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CHANGES IN BODY FAT DURING PUBERTY IN ATHLETIC BOYS

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Introduction

In studying athletic children adipose tissue has a particular importance. Intense physical training is an important factor in the regulation of body mass and some of its components. Surprisingly, knowledge about the trends in body fat content of athletic children is largely lacking. It would be important to know if individual fat patterns are stable or one should expect remarkable changes during childhood and puberty. Different events prefer or allow different amounts of body fat and adiposity also may be a limiting factor in athletic performance.

Another motivation to study body fat was the strange allusion in a few reports to the existence of a "preadolescent fat spurt" (Brook 1978) or "pre-adolescent fat wave" (Falkner 1975, Malina and Bouchard 1991) concerning which Brook admitted "... we do not understand [it] at all..."

The aim of this paper was to study the changes in body fat content during puberty. Our paper focused on both the relative and absolute mass of fat.

The approaches used were:

To follow the development of the fat stores with age.

To determine the peak of fat percentage wave and analyze the changes in fat mass using this criterion.

To study the relationship between the timing of the peak of fat percentage and other events of puberty.

Materials and methods

The sample consisted of 60 athletic boys of the longitudinal growth study of our sport club. They were measured in intervals of half a year. The criteria for including them in the present study were an age of between 10 and 15 years and having eight consecutive measurements at least. Many of them attended much more occasions of measurement so the whole age range that could be investigated became somewhat broader. At the extremes of the age range case numbers were above 25.

The 60 boys were engaged in 10 sports events. The majority of them were gymnasts (N=18) and judoists (N=12). No effort was made to have a sample representative of the events.

Fat mass was determined by the Drinkwater-Ross (1980) four-component body mass fractionation model. Fat percentage was obtained by dividing this fat mass estimate by individual body mass.

Relative and absolute body fat estimates were analyzed along age first.

Then the age of the peak fat percentage was determined set to zero age for the individual, to which levels of the preceding and following half-year measurements of fat percentage were compared. Aligned for these individual peaks, both fat percentage and fat mass estimates were averaged around the peak. The mean age at peak relative fat content was obtained by averaging the individual zero ages. To find peak velocities of height and mass (PHV, PMV) the increment method was used.

Dates of the first ejection were also collected and so mean age at spermarche as an indicator of sexual development could be calculated.

In addition to basic descriptive statistics (mean and SD) linear correlations were computed between the age at spermarche, the age at peak fat content and ages at the respective peak velocities.

Results and discussion

Figure 1 shows fat mass and percentage along age.

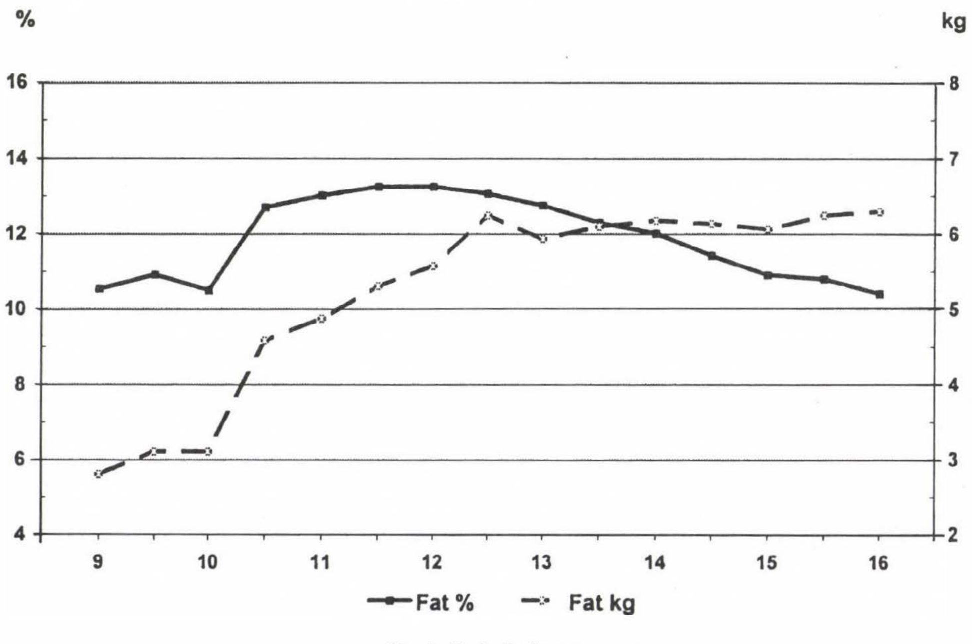

Fig. 1: Body fat by age
Dots and solid line: Fat%
Asterisks and dashed line: Fat mass

The overall increase in fat mass was 3 kg, in the age range between 10 and 12.5. Before 10 years of age and after age 13 there was very little change though body mass grew steadily.

