Anthrop. Közl. *26;* 59—67. 1982.

PHYSICAL FITNESS IN OBESE, NON OBESE, AND SPECIALLY TRAINED BOYS

by M. Peña, J. Blanco and P. Padrón

Higher Institute of Medical Sciences of Havana, Havana, Cuba;
Institute of Sport Medicine, Havana, Cuba

Abstract: Body composition, PWC_{170}, and oxygen uptake were assessed in a selected sample of 60 boys distributed in three homogeneous groups regarding age and sexual development: (a) obese (body fat percent over 25), (b) controls, and (c) specially trained boys attending to a swimming training program for at least 2,5 years. The aerobic capacity of the obese was significantly reduced. The swimmers, on the other hand, exhibited the best indices of fitness, as it might be expected due to the influence of systematic training on the development of positive conditioning factors. These differences, however, must not be related to an alteration of the work efficiency but to an extra work due to the permanent "overload" that constitute their excess of body fat, results that are in concurrence with previous reports in adults.

Key words: physical fitness, obesity, swimmers.

Introduction

In the so called developed countries and in those which are in an actual process of development a dangerous tendency to sedentarism, overconsumption of sugar, saturated fats, a low fiber content in the diet, among other factors, contribute to the deterioration of health.

There is an increasing interest in the preventive role concerning conditions which may cause morbidity in adulthood, and in which nutritional factors and physical activity play an important role (Boulton 1981). Obesity, indeed, is one of them. This multifactorial syndrome regarding its etiology, constitutes a major health problem at the present.

Obese subjects have been characterized as poor performers with a reduced economy of work, and a relative lower aerobic capacity (Balabansky 1979, Paříkzková 1977). It has also been suggested that their work efficiency is reduced (Apfelbaum et al. 1971). Otherwise many authors have studied the effect of systematic physical training and have demonstrated significant improvements of most of the functional indices of the cardiovascular and respiratory systems, when comparing with untrained individuals (Paříkzková 1977, Oelschlägel 1976, Peña et al. 1980). Dietrich et al. (1974) pointed out that physical activity is beneficial in the period of growth spurt, although an influence on the growth sport itself has not been yet demonstrated (Šprinarova 1973). Koch (1978) observed a positive effect of training on local muscle blood flow. Holloszy (1967) and Kiessling et al. (1971) reported an increase in the number and size of mitochondria of the skeletal muscle with exercise. In a recent study Placheta (1980) concluded that in a group of children with

a controlled physical training during three years their fitness were different and exceeded the natural increments of untrained boys by ten to forty percent.

The aim of our study was to compare three different groups of boys with same chronological age and sexual development.

Material and Methods

A selected sample of sixty boys from 10 to 14 years old have been studied, to each of them the body weight (BW) was recorded. Skinfold thickness on the right side of the body was measured over triceps, biceps, subscapular, suprailiac, and calf with a Holtain caliper with a standard pressure of 10 g/mm^2 according to the methodology recommended by the International Biological Program (WEINER—LOURIE 1969). Body fat percent was estimated by the prediction equation of PAŘÍZKOVÁ and ROTH (1972). The subjects were distributed in three homogeneous groups respecting chronological age and sexual development according to TANNER (1962) as follows:

Control group: Twenty healthy boys whose body fat percent was between 14 and 20.

Obese: Twenty boys, otherwise healthy, whose body fat percent was over 26.

Specially-trained group: Twenty swimmers who have a systematic training for at least 2.5 years whose body fat percent was in the same range as the fat percent of the controls.

Functional test: The subjects reported one hour earlier to their test in order to observe their companion being tested, enabling them to know the general details of the procedure. All of them established friendly competition and enhanced the likelihood of attaining maximum effort.

