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Monthly Changes in Pubertal Growth in Yucatecan Adolescents

Napoleon Wolanski[1,2], Armando Rojas[1], Graciela Valentin[1], Anna Siniarska[3] and Federico Dickinson[1]

[1] Departamento de Ecología Humana, Centro de Investigacion y de Estudios Avanzados, Merida, Mexico
[2]College of Physical Culture and Tourism, Poland
[3]Department of Human Biology, Cardinal Wyszynski University, Warsaw, Poland

KEYWORDS Monthly Changes. Puberty. Yucatan. Adolescent Spurt

ABSTRACT The problem whether the pubertal spurt is a single developmental effort or series of changes with dominance of intensified increments was considered. The examinations took place in the tropical climate of Yucatan and included 49 boys and 47 girls aged 11-13 years and being of the Maya, Mestizo and Creole origin. The youths were attending two schools located in rather poor districts of Merida city (Yucatan, Mexico). The measurements started in February 2002 and were continued monthly till November 2003. The standard anthropometric methodology was applied to measure body height, weight, arm, waist, hip and calf circumferences and five subcutaneous fat folds. Bioimpedance techniques were used to measure fat mass (FM), fat free mass (FFM) and total body water (TBW). Age at menarche was detected. The results show that each individual and its variable show a different rate of changes. It suggests that the rate of development and changes of body mass and fat mass are occasional. The only regularity shows that rather short (1-3 months) periods of rapid growth (saltations) are divided by slower growth periods (stasis), but their duration and time of occurrence have a very individual character. The rate and rhythm of each body build variables are also different. These phenomena depend rather on conditions in which the development of each individual occurs, probably as well as on its genetic predispositions and ecosensitivity. The differences in onset and intensity of pubertal spurt depend on alternations between periods of saltations and stasis of growth processes and on changes in body mass. The specific monthly rate of changes of body build measures, typical for studied group of youths and/or seasonal changes according to climatic conditions (cyclic changes in nature) were not observed. The preliminary results suggested that observed changes rather depend on an adjustment to local living conditions, mostly on nutrition and mode of life (physical activity and leisure). These studies need to be repeated during a longer period of time (at least within 5-year period), in different climatic conditions and social groups.

INTRODUCTION

The main aim of our study concerns the answer a question whether the general regularity of seasonal differences in changes of height, weight and body components during ontogeny exists (Wolanski et al. 1998, 2004a,b; Siniarska and Zielinska 2002; Siniarska et al. 2004; Siniarska and Wolanski 2005). If so, whether this phenomenon depends on cyclic changes in nature or this rather is an adjustment to local conditions and mode of life.

Bogin (1978, 1979) had conducted monthly measurements of height and weight throughout 14 months in Ladinos from "very wealthy families attended a private school in Guatemala City". His results revealed that 75% of children, 5-8 years of age show more rapid increments in height in the dry season and 25% of those children show the same effect in the raining season. Bogin, as well as other authors (Vincent and Derickx 1960) who conducted studies in Kinshasa (Leopoldsville) in Zaire, concluded that this phenomenon is caused by the strong insolation which is not related to the day duration but to the hours of sun action. During the hottest months in Yucatan (April and May) the brimming sun operates 7.5 hours daily, whereas during the raining season it diminishes to 5 hours. Such strong solar exposure causes the increased synthesis of vitamin D3 in the skin, which is probably related to acceleration of growth processes what is seen e.g. in case of the earlier onset of menstruation (Wolanski et al. 1998).

The summary of studies on seasonal growth processes during the last 75 years in Europe and USA had been published in *The Cambridge Encyclopedia of Human Growth and Development* (Bogin 1998; Cole 1998, p. 223). It states that the cyclic changes in growth processes, related mainly to yearly seasons, are observed, and they are manifested by increased rate of height growth in spring (March-July). This was confirmed by the knemometric studies of lower extremities. However, the increase in weight is rather small during this seasonal period, and it occurs when the changes in height are not observed. According to Cole (1998), seasonal

changes in growth processes are more marked in the countries with moderate climate than in tropics. Simultaneously, it is underlined than only 1/3 of children show this phenomenon. Cole had concluded that the yearly seasons are not the main reason of seasonal changes in growth processes which rather depend on the endogenic cycle of growth, and this cycle could be only synchronized with yearly seasons.

