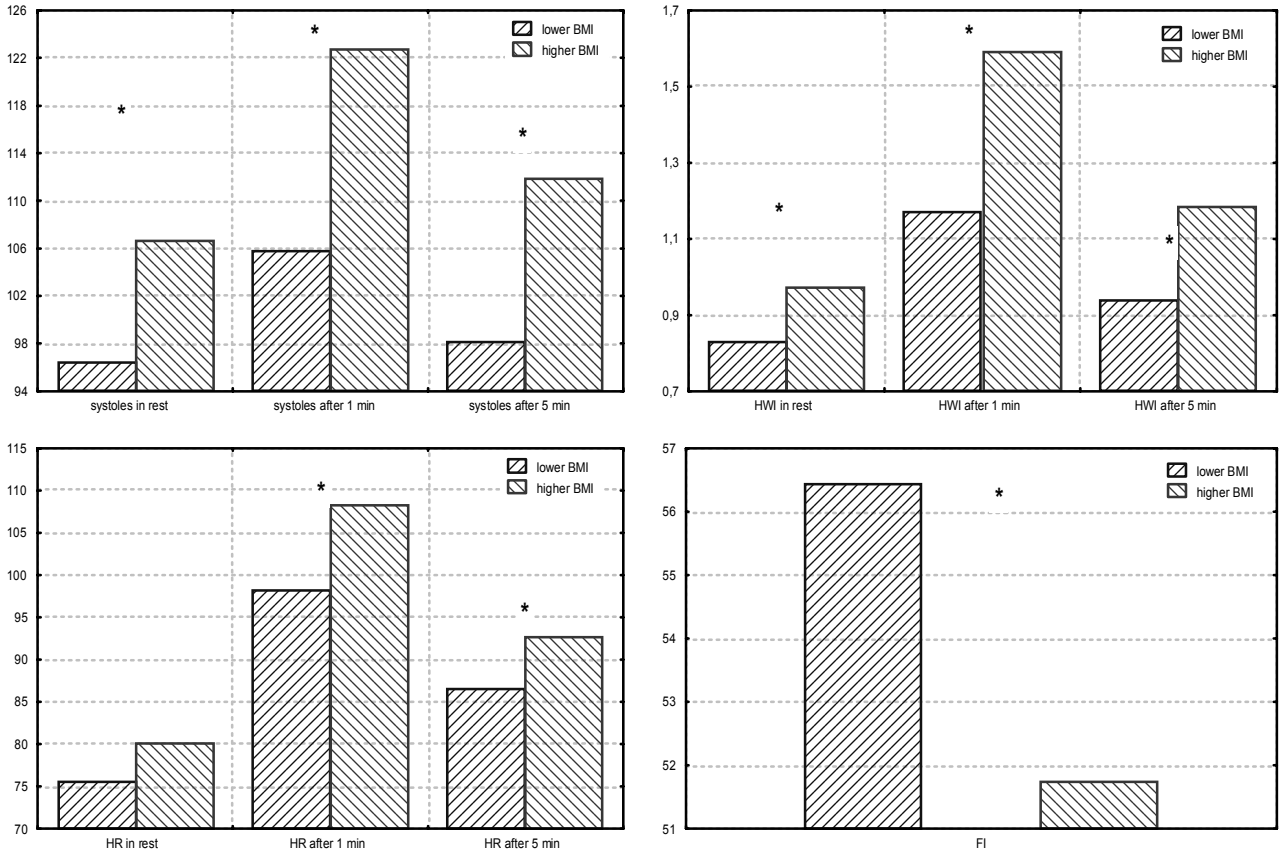

FIGURE 3. Mean values of HR, blood pressure, FI and HWI in rest, in 1' and 5' after effort in rural boys' groups.

