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A LONGITUDINAL STUDY OF THE BODY COMPOSITION AND THE PHYSICAL WORKING CAPACITY IN BUDAPEST PUPILS

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Abstract: *The authors studied the change of the body composition based on the LBM, TBF, BF% and E/P index, and the change of the physical working capacity on the basis of the PWC 170, PWC 170/BM and PWC 170/LBM in Budapest pupils between 11–13 years of age. The studied anthropological parameters show a significant increase by age. The significant differences of the body mass between the boys and the girls were caused by the different intensity of the TBF and the LBM. The mean values of the PWC were in each age of life significantly higher by the boys. The growth procession of the girls seemed to be equal in the studied age-intervals, while among the boys' between 12–13 years of age the increase of the body mass due to the significant rise in LBM was more intensive. The values of all of the three PWC parameters according to the passing age by girls were stagnated, but by the boys the PWC 170 have shown a steady increase while the PWC 170/BM and the PWC 170/LBM did not changed. On the basis of the simultaneous study of anthropological parameters and the working capacity, we may be concluded, that parallel with the increasing of the BF% decreases the working capacity, too.*

Key words: *Body composition; Working capacity; Budapest pupils.*

Introduction

The International Biological Programme involves investigations on various ecological systems. As a part of studies on the human adaptability, the human working capacity and physical fitness is assessed. Several authors dealt with the connection between human working capacity and various physiological and anthropological factors and search after parameters which could make easier the assessment of the human working capacity (Bar–OR et al. 1971, Kukkonen et al. 1982, Fraser et al. 1983, Ketkin et al. 1984, Wilson 1985). In Hungary, load tests are performed mainly for some selected groups (sportsmen, invalids, special employees, etc.).

The object of the present study is to survey the physical working capacity of 11 year old children and to follow its development in a subsequent period of 3 years. Though some standard values have been established in few European countries for the physical working capacity of children (Macek et al. 1973, Andersen et al. 1974, Rutenfranz et al. 1982), no Hungarian data are available for that of non-selected "healthy" children.

As another object, the characteristic differences between the male and female body compositions and physical working capacities as well as rates of their development are to be discovered in order to obtain information about the relations between the development in the body composition and in the physical working capacity.

Materials and Methods

The longitudinal investigation was started in 1982. 20 boys and 22 girls, 11 year old, were selected from inner district pupils of Budapest. Tests were repeated yearly for 3 years. Anthropometric data were recorded upon the IBP prescriptions (Tanner et al.

1969). For the analysis of the body composition the body-density was determined by the Durnin–Rahaman's is regression equation (1967) and the body fat percentage was calculated by the Siri's formula (1956). Lean body mass, middle arm area, calf area, muscle circumference, energy/protein indices of middle arm and calf were also determined.

The physical working capacity was tested by a bicycle ergometer, Type KE–11 (Medicor, Budapest), and by an electrocardiograph Type MR–11 (Medicor, Budapest). PWC 170 was determined according to the recommendations of WHO. The rising 6-min constant load level steps were adjusted to the sex, age, body mass, and constitution of the individual so that the pulse rate would be between 130 and 170 in at least two load steps. PWC 170 was then determined by linear extrapolation. Between the 6-min load steps, rest periods of 1 min were interposed. Pulse rate was recorded from the chest lead. Electrocardiograms were recorded during the 6th minute of each load step. Measured PWC 170 values were related to the body mass and lean body mass unit. Analitycal considerations are based on the results of Student's test, and paired sample test.

Results and Discussion

Statistical parameters of the physical working capacity characteristics are collected in Table 1.

The age-group average values of PWC 170 showed a significant uniform raise with the age of boys. PWC 170 values of girls, however, revealed no statistically significant change in this age period. The physical working capacities showed marked differences between boys and girls of the same age. PWC 170 related to the body mass was practically unchanged for boys during this age period, i.e. the rate of increase in PWC is parallel to that of the body mass. On the other hand, PWC 170 rose more rapidly than the lean body mass in the age from 11 to 12 while these two variables grew parallel from 12 to 13. In contrast, PWC 170 of girls, related either to the body mass or to the lean body mass, decreased consistently with the age.

PWC values, both to the body mass and to the lean body mass, were highly different between boys and girls in every examined age, in favour of boys.

The results concerning the body composition are collected also in Table 1. The body mass gain is significant for both sexes aged between 12 and 13 years. Girls are heavier in every age. However, the body mass gain of girls is steady during the range of age studied while that of boys is more rapid between 12 and 13 than from 11 to 12 as demonstrated statistically.

This sexual difference in body mass is resulted from the higher fat accumulation of girls in an earlier age. It is indicated by the greater gain in the body fat percentage of boys than that of girls in range of age studied.

While the average lean body mass shows no significant difference between the sexes, the rate of the lean body mass is different. The lean body mass of girls grows at a constant rate while that of boys increases much more rapidly between aged of 12 and 13 than from 11 to 12.