CLIMATIC CONDITIONS AND NUTRITION

Climatic Changes

In Yucatan, fluctuations in climatic conditions are rather feeble according to the temperature, but they are more marked in case of rainfall and humidity. Generally there are three climatic periods: the dry season (*epoca seca*) from March to May, the rain season (*epoca lluvias*) from June to October and the north wind season (*epoca nortes*) from November to February. The mean twenty-four hours' yearly temperature oscillates between 23 and 30°C. The hottest month is May, the coolest - December and January. The mean difference between these periods equals 9°C. The humidity increases together with the beginning of rainy season (Fig. 1). Even though the heaviest rainfalls are in the June-August period, the humidity is the highest in the July- October period.

During the time of present investigations the changes in temperature, humidity and intensity of rainfalls were observed, and was caused by the Isidoro hurricane, which hit the state of Yucatan in the fall of 2002 and caused many damages. In 2003, the high rainfalls occurred between June and October, and in the rest of months they were rather scanty. The relative humidity between June and October was close to 80%, in January and February - 75%, in March and April - 72%, and only in May it dropped below 70%. The mean temperature between March and October was over 27°C, the lowest was in January (21.5°C) and the highest (30.5°C) - in May (Fig. 1).

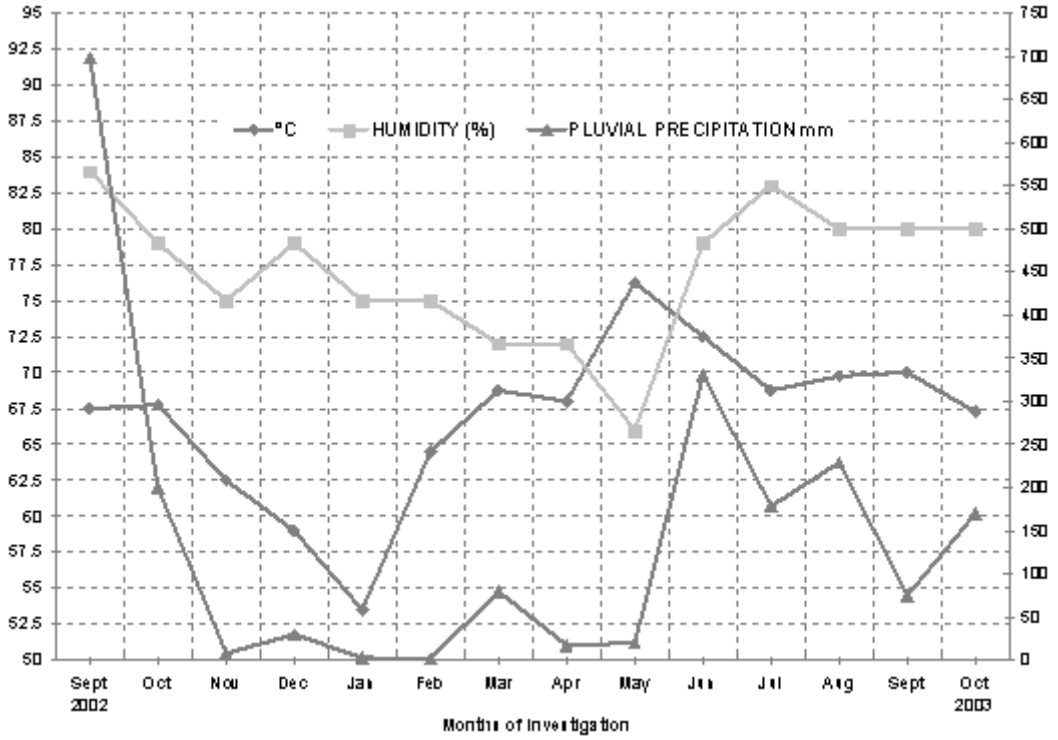

Fig. 1. Average monthly temperature (C), pluvial precipitation (mm) and humidity (%) in Merida, Yucatan (Mexico), from September 2002 to November 2003 (during adolescents' examinations); (data according to the Comision Nacional de Aqua, Gerencia Regional de Peninsula Yucatan – elaborated by A. Rojas 2004)

