Body composition and lipid metabolism

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The incidence of excess deposition of fat shows a characteristic developmental trend, which most often manifests itself in adult life and old age. In early periods of development as well as in advanced age marked obesity is rare. In the new-born child an increased amount of subcutaneous fat can be found e.g. in overweight children whose mothers are diabetic and metabolically decompensated, i.e. with hyperglycemia (Pařízková, 1963.) When hyperglycemia is suppressed by treatment children are of nearly normal weight at birth. (Přibylová & Znamenáček, 1971). In normal new-born children the skinfolds are very small but quite variable (Pařízková, 1963), indicating the influence of pre-natal factors on body fatness (Brook, 1972).

During the first year of life the amount of subcutaneous fat increases in normal children (Fig. 1), then temporarily decreases at about the time they begin to walk and with increased energy output, up to the age of 3–4 years; then a stationary period follows up to the age of 9 years (Pařízková, 1962). At this period of development we have not found in the normal child population any excessively increased

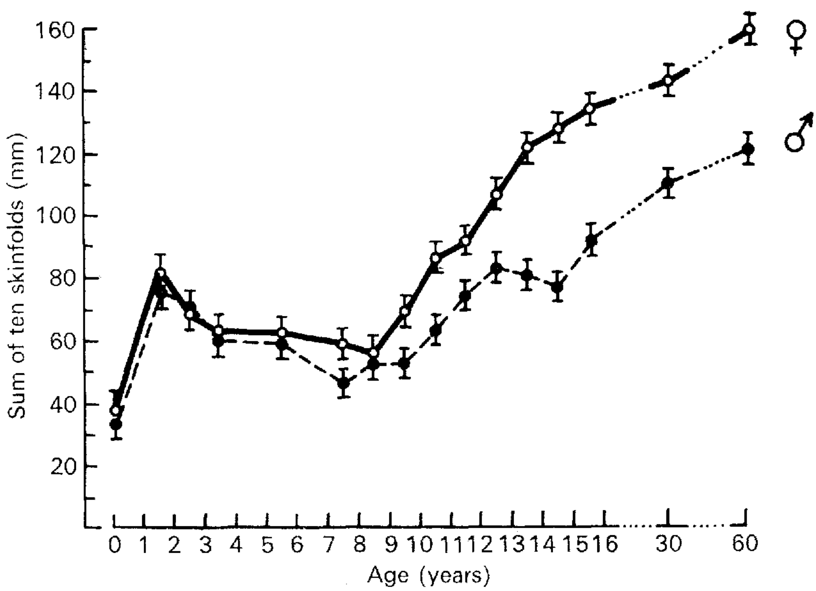

Fig. 1. The changes in the sum of ten skinfolds (cheek, chin, thorax I and II, triceps, subscapular, suprailiac, abdomen, thigh and calf) in human subjects of both sexes during development, starting immediately after birth (vertical bars, SE).

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amount of body fat. This was continued also by a further survey of more than 5000 children. More detailed measurements in another group of 153 preschool children, aged 4–6 years, showed that children who were found to have more subcutaneous fat than the average were also children with high body-height and body-weight. Better nutrition at this period of development apparently advances the over-all somatic development in the normal child population, but not the deposition of excess fat. At the same time, the cardiovascular system of children with greater skinfolds tended to show a more favourable reaction during a work-load, i.e. a modified step-test; therefore, the functional capacity of these children seemed to be better than that of children with low body fat, height and weight (Čermák, Pařízková, Venclík & Mařatková, 1973). This situation does not relate to adolescents and adults (Pařízková & Merhautová, 1970; Pařízková, 1973).

Similar conclusions were made on the basis of measurements in younger children of school age (Pařízková, 1962). The youngest patients in a special out-patient department for obese children were 8–10 years old (Pařízková & Vamberová, 1967). However, at this age the total body-weight was not as high as levels found later, and weight increments were due entirely to increased deposition of fat. From the beginning of puberty, the situation with body composition was different: it was shown, for example, that in 13–14-year-old boys and girls whose body-weight was increased by 30–40%, the lean body mass also increased by 10–15% as compared with normal adolescents of the same age (Pařízková, 1970). This has been shown by ^{40}K measurements (Forbes, 1964). Changes in body composition such as those mentioned were paralleled by further morphological differences, i.e. by increased pelvic breadth, even when corrected for subcutaneous layer of fat (Pařízková, 1970), or by increased heart size (Čermák, Tůma & Pařízková, 1970).

Increased fat deposition has a negative impact on the economy of work; the energy cost of the same work-load (during step-tests, bicycle ergometer measurements or tread-mill running) is higher in the obese (Vamberová, Pařízková & Vaněčková, 1971; Pařízková & Šprynarová, 1970). The results of the step-test correlate negatively with the amount of depot fat (Pařízková & Merhautová, 1970). Decreased body fat and body-weight after special reduction treatment in summer camps improved the economy of work and over-all fitness (Pařízková, Vaněčková, Šprynarová & Vamberová, 1970). Aerobic capacity of the organism, expressed as maximal oxygen uptake/kg body-weight, is significantly lower in the obese, with 30% body fat (Pařízková & Šprynarová, 1970) and is achieved after a shorter run on a tread-mill than with normal subjects.