Mean fat percentage varied between 10 and 14% a relatively low level compared to peer-age non-athletic boys, a fact due to sports selection, in our opinion. Inter-individual variability was high throughout the whole age range. Gymnasts were the leanest (between 8 to 12%) and waterpolo players were the fattest (20 to 28%). Except the time of the peak intraindividual values varied little with age, however.

There was a sharp increase of 2.2% between 10 and 10.5 years, then until age 12 all the increase was merely 0.5%. After that age a more or less steady decrease followed. The sharpness of the increases in both absolute and relative fat mass between ages 10 and 10.5 might in part be attributed to an increase in the number of events in the sample at this age. Nevertheless, the further course of both curves suggests that even without this interference there would have been a steeper increase than either before or later.

The increase and decrease in fat content observed in our material has already been described in non-athletic subjects by other authors, few of whom, however, could provide reasons for it. Tanner and Whitehouse (1975) examining the ontogenetic changes in triceps and scapular skindfold thickness found a fat wave to occur in boys age between 10 and 14 years. Falkner (1975) reported that the "pre-adolescent fat wave", though less marked, was present also in girls, but has criticized the term because he thinks the phenomenon belongs to adolescence.

Knittle (1978) studied the size and number of adipose cells in normal and obese children longitudinally. He found little changes in this respect in nonobese children between 2 and 10 years of age but after this age both fat cell size and number increased. Brook (1978) in a longitudinal study corroborated Knittle's results and opined that the accumulation in body fat was due to an increase in cell number rather than to one in cell size. Referring to Tanner and associates' 1966 study he remarked "... the fluctuations in skinfold thicknesses suggest cyclical accumulations of fat and lean tissue during childhood with fat accumulation predominating in early childhood and at puberty" (Brook 1978).

Malina and Bouchard (1991) studying the ratio of the sum of skinfold thicknesses on the trunk and the extremities also referred to the fat wave and tentatively attributed it to a feature of subcutaneous fat on the trunk since they found the relative amount of fat on the trunk larger than on the extremities in this period.

The phenomenon was also observed in two of our previous mixed longitudinal studies (Pápai et al. 1991, 1992). Both the one in athletic boys and the other in non-athletic boys displayed this increase and decrease of fat content, the rise being slightly larger, the decrease slightly smaller in non-athletes. As for its timing, the onset of the increase was earlier (age 8) and lasted longer (4 years) in non-athletes who also were consistently fatter than the athletes, a difference of about 4%. It is noted that the method of fat estimation was the same in all of these studies.

Figure 2 shows the peak-aligned curves of fat% and the amount of fat mass belonging to the respective fat percentage. As noted, on the abscissa was that age at which the child's fat percentage was the highest, starting from which point all half-yearly means were plotted symmetrically. The mean age at the peak of fat% was 12.15±0.98 year.

As shown rapid fat apposition began one and a half years before the peak. In this representation the rise was about 3.5%, starting from 11.2% of fat. After the peak first a sharp decrease of 1.5% was observed followed by a less one. Two and half years after the peak the share of fat percentage in body mass was the same as before the increase.

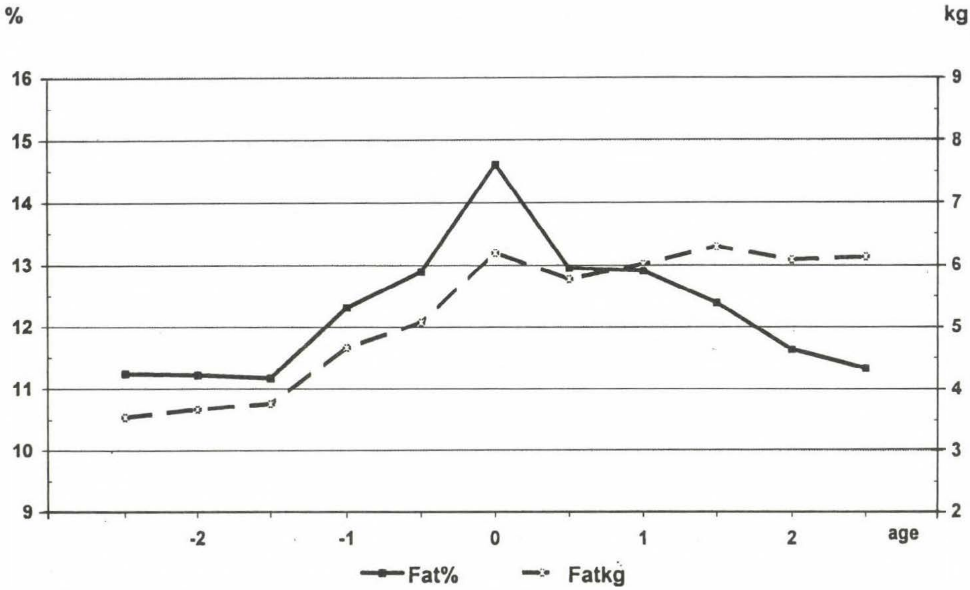

Fig. 2: Body fat by the peak of fat percentage
Legend as in Fig. 1.
Zero point of abscissa: Mean age at the highest fat%.