Feeding Patterns in the Merida Children Coming from the Poor Socioeconomic Strata

The studies on nutrition of children in Yucatan revealed that girls in 34.1% showed a deficit of carbohydrates, 45.5% - lipids and 52.3% - proteins (Canul 2004; Solis 2004). In boys, it was 35.9%, 31.1% and 49.0%, respectively. Simultaneously, 20.5% of the girls showed the excess in consumption of carbohydrates, lipids (25%) and proteins (22.7%). In boys, it was 28.9%, 35.6% and 22.2%, respectively. Most of studied children (70.5% of girls and 53.3% of boys) had the BMI adequate to their age. However, in 11.4% of girls and 20% of boys the BMI was high (between 85 and 95 of percentiles) and in 18.2% of girls and 24.4% of boys the values of BMI were very high (above 95 of percentile). There was statistically significant positive correlation between BMI and absolute consumption of nutrients below and above the norm. In the girls it was observed significant correlation for carbohydrates and lipids (r=.267*) and proteins (r=.314*), whereas in the boys - only for proteins (r=.249*). The correlation between BMI and percentage of each nutrient in the total food consumption showed different results. The statistically significant correlation occurred only in boys for carbohydrates (r=-.248*), which showed that higher consumption of carbohydrates coexists with lower BMI values. This result is seemingly illogical, because in the poor social strata of Yucatan most children consume a lot of carbohydrates for breakfast and lunch, which is the cheapest sort of food (many kinds of biscuits), and carbohydrates must cover lack of lipid and protein nutrients. This indicates that consumed carbohydrates were utilized during any kind of physical activity, and were not accumulated as adiposity. The positive correlation between protein consumption and muscular mass measured by arm circumference (r=0.390**) was also found, but it did not exist for adiposity. Most of studied children (70.5% of girls and 53.3% of boys) had the BMI adequate to their age. However, in 11.4% of girls and 20% of boys the BMI was high (between 85 and 95 of percentiles) and in 18.2% of girls and 24.4% of boys the values of BMI were very high, above 95 of percentile (Canul 2004; Solis 2004).

SUBJECTS AND METHODS

The examinations took place in the tropical climate of Yucatan and included 49 boys and 47 girls aged 11-13 years and being of the Maya, Mestizo and Creole origin. The youths were attending two schools located in rather poor districts of Merida city (Yucatan, Mexico). The measurements started in February 2002 and were continued monthly till November 2003.

The standard anthropometric methodology was applied to measure body height, weight, arm, waist, hip and calf circumferences and five subcutaneous fat folds (biceps and triceps brachii, subscapular, suprailiac and calf). Bioimpedance techniques were used to measure fat mass (FM), fat free mass (FFM) and total body water (TBW). During the study girls reported the date of menarche (Siniarska et al. 2004).

RESULTS

Generally, the rate of stature increase in girls was greater during the north wind season; it diminished in the dry season and was again greater at the end of summer vacation (Fig. 2). In boys this rate increased at the beginning of vacation, but decreased during vacation and at the beginning of the school year. This is difficult to conclude the above observations, but it is worth to notify the radically different direction of changes between two sexes at the beginning of vacation and at the school year periods.

The rate of weight changes presented a kind of jumps, which did not show any connections with seasonal changes (Fig. 2). The greatest weight increase in both sexes took place at the end of year (Christmas vacations), whereas the weight decrease was observed at the beginning of vacations in girls and during vacations in boys (it may be related to the processes of intake and spend of energy), together with the restrain in height increase.

Changes in height and weight are generally not equal (c. 50% of changes is similar, and another 50% is different). Summer vacations were the exception, where the increase of these two variables was more rapid in boys, and girls showed a kind of restrain in growth; in the first month they were slimmer and in the second month - gained the weight.