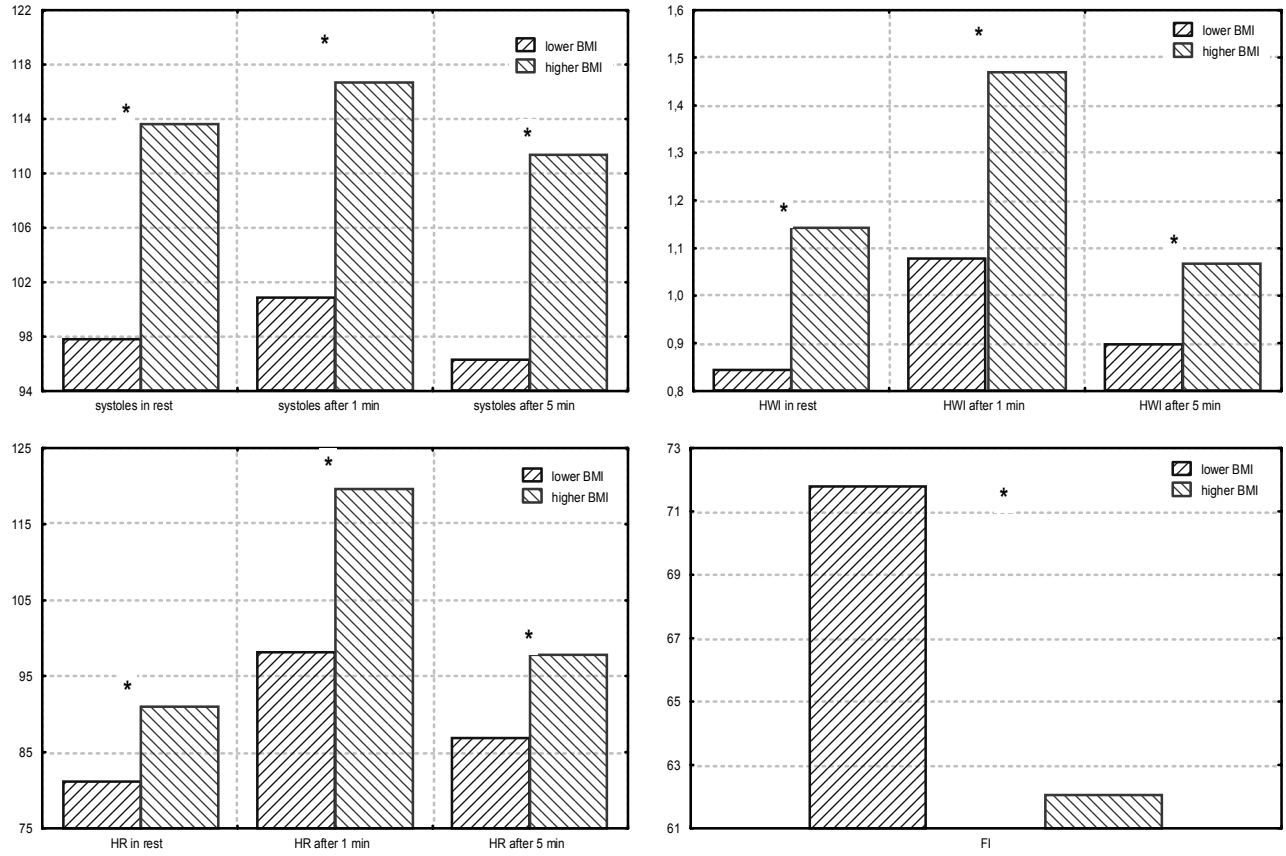

FIGURE 4. Mean values of HR, blood pressure, FI and HWI in rest, in 1' and 5' after effort in town Polkowice boys' groups.