The exercise protocol consisted of three loading periods until a steady state is reached, with one minute of rest between them. After the third period and two minutes of rest the load was increased 15 watts until the maximal effort was achieved. The load was related to body weight and the subjects started with 1 watt per kg of BW, each successive period it was increased and based on the heart rate reached in the preceding one (KEMPER et al. 1978). A Mijnhardt electronic bicycle ergometer was used with parabolic and hyperbolic systems, hence the variations of pedalling frequency did not affect the power output. The subjects were coupled to a computerized Mijnhardt Ergo-analyzer which registered every minute the oxygen uptake ($\dot{V}O_2$), the ratio $\dot{V}CO_2/\dot{V}O_2$ — respiratory quotient — heart rate (fh), and the oxygen pulse ($\dot{V}O_2$/fh), all these variables were recorded until the subject appraised the maximum effort.

The Physical Working Capacity (PWC) was calculated by a regression line obtained through a correlation between heart rate and the watts of each work load. The PWC that could produce a heart frequency of 170 was recorded as PWC_{170} of the individual.

A one-way analysis of variance (ANOVA) was performed to assess the differences among the three groups with respect to each of the variables studied. When the differences were found to be significant pairwise comparisons were done using the Student's t test. Regression line and correlation coefficient between log PWC as dependent variable and the percent of body fat (%BF) as independent variable were also determined (DANIEL 1974).

Results

The body weight and the %BF for the three groups are summarized in Table 1. ANOVA yielded highly significant F values ($p < 0.001$). Obviously, by definition, the obese exhibited the highest figures of BW and %BF. The trained boys — although slightly heavier than the controls — had less %BF due to the known influence of systematic training upon body composition (PAŘÍZKOVÁ 1977, PEÑA et al. 1980).

Figure 1 shows the means and standard deviations of the PWC_{170} and Figure 2 the PWC_{170} related to BW and to lean body mass of the three groups. The swimmers, as it could be expected, achieved the highest values; on the

Table 1

Body weight and percent of body fat of the three groups studied

Group	Body weight (kg)	Body fat (%)
Controls	41.6 ± 9.4	18.0 ± 2.6
Obese	55.4 ± 14.6	29.2 ± 1.9
Swimmers	46.5 ± 8.7	16.5 ± 2.5
F	128.31	173.11
Probability	0.001	0.001

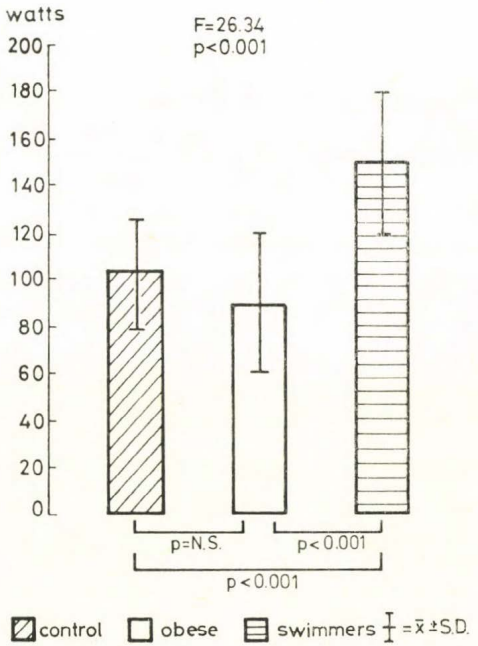

Fig. 1. PWC_{170} of obese, non-obese, and specially trained adolescents

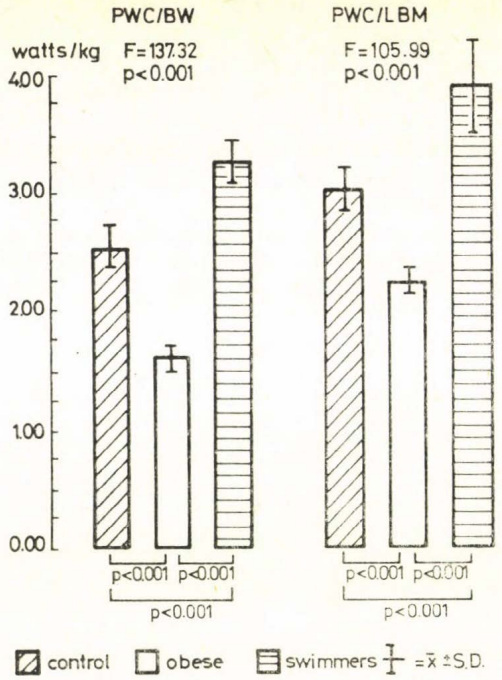

Fig. 2. Relative values of PWC_{170} of obese, non-obese, and specially trained adolescents

other hand, no differences were seen between the obese and the non trained boys regarding PWC_{170}, but when comparing their relative values the obese yielded lower results.