The changes of BMI were more clear and regular according to their direction and similar in both sexes. They show the 2-3 month rhythm of changes with the decrease tendency between January and August and then the increase of BMI was observed. The first increase of BMI occurred

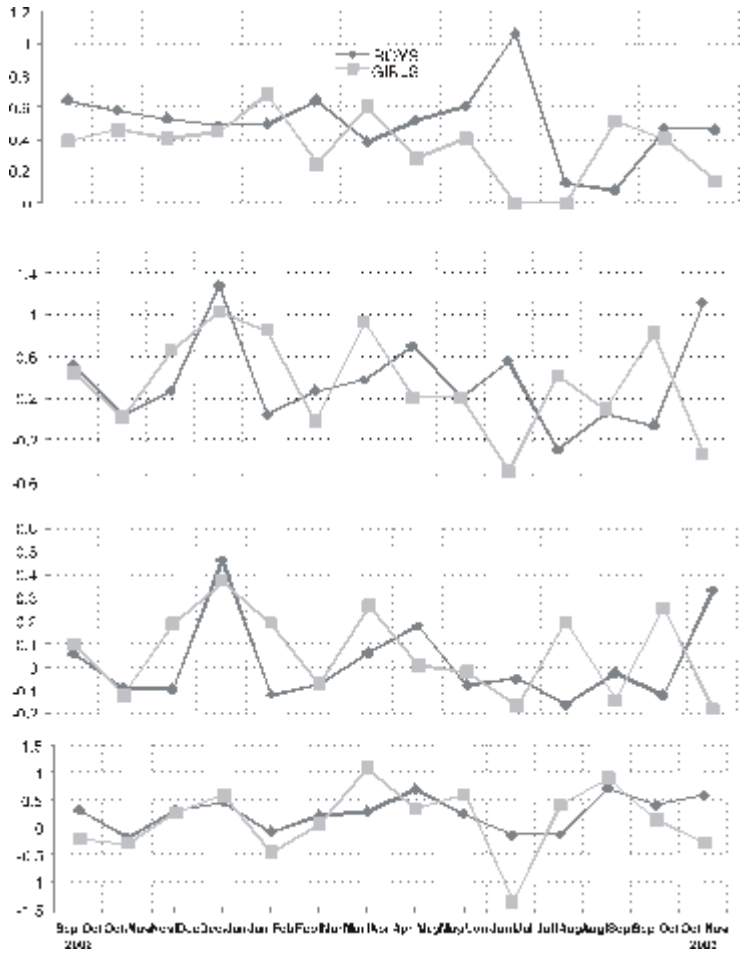

Fig. 2. Monthly changes of body height, weight, Body Mass Index (BMI), and Fat Free Body Mass (FFM) in the 11-12-year-old adolescents from Merida (Yucatan, Mexico).

in the season of north winds, mostly because the increase in adiposity, but not in subcutaneous fat tissue (Fig. 4). The greatest decrease of BMI was observed between October and November and between January and February/March, what was related to changes in body weight.

In boys changes in the fat free mass (FFM) were different from observed for height and weight (Fig. 2), but in girls they were rather similar to changes in weight. There were differences in the sequence of the pick velocity of FFM and weight. During winter holidays (between December and January) the contribution of fat component was more marked, whereas during the dry season the contribution of the fat free component dominated.

In girls, monthly changes in arm, waist and hip circumferences were rather similar to changes in weight, whereas changes in calf circumference were similar to those observed for FFM (Fig. 3). There was a monthly considerable increase of all circumferences which took place three times: at the beginning of the dry season (March-April), during summer vacations and in the season of north winds (November-February). However, a rather strong decrease in circumferences of the lower part of the body in girls occurred at the beginning of vacations, in both sexes at the beginning of the dry season (February-March), at the end of vacations and beginning of the school year (excluding the calf circumference), and partly, between October and November (excluding the hip circumference).