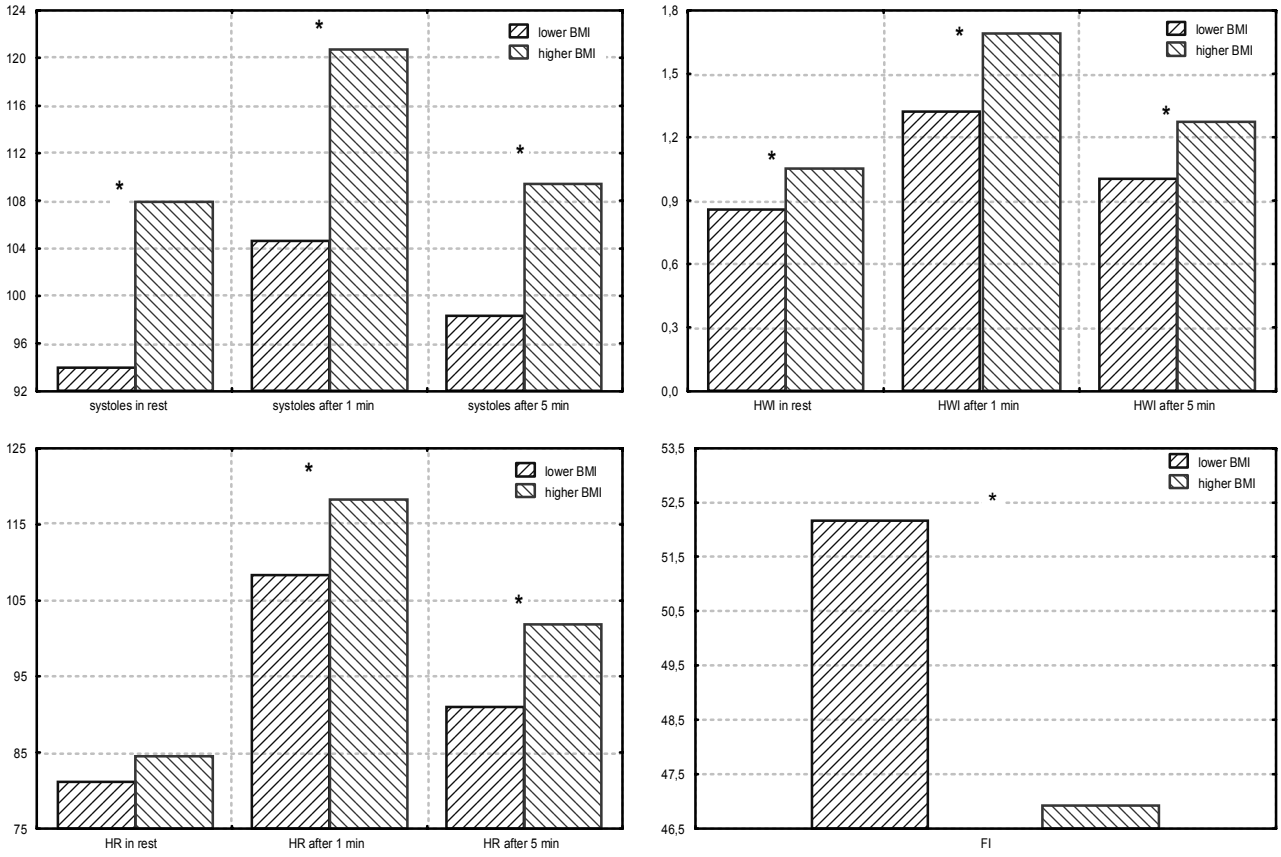

FIGURE 5. Mean values of HR, blood pressure, FI and HWI in rest, in 1' and 5' after effort in rural girls' groups.