Even when the limits given usually for obesity are not yet reached, the effect of the proportion of fat on performance capacity is obvious. This was shown in another study with groups of boys selected so that they showed no significant difference in height, total body-weight and lean body-weight, but had either a smaller or greater proportion of depot fat. The markedly different fat proportion of these boys was maintained from 11 (8·3–20·7%) to 18 years (6·9–17·3%). It was shown that at the age of 15 and 18 years the same level of maximal oxygen consumption was achieved at a significantly lower speed of the tread-mill in fatter boys (Šprynarová & Pařízková,

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1972); these results seem to indicate that the organism with a smaller amount of fat can, with the same level of maximal aerobic processes, achieve higher speed during maximal work-load than an organism which has to expend more energy carrying an excess load of body-fat.

The secular trend in body development shows a constant increase in height which is mostly accompanied by increased body-weight, and is mainly the result of better nutrition, especially during early periods of development (Widdowson, 1964). Changes in body composition in this respect have not yet been studied systematically. The comparison of smaller groups of boys and girls at the age of 11–12 years randomly selected in 1959 and 1971 confirmed the increase in height and body-weight. Results of densitometric analysis showed that there was also an increase in lean body mass (Fig. 2) and a decreased proportion of fat in 1971 compared with 1959. This finding shows the over-all acceleration of growth at this period of development.

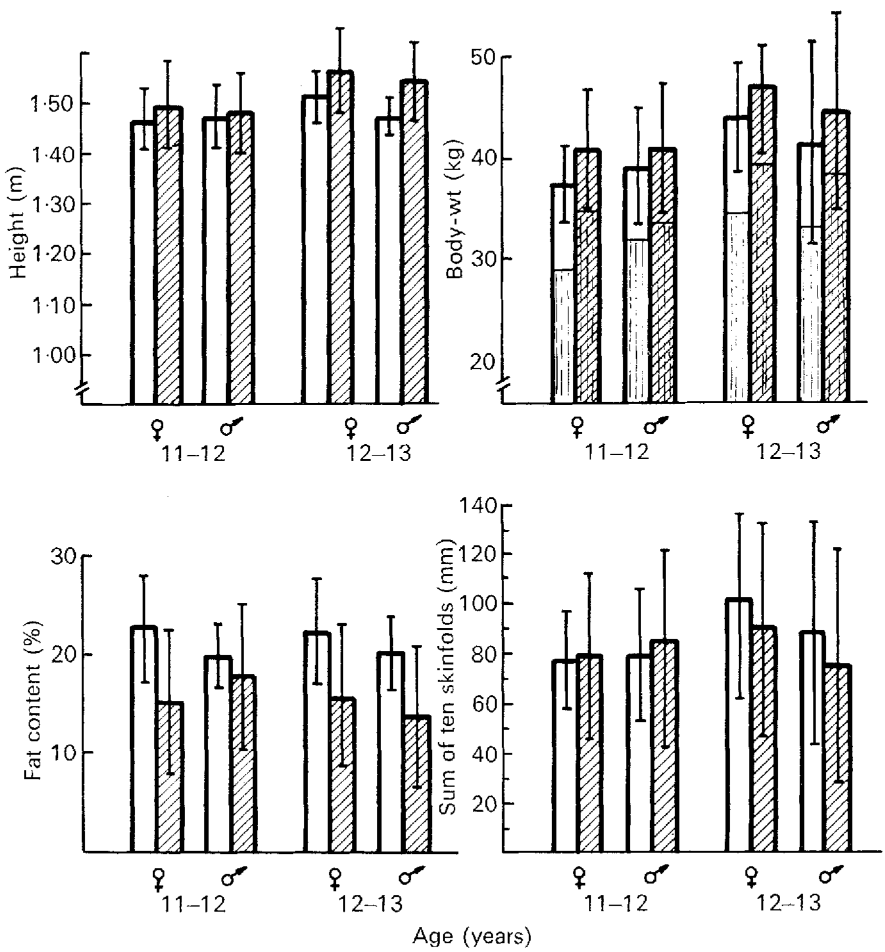

Fig. 2. Comparison of height, body-weight, percentage of fat and sum of ten skinfolds in 11- and 12-year-old boys and girls; measurements made in 1959 (□) and 1971 (▨). ▥, lean body mass (vertical bars, SD).