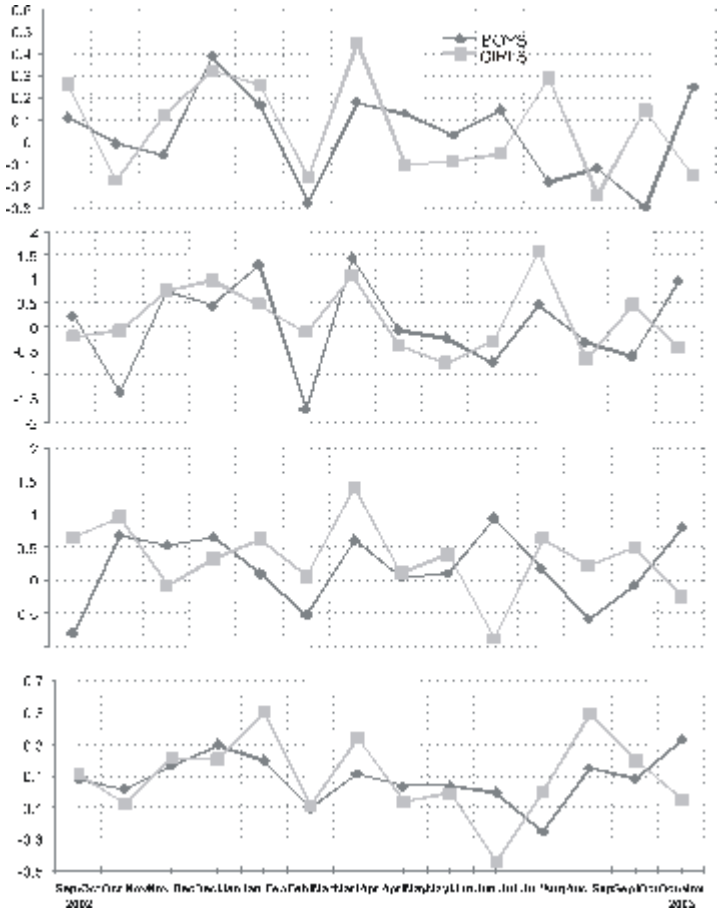

Fig. 3. Monthly changes in arm, waist, hip and calf circumferences in the 11-12-year-old adolescents from Merida (Yucatan, Mexico).

Changes in the subcutaneous fat tissue were a little different in various parts of the body (Fig. 4). Between January and February there was observed the increase in adiposity in girls and the decrease – in boys (excluding the hip fatfold), and the reverse phenomenon occurred in the next month. It means that at the end of the "north wind season" the rapid and opposite changes in subcutaneous fat tissue took place. Generally in both sexes the decrease in subcutaneous fat tissue was observed at the beginning of the summer vacations, and then the increase was observed at the end of vacations and at the beginning of school year.

The results show that permanent monthly or longer rates of stature increments and increments or declines of body mass, circumferences and fatfold thickness do not exist. The only regularity shows that rather short (1-3 months) periods of rapid growth (saltations) are divided by slower growth periods (stasis), but their duration and time of occurrence have a very individual character (Wolanski et al. 2004). The rate and rhythm of each body build variables are also different. These phenomena depend rather on conditions in which the development of each individual occurs, as well as on its genetic predispositions and ecosensitivity.

In above studies changes in particular individuals were analyzed to verify hypothesis suggesting that the rate of development has an immediate (causal) sense. The problem whether the pubertal spurt is a single developmental effort or series of changes with dominance of intensified increments was considered (Siniarska and