The results for the total body fat and for the lean body mass are supported by the age data for the cross-sectional areas of middle arm and calf, for the muscle area, and for the

Table 1. **Parameters of investigated body measurements**

Measurements	Age (in years) Mean and SD 11.0	12.0	13.0
PWC 170	♂ 76.90 ± 11.43	89.50* ± 20.34	100.55 ± 33.82
	♀ 71.14 ± 14.88	73.91* ± 13.54	72.59* ± 14.65
PWC 170/BM	♂ 1.97** ± 0.36	1.98** ± 0.36	1.91** ± 0.34
	♀ 1.57** ± 0.25	1.45** ± 0.23	1.33** ± 0.27
PWC 170/LBM	♂ 2.63* ± 0.37	2.84** ± 0.47	2.83** ± 0.82
	♀ 2.40* ± 0.35	2.33** ± 0.41	2.12** ± 0.41
Body mass (kg)	♂ 37.78* ± 6.53	42.60* ± 9.04	50.03 ± 10.48
	♀ 43.77* ± 12.67	49.61* ± 13.50	54.77 ± 13.48
Body Fat%	♂ 21.31** ± 5.96	25.22** ± 5.12	28.69** ± 3.41
	♀ 29.86** ± 6.50	32.57** ± 4.98	35.29** ± 3.87
Total body fat (kg)	♂ 8.36* ± 3.62	11.10* ± 4.44	14.64* ± 4.47
	♀ 13.98* ± 7.02	16.53* ± 6.95	19.88* ± 7.16
Lean body mass (kg)	♂ 29.42 ± 3.43	31.50 ± 5.13	35.59 ± 6.28
	♀ 29.80 ± 5.89	32.17 ± 6.30	34.80 ± 6.51
Middle arm area (cm^2)	♂ 35.87 ± 7.75	38.90 ± 10.29	44.07 ± 11.56
	♀ 38.97 ± 11.13	41.95 ± 11.55	45.63 ± 11.71
Middle arm muscle circumference (cm)	♂ 17.27 ± 1.63	16.57 ± 2.29	16.63 ± 2.69
	♀ 16.89 ± 1.48	16.47 ± 1.45	15.51 ± 1.71
Middle arm muscle area (cm^2)	♂ 23.95 ± 4.54	24.27 ± 6.52	25.58 ± 7.31
	♀ 22.90 ± 4.21	22.74 ± 3.96	23.40 ± 4.26
E/P index (arm)	♂ 1.60* ± 0.20	1.77 ± 0.18	1.88* ± 0.16
	♀ 1.73* ± 0.15	1.94 ± 0.41	1.98 ± 0.15
Calf area (cm^2)	♂ 71.96 ± 10.20	78.96 ± 13.46	85.63 ± 16.07
	♀ 77.79 ± 18.63	83.23 ± 19.28	88.43 ± 18.89
Calf muscle circumference (cm)	♂ 24.51 ± 1.59	25.10 ± 2.01	24.69 ± 2.51
	♀ 24.74 ± 1.72	25.10 ± 2.09	24.15 ± 2.32
Calf muscle area (cm^2)	♂ 48.03 ± 6.17	50.27 ± 7.84	59.04 ± 9.97
	♀ 48.40 ± 6.82	50.50 ± 8.52	53.86 ± 9.18
E/P index (calf)	♂ 1.56 ± 0.13	1.59* ± 0.10	1.70* ± 0.08
	♀ 1.62 ± 0.12	1.65* ± 0.09	1.75* ± 0.08

Significant level of difference between sexes: $^{*}p < 0.05$; $^{**}p < 0.001$

In order to decide whether a linear relationship exists between the body composition and the PWC, a correlation calculation was conducted (Table 2). The correlation of PWC 170/BM of boys was negative with the body fat percentage at age of 11. The correlation between the physical working capacity and the body composition of girls decreases or even disappears with the advancing age.

In spite of the methodological variations, the oxygen uptake of Budapest boys and girls at the age of 13 is attempted to compare to standard oxygen uptake values of some European countries (Rutenfranz et al. 1982) in Figure 1. The backwardness of the Hungarian boys is about 20 percent and that of the Hungarian girls is more than 50 percent to the average oxygen uptake in the European countries.