It may be observed in Figure 3 the $\dot{V}O_{2\,max}$ and in Figure 4 its relative values. The controls, — with similar figures reported by SUZUKI et al. (1978) and the obese raised to practically similar values of $\dot{V}O_{2\,max}$; however, respecting the relative ones the obese revealed the poorest results. Evidently, since the swimmers were able to perform more work, they got the highest $\dot{V}O_{2\,max}$, values comparable to those obtained earlier in a similar sample (ŠPRINAROVÁ et al. 1978).

A correlation study between %BF and the logarithm of PWC_{170}/BW appears in Figure 5 showing that the higher the %BF is, the lower the functional capacity confirming once more the disadvantages of overfatness in performances.

An attempt was done to know how much oxygen the boys consumed per kg-m of work performed during a submaximal work load in which the establishment of a steady-state was guaranteed in order to obtain an accurate measurement, as recommended by MARGARIA et al. (1965). The obese consumed more oxygen per unit of work done than the non obese groups did (Figure 6) and this was also seen in the same proportion in each of the submaximal work loads, result that agrees with previous findings (WHIPP et al. 1975a, BRAY 1977) which have been explained by the increased work of moving the greater

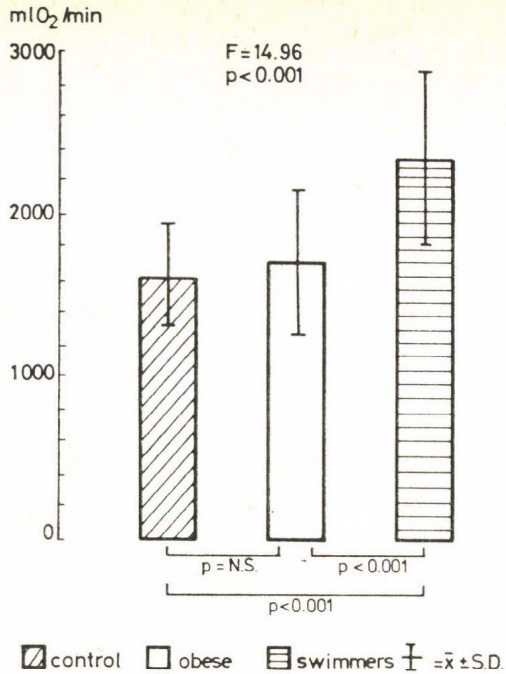

Fig. 3. Maximal oxygen consumption of obese, non-obese, and specially trained adolescents

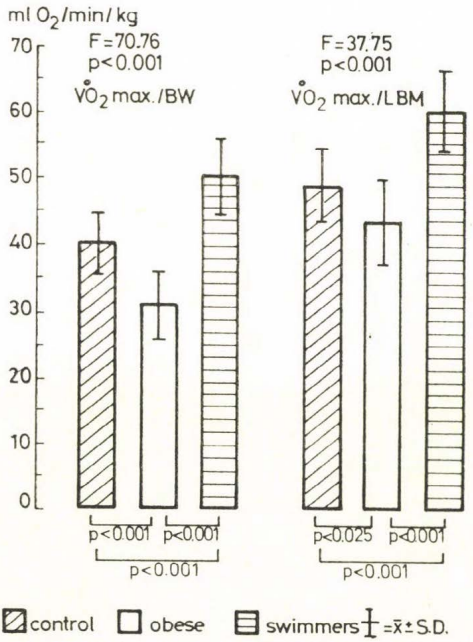

Fig. 4. Relative values of maximal oxygen consumption of obese, non-obese, and specially trained adolescents