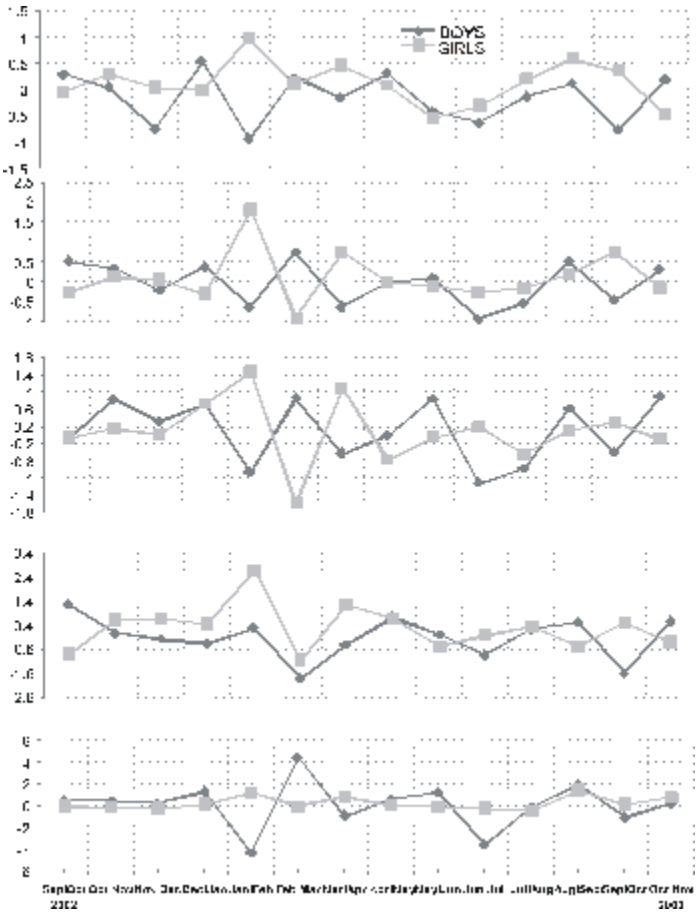

Fig. 4. Monthly changes in subcutaneous fat tissue (5 different fat folds) in the 11-12-year-old adolescents from Merida (Yucatan, Mexico).

Zielinska 2002). Each individual and its variable show a different rate of changes.

It is probable, that differences in onset and intensity of pubertal spurt depend on alternations between periods of saltations and stasis during growth processes and on changes in body mass. The menarche in Merida girls occurred mostly 3 months (0.25 a year) after the greatest SD variation in height, which identified the beginning of pubertal spurt, but in most cases saltations exist also after menarche. The pubertal spurt is not a single developmental effort but rather series of changes with dominance of intensified increments. The results show that each individual show a different rate of changes. The rate and rhythm of each body build variables are also different. It suggests that the rate of development and changes of body mass and fat mass are occasional. It rather depends on living conditions, mostly on nutrition and mode of life (physical activity and leisure).

It is seen that there are differences between boys and girls in the relation concerning studied variables and in separated factors. It is rather manifested by differences in the phase of puberty (more advanced girls than boys in this process), although the same calendar age.

Girls who mature earlier are characterized by greater initial stature and greater body weight, BMI, fat mass (including subcutaneous fat tissue) and fat free mass at the beginning and end of study than girls who matured later (Fig. 5). However, later matured girls show greater increments in stature and weight than earlier matured ones (Wolanski et al. 2004).

DISCUSSION

The analysis of changes in standard deviations of height revealed that in boys the greatest variation was observed 1.17 of a year later than in girls. The mean age at menarche of studied girls occurred about three months (0.25 of a year) after the pick height velocity. If the pollution existed several months before height pick velocity (maximal variation in SD), the mentioned difference 1.17 of a year between menarche and pollution might be diminished by half. According to actual views the first menstruation (menarche) occurs in girls usually in the year following pubertal spurt and the pollution in boys takes place the year before this spurt (Bogin 1999), these both phenomena characterizing physiological age, may occur at the similar calendar age. Similar results were also presented by Jaczewski and Pyzuk (1965).

The problem is if really the first menstruation (menarche) occurs in girls in the year following pubertal spurt (see Figs. 4, 5, 6, 10 and summary in Fig. 9 in the paper of Wolanski et al. 2004).

In the group of children with complete data, the maximal variation of SD in boys and girls occurred at the same months (May-June) but in different year. It may be caused by the intensive