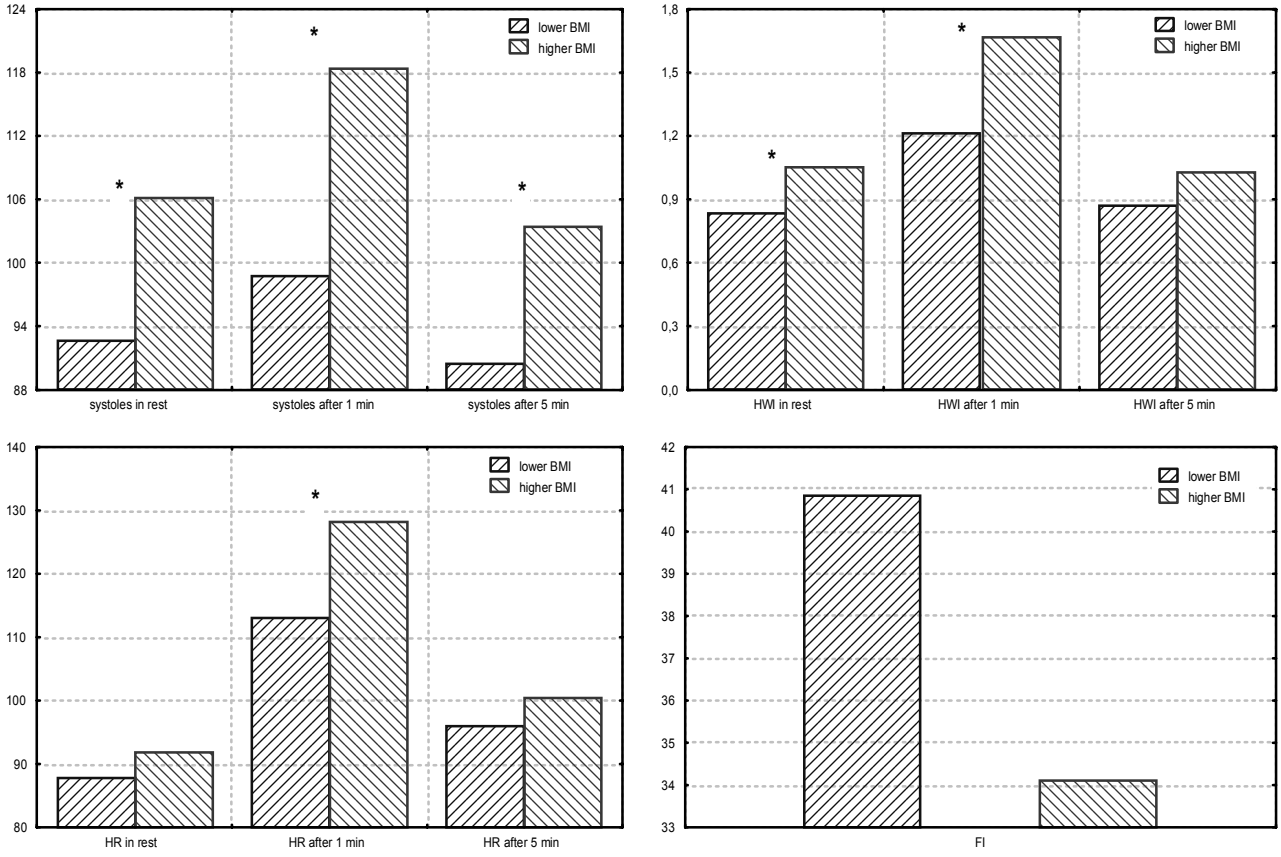

FIGURE 6. Mean values of HR, blood pressure, FI and HWI in rest, in 1' and 5' after effort in town Polkowice girls' groups.

The data on blood pressure is similar to heart rates. As in rest as after effort systoles are lower in children with lower relative body mass. It concerns boys as well as girls (*Figures 1, 2*).

The two relative parameters were calculated on the basis of heart rates and blood pressure. It was efficiency index (FI) and heart work index (HWI). The criteria of estimation were the same as proposed by Goncarzewicz *et al.* (1979). Analysis of values of these indexes suggests that physical efficiency both boys and girls is on higher level. The children with lower BMI had better values of this parameter than their colleagues with higher BMI. Analysis of the heart work index suggests similar conclusions. Both boys and girls with lower relative body mass had better values of HWI than the groups of children with higher BMI (*Figures 1, 2*).

With regard to the fact that examined population of children live in villages and a small town in the ecologically endangered Coppermine District, we decided to estimate measured parameters against urbanisation factor.

Body mass index differentiated all measured parameters of circulatory system independently of area of living. The boys from villages and town with lower BMI have better level of heart rates, blood pressure and efficiency index and heart work index than boys from villages or town with higher BMI. Almost all differences were statistically significant (*Figures 3, 4*).

In both groups of girls measured features had the same direction of changes, but differences in urban girls groups were more often statistically significant (*Figures 5, 6*).

If we accept that physical efficiency, determined by environmental factors, is the feature more labile (Siniarska 1984, Szopa, Żak 1986), and also more ecosensitive in boys than in girls, more statistically significant differences in boys groups from both environments are expected.

The analysis of results suggests that relative body mass index (BMI) is a parameter which differentiates circulatory system's features in early phase of ontogenesis.