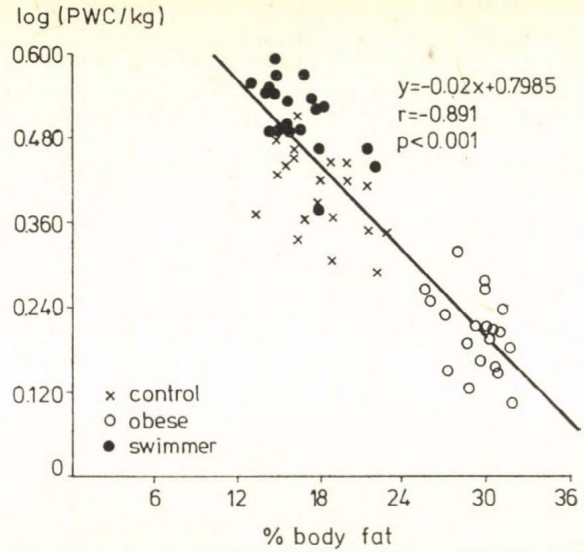

Fig. 5. **Correlation between log (PWC/kg) and percent of body fat**

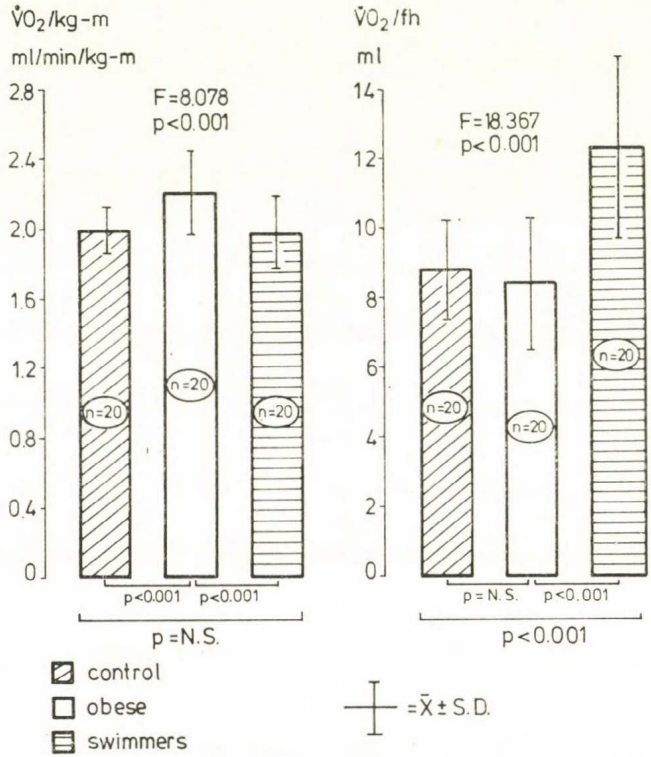

Fig. 6. **Oxygen consumption per kilogrameter of work performed and oxygen pulse of obese, non-obese, and specially trained adolescents**

leg mass during a bicycle test. Moreover, swimmers and controls did not differ in their results, thus, confirming that training itself does not modify the work efficiency (ÅSTRAND—RODAHL 1970). Also in this Figure the oxygen pulse of each group may be seen, the highest values were obtained by the swimmers, while no differences existed between the obese and the controls.

Discussion

Obese subjects are handicapped when performing a given physical work with respect to lean ones, this fact contributes to their "laziness" and aggravates the well known cycle: overfatness-sedentarism (PEÑA—PEÑA 1977).