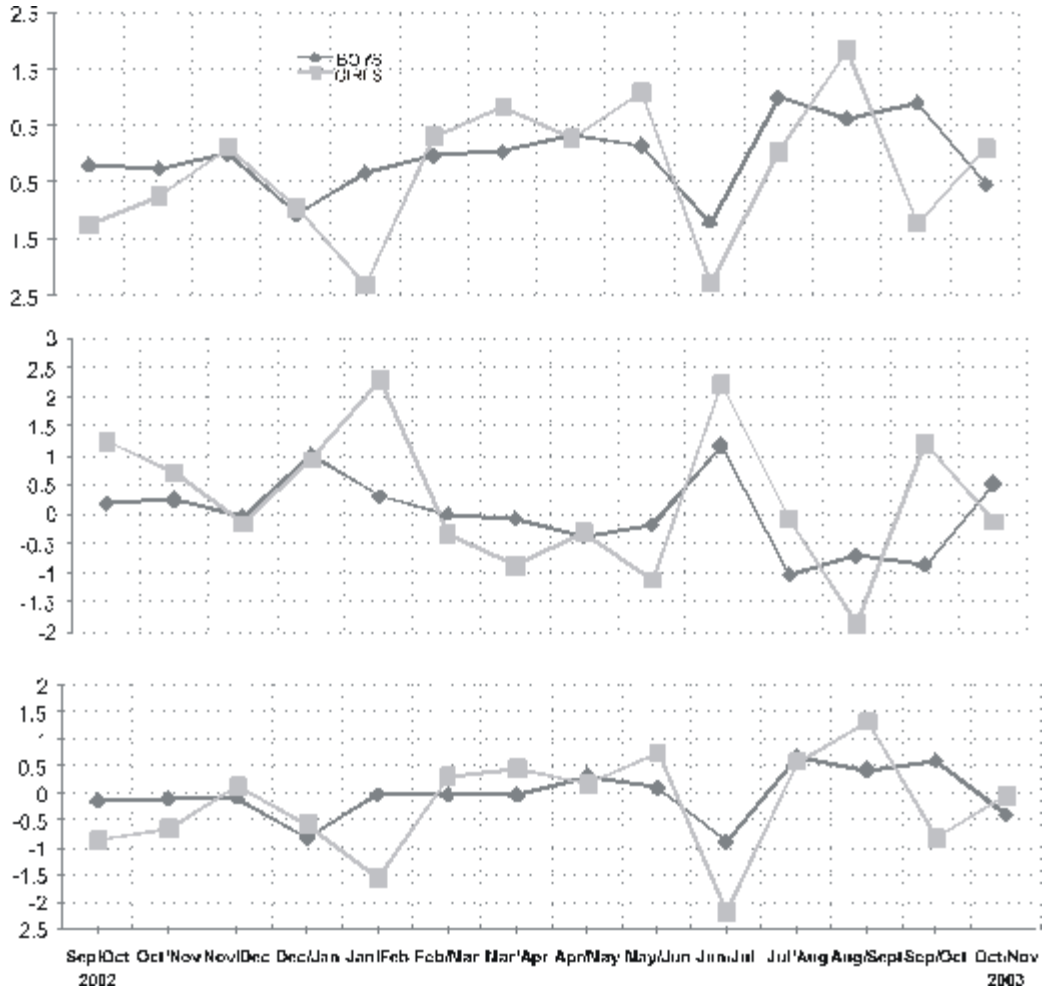

Fig. 5. Monthly changes in percentage of body components: Fat Free Mass (PFFM), Fat Mass (PFM) and body water (PTBW) in total body mass in adolescents in age 11-12 year old from Merida (Yucatan, Mexico).

insolation at that time, accelerating the process of puberty in both sexes. This phenomenon in girls has been already found in earlier studies (Wolanski et al. 1998).

The lack of farther studies in subsequent years makes this analysis more difficult and does not allow making final conclusions, e.g. verifying the hypothesis related to the fat accumulation before puberty (Frisch 1988). Because, in the same region the menarche occurs most frequently in April and May (Wolanski et al. 1998), the accumulation of fat tissue is expected at the same period of time. However, the present results show that even thought the greater variation of SD in FM exists; the fat does not increase. There is even observed the opposite phenomenon showing that between February and June the decrease in the PFM of total body mass occurred. The similar phenomenon was also observed in boys (Fig. 5).

Changes in the variation of SD in FFM were similar to the observed for height. In girls the decrease in SD variation started from May 2002, whereas in boys it was increasing till October 2003 (Fig. 6). The difference between sexes was about a year and 5 months. If the curves were replaced by 17 months, what gave that picks of SD values for both sexes were at the same place, the beginning of the SD variation corresponded to the earlier phase of boys' puberty, and after pick velocity, the variation started to diminish (Fig. 7). It corresponded to the later phase of girls' puberty.

The results of Polish cross-sectional studies

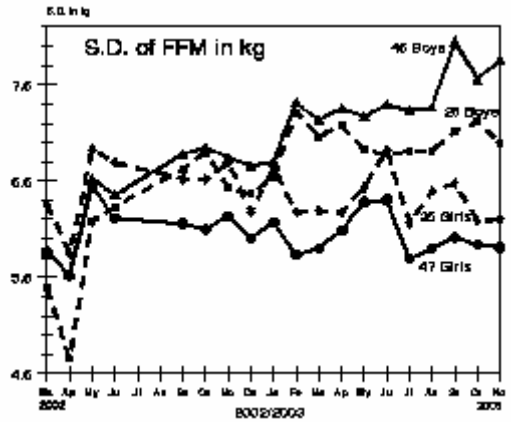

Fig. 6. Monthly changes in SD of fat free mass in kg (FFM) in boys and girls in the group with complete measurements (25-26 individuals) and the total group (47-49 individuals).

