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Does a Seasonal Developmental Rhythm Exist in Tropical Living Populations?

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A B S T R A C T

The main aim of this work concerns the answer a question whether the general regularity of seasonal differences in changes of height, weight and body components during ontogeny exist. If so, whether this phenomenon depends on cyclic changes in nature or this rather is an adjustment to local conditions and mode of life. To answer this question the studies took place in the tropical climate of Yucatan and included 49 boys and 47 girls aged 11–12 years and being of the Maya, Mestizo and Creole origin. The youths were attending two schools which were located in rather poor districts of Merida (capital city of the Yucatan State, Mexico). The investigations started in February 2002 and ended in November 2003 and were continued monthly. 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). The results show that monthly or longer rates of stature increments and increments or declines of body mass do not exist. The similar observations were mentioned according to daily studies of similar type in literature. There are not similar regularities of changes even in groups of coevals of the same gender and within the youths coming from the same district. Each variable shows a quite specific rate of changes.

Key words: *seasonal changes, monthly measure, tropical climate, adolescent, Yucatan, body composition*

Introduction

Climatic conditions and their impact on growth and development of people living in different geographic locations were considered by various researchers[11,12,15,23,28,29,33]. Bogin had conducted monthly measurements of height and weight throughout 14 months in Ladinos from »very wealthy families attended a private school in Guatemala City«[5,6]. His results reveled that 75% of children, 5–8 years of age show more rapid increments in height in the dray season and 25% of those children show the same effect in the raining season. He[5,6] focused on »wealthy children because children from poor families will have nutrition and disease problems that will influence their growth during the year«. He »was looking for a seasonal pattern due to meteorological changes, not nutrition and disease«.

Bogin, as well as other authors[35] 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 insolation 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[38].

Several authors have stated that seasonal changes in the growth rate are more manifested in children from the lower than higher social strata what is probably related to nutrition, sufficient in better-off families during the whole year and showing seasonal deficiencies in poor families. The observations of seasonal changes in weight in the Gambia population have revealed[1,2] that those fluctuations have been adequate to disturbances in the sustainable energetic management. Also Bogin has stated that during dry season the increase of body weight was the lowest or even the decrease was observed, especially when increase in height was the highest. Unfortu-

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nately, he did not study changes in the subcutaneous fat tissue what could clarify this phenomenon.

Several studies have also pointed out that yearly initiation of growth rate is not related to insolation and temperature alterations; however environmental factors (e.g. sun light, temperature and nutritional patterns) may modify this phenomenon. Simultaneously, seasonal developmental rhythm belongs to the very individual characteristics and even in offspring brought up together, some differences in this matter have been found[3,4,19–22,34]. Additionally, only some children show clear seasonal changes in growth processes and they are not only synchronized with seasonal cycles of insolation.

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«[7,8]. 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 decrease in height is observed. According to Cole[8], 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.

The hypothesis, which presently is going to be verified, states that if the cyclic rate of growth exists, it has rather the endogenic than egzogenic background. Furthermore, if the increase of growth processes according to certain yearly seasons or months are found, it will be important to verify the periods of growing-up (increase in height) and gaining-up (increase in weight), appearing alternately, in the aspect of seasonal changes. Some other body characteristics will be also included, and those are: total body fat, subcutaneous fat tissue and total body water. The presented problem concerns mostly tropical conditions, where changes in temperature and insolation are smaller than in regions having the moderate and cold climates.

Material and Methods

The studies were conducted in Yucatan (Mexico), in the state with the same name. This is the limestone lowland, where are lack of rivers and the main sources of water are named cenotes (large and deep natural wells). The main nutritional products are corn, black beans, different kinds of squash and abundant kinds of tropical fruits. There are also hog and chicken raising farms.

It is important to note that most Indians suffer for intolerance of lactose and it concerns some inhabitants of US as well, where 55% of Mexican Americans have this metabolic problem. Even though the problem with lactose exists, the consumption of milk and dairy products is rather high. The native inhabitants have also problems with diabetes[10]. It is suggested that typical for Mayas stocky body build and short neck is caused by problems with the carbohydrates metabolism[13].