PWC_{170} and $\dot{V}O_{2\,max}$ relative values, considered as reliable parameters for measuring aerobic capacity, were significantly reduced as it has been reported by many authors (PAŘÍZKOVÁ 1977, NORGAN—FERRO-LUZZI 1978, PEÑA et al. 1980). Moreover, although physical fitness is a biological feature dynamically influenced by the combined action of several factors involved — body composition among them — the excess of body fat exerts a negative influence (Figure 5) contributing to a constant increase in the energy cost of external work. Usually this energy cost of physical activity is expressed in total values rather than net ones (MILLER 1978), therefore, in this angle, work is a more expensive task for them than for the leans when we related to the kg-m of work performed during a steady state. In studies carried out very carefully in adults by several investigators (WHIPP et al. 1975b, BRAY et al. 1977, DEMPSEY et al. 1966) the rate of oxygen uptake was not really increased, and work efficiency was not really reduced. Our findings are in agreement with these considerations. Other mechanism by which fat could limit the continuation of exercise is interfering even more the rate of heat transfer from the body core to the skin (NADEL 1980) inducing a greater anaerobiosis.

The swimmers who were attending to 11 sessions per week of training during — at least — a period of 2.5 years, were able to perform more work and they developed skills of positive conditioning factors. Enhanced fitness, and resistance as it is observed in the higher oxygen pulse, — but again —, no differences in the efficiency of work can be stated.

Relying upon all these and the tendency to a growing lack of exercise influenced by "civilization" (EIBEN 1977) it is extremely necessary to promote physical activity from early childhood associated with adequate nutritional habits. These facts are of great importance and could have a beneficial impact upon human health.

REFERENCES

APFELBAUM, M.—BOSTSARRON, J.—LACATIS, D. (1971): Effect of caloric restriction and excessive caloric intake on energy expenditure. — Am. J. Clin. Nutr. *24;* 1405—1409

ÅSTRAND, P. O.—RODAHL, K. (1970): *Textbook of work physiology.* — McGraw-Hill Book Co. New York, N. Y. p. 408.

BALABANSKY, L. (1979): Diet and physical performance in the rehabilitation of obesity. — Biblthca. Nutr. Dieta, *27;* 33—40.

BOULTON, J. (1981): Nutrition in childhood and its relationships to early somatic growth, body fat, blood pressure, and physical fitness. — Acta pediatr. Scand. Suppl. 284.

BRAY, G. A.—WHIPP, B. J.—KOYAL, S. N.—WASSERMAN, K. (1977): Some respiratory and metabolic effects of exercise in moderately obese men. — Metabolism *26;* 403—412.