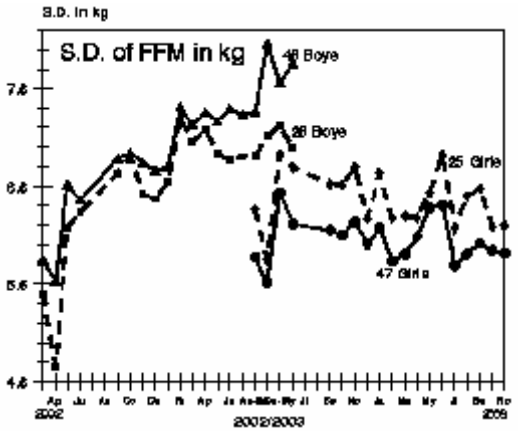

Fig. 7. Monthly changes in SD of fat free mass in kg (FFM) in boys and girls in the group with complete measurements (25-26 individuals) and the total group (47-49 individuals). The peak values of SD in girls' curves were moved to the peak values of SD observing in boys.

(Wolanski 1962) showed that the maximal variation as measured by SD occurred in boys at the age of 14 years in height and at the age of 15 years in weight, and in girls at the age of 11 and 12, respectively, what means that this phenomenon for height was the year before the maximal SD variation in weight. However, the pick of height and weight velocity occurred between the years stated above (Fig. 8). The greatest variation in height takes place immediately after the pick height velocity, whereas the same pheno-

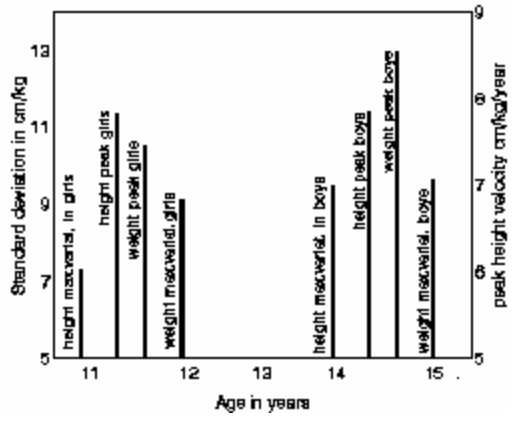

Fig. 8. Age at maximal variation (in SD) of body height and weight and age at maximal peak velocity of body height and weight in Warsaw boys and girls (crossectional data from Wolanski 1962).

menon for body weight is manifested before the pick weight velocity. The last observation needs to be confirmed in the further studies.

These studies need to be repeated during a longer period of time (at least within 5-year period), in different climatic conditions and social groups.

CONCLUSIONS

1. There are not regularities between seasonal changes and growth processes in the whole studied sample. Similarly, there are not similarities between genders in monthly changes of growth processes.
2. The observed changes do not seem to be related to the rhythm of nature. In the tropical conditions, where the maximal difference in the mean temperatures is about 9°C, the seasonal fluctuations of growth rate seem to be inde-pendent from climatic conditions, at least, they do not have the cyclic character.
3. The certain regularities in the growth rate are rather related to the rhythm of school year, period of vacations and longer holidays (summer vacations and Christmas holidays). It concerns changes in life style and physical activity during these periods.
4. The pick of weight variation (measured by SD) occurs a year later than this phenomenon observed in height.
5. The difference between genders in the picks of height SD is about 1.2 of the year. Because the pick height velocity (PHV) occurs at the end of the pick height SD variation (pollution is observed before the PHV and menarche after PHV), it suggests that the calendar and developmental age difference between genders is less than a year.
6. Changes in the rate of growth are rather determined by endogenic factors than by exogenic ones.
7. The differences in onset and intensity of pubertal spurt depend on alternations between periods of saltations and stasis of growth processes and on changes in body mass.
8. The specific monthly rate of changes of body build measures, typical for studied group of youths and/or seasonal changes according to climatic conditions (cyclic changes in nature) were not observed.
9. The results suggested that observed changes rather depend on an adjustment to local living conditions, mostly on nutrition and mode of life (physical activity and leisure).

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