The rise in fat percentage and its peak were found to precede the first signs of sexual maturation in only one-third of the sample. In one of our cross-sectional studies athletic boys were grouped by the developmental stages of genitalia (Pápai, unpublished data). Here too fat percentage was higher in genital stages G1-G2 of the boys than in the later ones. These data suggest that this observed fat accumulation occurs before or around the onset of sexual maturation. The curve of the absolute fat mass in this representation displays a concurrent rise of 2.5 kg. After the peak of fat percentage fat mass did not change practically in the observed period.

We also studied the timing of maturation and somatic events in relation to the observed fat peak. The mean ages for spermarche, PHV and PMV are shown in Table 1. The fat peak preceded all these events. One of our regional cross-sectional studies referring to non-athletic children showed that the boys after the age of their first ejection had less fat in the same chronological age than their counterparts (Pápai 1992). The ages at which these developmental phenomena occurred lay already in the decreasing phase of fat percentage and coincided with a stability in fat mass.

Table1:. Mean ages of some pubertal events

Mean age	Mean	SD
Fat% peak	12.15	0.98
Spermarche	13.57	0.76
PHV	14.04	0.93
PMV	14.20	1.02

Spermarche can be regarded as a midpubertal event. Reviewing the few Hungarian studies on this topic, it was found to occur between genital stages 3 and 4 (Eiben et al. 1992) or in G4 (Pápai et al. 1994, Pápai and Szabó 1996), before or close to peak height velocity (PHV). In this sample spermarche occurred about 1.5 years later than the peak of fat percentage and a half year before PHV. The timing of PMV was the latest and it showed the greatest variability.

Table 2: Correlations between the timing of pubertal signs and fat peak

Mean ages	1	2	3	4
1 Fat% peak	-	0.52	0.58	0.50
2 Spermarche		-	0.72	0.63
3 PHV			-	0.85
4 PMV				-

r (P<5%)= 0.27

Note: Case number is 53 because in 7 subjects neither PHV nor PMV could be reliably assessed.

The connections between the ages of these variables are presented in Table 2. The correlation between spermarche and the peak velocity of fat percentage was not too close, although it shows that there may be some link in also males between sexual maturation and the changes in fat content. The relationship between the timing of the fat peak and PHV was somewhat closer than with spermarche. The connection with the age at PMV was moderate too. These results also show that the peak in body fat percentage is an early event of adolescence and is only moderately related to other somatic signs of puberty and maturation.

Summary conclusions

Development of body fat percentage in this athletic sample agreed in its time course with previous reports of Hungarian and other authors, but was consistently less.

The phenomenon of "pre-adolescent fat wave" (Falkner 1975, Brook 1978, Malina and Bouchard 1991) or spurt was demonstrable also in these athletic boys. Chronologically, relative body fat peaked between 12 and 12.5 years of age but this peak was quite flat distributed over several years. This peak amounted to an increase of about 2.7% parallel with a change of 3.2 kg in fat mass.

When the data were aligned according to the peak of fat percentage, similar values were obtained (3,5%, resp. 2.5 kg), but the time course was more pregnant.

This "fat wave" preceded the time of spermarche, an indicator of functional gonadal development. Fat% peak also preceded the mean ages at PHV and PMV.

The correlations with the time of peak height and mass velocities, respectively spermarche were moderate, but not negligible.

During the period of advancing sexual maturation and intense somatic growth the decreasing share of fat in body mass was associated with an almost unchanged fat mass. Body fat in young athletic males appears to have small contribution to the steep increase of body mass in puberty. This observation as well as the low level of body fat may be related to the more intense physical activity.

Studying the "pre-adolescent fat wave" we tried to reveal some of its characteristic features and its connection to other events of puberty. We have to admit that we could not add too much to the nature and reasons of it. One cannot but speculate about its importance. It could be an expression of the changing metabolism and maturation of adipose tissue. It may be one of the early signs of the onset of male puberty.

So far as the term "pre-adolescent fat wave" is concerned our opinion is near to Falkner's (1975). Its appearance seems to signal the approach of pubertal changes and closes pre-adolescence rather than specifies it. Thus the term "proto-adolescent fat wave" seems to be preferable.

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