CONCLUSIONS

1. The results that we obtained suggest that relative body mass index (BMI) connects with level of basic circulatory system's features. The people with lower BMI have better values of it.
2. The urbanisation factor did not affect on directions of differences between children, both boys and girls, with different values of BMI.

REFERENCES

BEUNEN G., 1994: Size fatness and relative fat distribution of males of contrasting maturity status during adolescence and adults. *Intern. J. of Obesity*, 18, 670–678.

BIELICKI T., SZKLARSKA A., WELON Z., ROGUCKA E., 2001: Variation in the body mass index among Polish adults. Effects of sex, age, birth cohort and social class. *Amer. J. of Phys. Anthrop*. 116: 166–170.

BLAIR S. N., LUDWIG D. A., GOODYEAR N., 1988: A canonical analysis of central and peripheral subcutaneous fat distribution and coronary heart disease risk factors in men and women aged 18–65 years, *Hum. Biol.* 60, 1: 111–122.

GONCARZEWICZ M., KRAWCZYŃSKI M., CICHY W., 1979: *Kontrola lekarska wychowania fizycznego i sportu dzieci i młodzieży*. PZWL, Warszawa.

HULANICKA B., BRAJCZEWSKI C., JEDLIŃSKA W., SLAWIŃSKA T., WALISZKO A., 1990: *City – Town – Village. Growth of children in Poland in 1988.* PAN, Wrocław.

IGNASIAK Z., PIESIEWICZ E., PIESIEWICZ R., JANUSZEWSKI A., 1997: Próba określenia zależności pomiędzy wydolnością fizyczną, a wskaźnikami pracy u chłopców wiejskich ze środowiska ekologicznie zagrożonego. Materiały Konferencji Naukowej nt. "Dziecko w skażonym środowisku, problemy ekologiczne i zdrowotne", Legnica.

KOZIEŁ S., KOŁODZIEJ H., LIPOWICZ A., BOZNAŃSKI A., 2000: *Otłuszczenie a ryzyko chorób sercowo-naczyniowych u czternatoletniej młodzieży.* Monografie Zakładu Antropologii PAN, Wrocław.

MALARECKI I., 1979: Wydolność i sprawność fizyczna w świetle fizjologii człowieka. *Wychowanie Fizyczne i Sport* 14, 4, 45–63.

MLECZKO E., 1991: *Przebieg i uwarunkowania rozwoju funkcjonalnego dzieci krakowskich między 7 a 14 rokiem życia.* Wydawnictwo Monograficzne, 44, AWF, Kraków.

OSIŃSKI W., 1988: *Wielokierunkowe związki zdolności motorycznych i parametrów morfologicznych. Badania dzieci i młodzieży wielkomiejskiej z uwzględnieniem poziomu stratyfikacji społecznej*. Seria: Monografie, 261, AWF, Poznań.

OSIŃSKI W., 1994: Rozwój motoryczny człowieka w procesie ontogenezy. In: W. Osiński (Ed.): *Motoryczność człowieka – jej struktura, zmienność i uwarunkowania*. Monografie Podręczniki Skrypty, 310, AWF, Poznań.

RYWIK S., WĄGROWSKA H., PIOTROWSKI W., BRODA G., 1995: Otyłość jako czynnik ryzyka chorób układu krążenia. *Polski Tygodnik Lekarski.* Supp. 1: 63–67.

SINIARSKA A., 1984: Rozwój psychoruchowy mieszkańców niektórych regionów Polski o różnym stopniu uprzemysłowienia. In: *Rozwój fizyczny dziecka w środowisku przemysłowym.* Materiały Sympozjum Naukowego, Zeszyty Naukowe, 31, AWF, Kraków.

SZOPA J., MLECZKO E., ŻAK S., 1996: *Podstawy antropomotoryki*. PWN, Warszawa–Kraków.

SZOPA J., ŻAK S, 1986: Zmiany sprawności fizycznej dzieci i młodzieży Krakowa w latach 1974–1983 na tle trendu sekularnego wysokości ciała. *Wychowanie Fizyczne i Sport* 1: 36–45.

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