DANIEL, W. W. (1974): *Biostatistics: A foundation for analysis in the health science.* Chapter 8 and 9. John Wiley and Sons Inc. New York.
DEMPSEY, J. A.—REDDAN, W.—BALKE, B.—RANKIN, J. (1966): Alveolar-arterial gas exchange during muscular work in obesity. — J. Appl. Physiol. *21;* 1807—1814.
DIETRICH, R.—KIESS, C.—SCHENDERLEIN, P.—WUNDER, K.—POKRANDT, S. (1974): Die Trainierbarkeit von Jugendlichen im Alter von 14 bis 19 Jahren. — Med. u. Sport *14;* 142—147.
EIBEN, O. G. (1977): Changes in motor activity and mode of life expected changes in the human organism. — Metody kontroli rozwoju czlowieka i zmian struktury populacji ludzkich, Ossolineum, 207—221.
HOLLOSZY, J. D. (1967): Effects of excercise on mitochondrial oxygen uptake and respiratory activity in skeletal muscle. — J. Biol. Chem. *242;* 2278—2287.
KEMPER, H. C. G.—VERSCHUUR, R.—RAS, K. G. A.—INEL, J.—SPLINTER, P. G.—TAVECCHIO, I. W. C. (1978): Investigation into the effects of two extra physical education lessons per week during one school year upon the physical development of 12- and 13 year-old boys. — Med. Sport *11;* 159—166.
KIESSLING, K. H.—PIEHL, K.—LUNDQVIST, C. G. (1971): Number and size of skeletal muscle mitochondria in trained sedentary men. — *In:* LARSEN and MALMBORG (Eds): *Coronary heart disease and physical fitness,* p. 143. Munkgaard, Copenhagen.
KOCH, G. (1978): Muscle blood flow in prepubertal boys. Effect of growth combined with intensive physical training. — Med. Sport *11;* 39—46.
MARGARIA, R.—MANGILI, F.—CUTTICA, F.—CERRETELLI, P. (1965): The kinetics of oxygen consumption at the onset of muscular exercise in man. — Ergonomics *8;* 49—54.
MILLER, D. S. (1978): Food intake and energy utilization. — *In:* PAŘÍZKOVÁ and ROGOZKIN (Eds): *Nutrition, Physical fitness and health,* pp. 3—8. Univ. Park Press, Baltimore.
NADEL, E. R. (1980): Circulatory and thermal regulations during exercise. Federation Proc. *39;* 1491—1497.
NORGAN, N. G.—FERRO-LUZZI, A. (1978): Nutrition, physical activity and physical fitness in contrasting environments. — *In:* PAŘÍZKOVÁ and ROGOZKIN (Eds): *Nutrition, physical fitness, and health,* pp. 167—193. Univ. Park Press, Baltimore.
OELSCHLÄGEL, H.—WITTEKOPH, G. (1976): Physiologische Grundlagen der sportlichen Leistungsfähigkeit im frühen Schulter. — Med. Sport *16;* 126—130.
PAŘÍZKOVÁ, J. (1977): *Body fat and physical fitness.* Martinus Nijhoff, The Hague.
PAŘÍZKOVÁ, J.—ROTH, Z. (1972): The assessment of depot fat in children from skinfold thickness measurements by Holtain (Tanner and Whitehouse) caliper. — Hum. Biol. *44;* 613—620.
PEÑA, M.—PEÑA, L. (1977): Algunas consideraciones sobre la obesidad exógena primaria en el nino. — Rev. Cub. Ped. *49;* 707—722.
PEÑA, M.—BARTA, L.—REGÖLY-MÉREI, A.—TICHY, M. (1980): The influence of physical exercise upon the body composition of obese children. — Acta Paed. Acad. Sci. Hung. *21;* 9—14.
PEÑA, M.—BARTA, L.—REGÖLY-MÉREI, A.—SIMON, Gy.—GEDEON, É. (1980): Changes in body composition and physical working capacity after a high fibre diet and physical training. — Anthrop. Közl. *24;* 179—184.
PLACHETA, Z. (1980): Youth and physical fitness. — Acta Facult. Med. Univ. Brunensis, Brno.
ŠPRYNAROVÁ, Š. (1973): The impact of motor activity level on physical fitness during adolescence. — *In:* Physical Fitness, pp. 371—374. Universitas Carolina, Praha.
ŠPRYNAROVÁ, Š.—PAŘÍZKOVÁ, J.—JUŘINOVA, I. (1978): Development of the functional capacity and body composition of boys and girls swimmers aged 12—15 years. — Med. Sport *11;* 32—38.
SUZUKI, S.—OSHIMA, S.—TSUPI, E.—TSUPI, K.—OHTA, F. (1978): Interrelationships between nutrition, physical activity, and physical fitness. — *In:* PAŘÍZKOVÁ and ROGOZKIN (Eds): *Nutrition, physical fitness, and health,* pp. 194—214. Univ. Park Press, Baltimore.
TANNER, J. M. (1962): Growth at adolescence. —Blackwell, Oxford.
WEINER, J. S.—LOURIE, J. A. (Eds) (1969): *Human biology. A guide to field methods.* IBP 9, Blackwell, Oxford.
WHIPP, B. J.—BRAY, G. A.—KOYAL, S. N.—WASSERMAN, K. (1975): Exercise energetics and respiratory control in man following acute and chronic elevation of caloric intake. *In:* BRAY (Ed.): *Obesity in Perspective,* pp. 157—163. Fogarty, International Center U.S.G.P.O. Washington DC.

WHIPP, B. J. (1975): The physiological and energetic basis of work efficiency. — *In:* BRAY (Ed.): *Obesity in Perspective*, pp. 121—126. Fogarty International Center U.S.G.P.O.. Washington D.C.

Author's address: MANUEL PEÑA M.D.
Instituto Superior de Ciencias Médicas de La Habana
Ave. 31 y Calle 146, Cubanacán,
Ciudad de La Habana
Cuba