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However, similar comparisons of relative muscular strength of various muscle groups (kp/kg body-weight) showed a decrease during the same period, i.e. there was no corresponding acceleration in the development of muscular strength as total body mass increased (Merhautová, 1973). Further comparisons of performance ability in different sporting disciplines (long jump, running different distances, etc.) measured at the present time and 20–50 years ago showed that also the increase in sporting efficiency of the average child and adolescent population is not related to accelerated body development (Juřinová, 1973). In groups of boys 12–16 years old, but measured only at 5–7 year intervals (1959, 1964–7), an increase in height, total and lean body-weight was found again, but there was also an increase in relative and absolute amounts of fat. This finding is related to the relatively slower development of functional efficiency compared with the accelerated body development. With respect to the secular trend of growth acceleration it would be of essential importance to obtain more detailed results, not only of the progress of lean body mass and depot-fat development, but also on development of different vital organs (mainly the heart muscle), together with functional measurements. The results mentioned seem to indicate a possibility of a certain disproportion in this respect.

All this could have an important impact on the development of obesity with respect to further metabolic deviations, especially those concerning fat metabolism in the adult and in advanced age. Atherosclerosis is considered actually as a 'pediatric problem' (Kannel, 1972).

In advanced age the incidence of obesity is very limited; in the group of 170 men 55–79 years old, studied during the period 1959–1969, excess deposition of fat was exclusive; mean values for the proportion of fat varied from 18·9–21·9% (Pařízková & Eiselt, 1966). Men who survived the experimental period in relatively good health and fitness (seventh and eighth decade of life) were found to have constant body-weight and fat proportion which varied from 19·3–20·3% (Pařízková & Eiselt, 1971). The prevention of increase in fat is apparently one of the guarantees of survival and relatively good condition in advanced age.

There is another important item influencing increases in body fat: positive energy balance may be found with normal or even lowered energy intake as the result of a marked decrease in energy output. In actual ecological situations the reduction in physical activity is considerable, especially in industrially-developed countries. Increased deposition of fat is therefore frequent, even when total body-weight is not markedly increased, or is normal (Pařízková, 1962, 1973).

Experiments with laboratory animals whose physical activity was markedly reduced showed changes in body composition and significant variations in lipid metabolism. Three groups of male rats 90 d old with different physical activity were compared. One group had a daily run on a tread-mill (adaptation to exercise); one group were restricted in activity in small cages 80 × 120 × 200 mm (hypokinesia) and one group were controls. Body-weight was the same in the rats in the exercised group and in the hypokinetic group and was significantly lower than in the controls. (Fig. 3). Percentage of body fat was lowest in the running group; and was the

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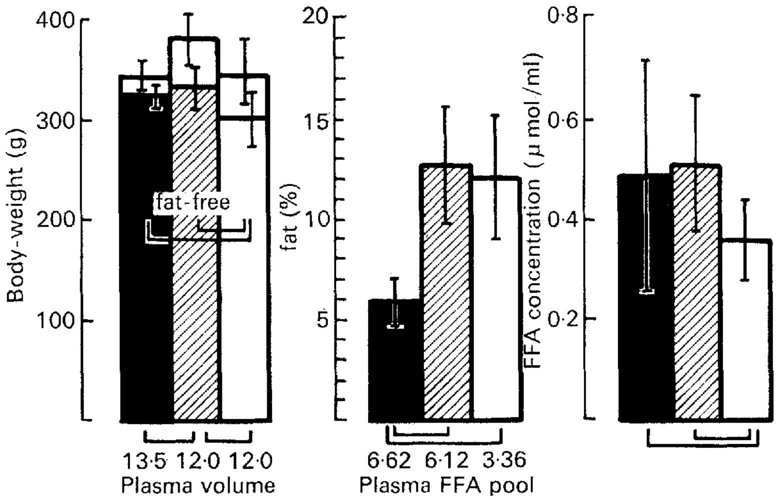

Fig. 3. Body-weight (total and fat-free), percentage of fat and plasma free fatty acid (FFA) concentration in 90 d-old male rats adapted to different levels of physical activity. ⌴, significant differences ($P < 0·05$), ■, exercised rats; ▨, control rats; □, hypokinesic rats (vertical bars, SD).

same in control and hypokinetic rats. Plasma volume (measured by means of [^{131}I]-albumin) was greatest in running exercised animals. Energy intake was highest (g Larsen diet/kg body-weight) in running animals, and lowest in hypokinetic rats. Concentration (μmol/ml) and content of the pool (μmol) of plasma free fatty acids (FFA) was lowest in hypokinetic rats as well as the influx-outflux rate of FFA (measured by means of [^{14}C]palmitate) (Pařízková & Poledne, 1973). Influx of FFA to the skeletal muscle (i.e. soleus muscle) was highest in running rats, and the same in control and hypokinetic animals (Poledne & Pařízková, 1973).

These results seem to indicate that even with reduced energy intake hypokinesia can result in increased deposition of fat, obviously the result of lower influx of FFA to the utilizing tissues, and an over-all decrease in the turnover of fat metabolites. This shows itself especially during the growth and development period when the usual level of physical activity is spontaneously high, which *inter alia* keeps the proportion of depot fat at a low level due to increased energy turnover. Reduction of physical activity therefore has an important impact on basic processes of the lipid metabolism which results also in significant changes in body composition; in certain cases, especially those which do not regulate well the energy intake, this can be the origin of obesity.

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