Table 2. **Correlation matrix of measurements**

	Age (year)	Body mass (kg) 11	12	13	Body Fat% 11	12	13	Total body fat (kg) 11	12	13	Lean body mass (kg) 11	12	13
Boys													
	11	0.41	0.42	0.34	0.16	0.21	0.26	0.28	0.34	0.35	0.49	0.45	0.34
PWC 170	12	0.59	0.62	0.61	0.33	0.24	0.31	0.42	0.43	0.53	0.68	0.72	0.67
	13	0.57	0.52	0.48	0.45	0.29	0.38	0.52	0.43	0.49	0.52	0.55	0.48
	11	-0.53	-0.51	-0.58	-0.63	-0.53	-0.38	-0.61	-0.55	-0.54	-0.36	-0.42	-0.55
PWC 170/BM	12	-0.23	-0.21	-0.23	-0.36	-0.40	-0.22	-0.35	-0.37	-0.27	-0.07	-0.60	-0.16
	13	-0.60	-0.60	-0.15	-0.60	-0.19	-0.10	-0.50	-0.12	-0.10	-0.07	-0.11	-0.12
	11	-0.30	-0.28	-0.34	-0.27	-0.15	-0.02	-0.29	-0.23	-0.25	-0.27	-0.29	-0.38
PWC 170/LBM	12	-0.04	-0.01	-0.28	-0.08	-0.11	-0.03	-0.11	-0.11	-0.02	0.04	0.08	0.02
	13	0.19	0.05	-0.03	0.10	-0.02	0.15	0.13	0.02	0.05	0.07	0.07	-0.40
Girls													
	11	0.67	0.70	0.68	0.66	0.67	0.65	0.62	0.58	0.67	0.71	0.53	0.68
PWC 170	12	0.67	0.70	0.68	0.61	0.69	0.61	0.62	0.61	0.66	0.69	0.53	0.70
	13	0.20	0.31	0.36	0.19	0.36	0.40	0.16	0.20	0.37	0.25	0.12	0.39
	11	-0.64	-0.60	-0.58	-0.51	-0.54	-0.50	-0.65	-0.63	-0.58	-0.61	-0.60	-0.55
PWC 170/BM	12	-0.72	-0.73	-0.74	-0.72	-0.71	-0.73	-0.74	-0.77	-0.76	-0.66	-0.75	-0.72
	13	-0.68	-0.61	-0.58	-0.64	-0.50	-0.45	-0.70	-0.65	-0.55	-0.63	-0.67	-0.58
	11	-0.23	-0.20	-0.18	-0.04	-0.11	-0.11	-0.22	-0.25	-0.18	-0.23	-0.27	-0.18
PWC 170/LBM	12	-0.15	-0.16	-0.14	-0.14	-0.08	-0.14	-0.19	-0.30	-0.16	-0.10	-0.43	-0.13
	13	-0.58	-0.50	-0.47	-0.51	-0.37	-0.32	-0.60	-0.54	-0.43	-0.53	-0.59	-0.48

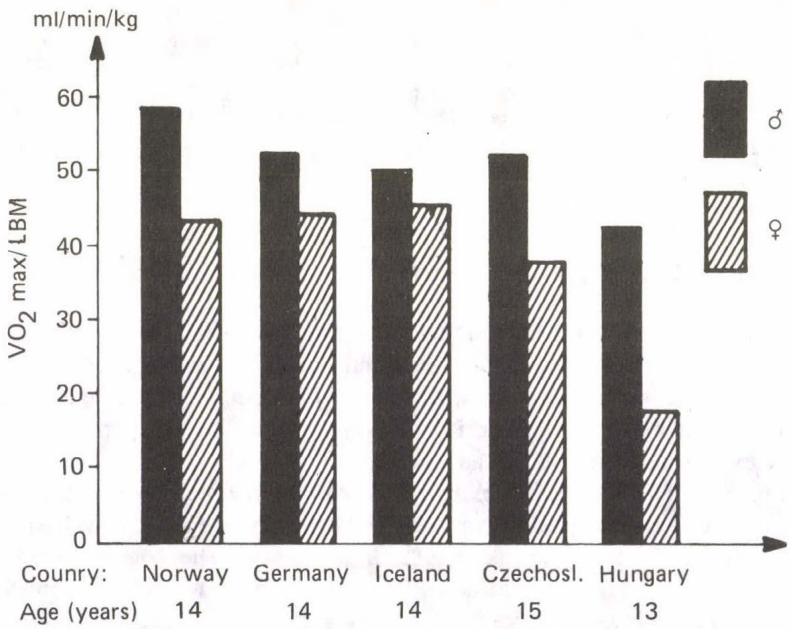

Fig. 1: Comparison of mean values of maximal aerobic power in 13–15 year old children from different countries

Considering the finding that the maximum oxygen uptake can be developed during the teenager period, later it can be maintained at most with an appropriated training (Frenkl 1977), it may be concluded that its main development takes place up to the completion of the pubertal growth spurt and not later. Just for this reason, everything must be done is this period of life for attaining the highest possible oxygen uptake in order to ensure the optimum cardiorespiratoric performance of children. This is the indispensable goal for preserving them from the growing risks, hazard factors, and stress effects of urbanization and, in addition, for prevention of cardiovascular diseases that occupy the first position on the list of causes of death in Hungary.

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