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 dray 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-

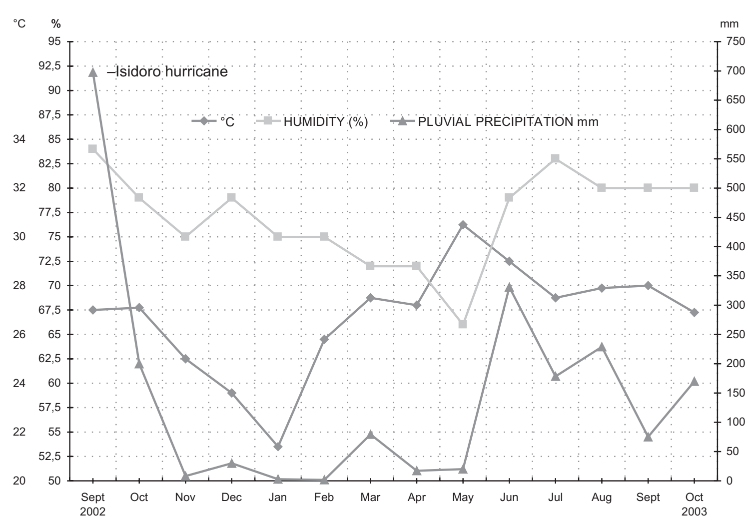

Fig. 1. Average month temperature in Centigrade, rain falls in mm and relative humidity in percent in Yucatan (Mexico) in time of examinations of adolescents since September 2002 till November 2003, for which are complete monthly measurements of 11–12 years old subjects (data according to Comision Nacional de Aqua, Gerencia Regional de Peninsula Yucatan – elaborated by A. Rojas, 2004).

TABLE 1
AGE AT MARCH 2002 OF ADOLESCENTS UNDER STUDY

Sex	School	N	Minimum	Maximum	Mean	Std. Deviation
Boys	Chuburna	18	10.60	11.42	11.0077	0.2249
	Cordemex	28	10.52	11.47	10.9262	0.2550
Girls	Chuburna	22	10.66	11.52	11.0558	0.2632
	Cordemex	25	10.52	11.45	10.9647	0.2800
Boys		46	10.52	11.47	10.9581	0.2444
Girls		47	10.52	11.52	11.0074	0.2732
Boys&girls		93	10.52	11.52	10.983	0.5291

-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 (Figure 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 were 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 drooped 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 (Figure 1).

The studies included two schools in Merida, the capital of Yucatan State (Mexico). Children and youth attending these schools came from the mixture population of Mayas and Creoles. The first school named *Felipe Carillo Puerto* is localized in the poor district named Chuburna and studies were performed between February (for some subjects March) 2002 and November 2003. The second school named *Zamna* is localized in the labor district named Cordemex, a slightly more affluent than the first one. The studies had been conducted between February 2002 and November 2003. The district of Cordemex was build for workers of the henequen factory localized there. The factory was closed at the end of 20th century, because the artificial ropes displaced the sisal (henequen) ones produced there.

There was a short brake in the studies during July and August 2002, but in 2003 studies were continued also in these two months. The initial number of investigated pupils was 50 boys and 50 girls, but at the end of June 2002 it diminished to 48 of individuals of each gender. After the vacation time the new school year attended only 38 boys and 39 girls from the previous group. Finally, the complete data from September 2002 to November 2003 included 26 boys and 25 girls. However, in October/November 2003, 46 boys and 47 girls were investigated, what allowed comparing changes in 22 months.

In March 2002 the mean age of boys from the Cordemex school was 10.93 (SD=0.23) years, from the Chuburna school 11.01 (SD=0.23). Within the girls it was 10.96 (SD=0.28) and 11.06 (SD=0.26), respectively. The group of adolescents from Chuburna was a little bit older (0.1 of a year) than from Cordemex (Table 1). The total material included boys and girls at the same age. In March 2002 the boys' mean age was 10.96 and that for girls 11.01 years (~11 years of age). At the end of the studies they were 20 months older (1.7 of a year), it means they were ~12.7 years old. The differentiation was rather small, because about 70% of studied adolescents were located in the division a little above of half the year.

The measurements included body height and weight, arm, waist, hip and calf circumferences (followed the methods of Martin and Saller, in the book of Malinowski &Wolanski[26]), subcutaneous fat folds on arm (2 places above biceps brachii and triceps brachii), subscapular, on 10th rib, above hip and on calf below knee. Fatfolds measurements were done following the Parizkova, in the book of Malinowski&Wolanski[26] method and using Lange Skinfold Caliper (Cambridge Scientific Industries Inc.). Body composition parameters (fat free mass [FFM], fat mass [FM] and total body water [TBW]) were measured using Valhalla 1990B bio-resistance body composition analyzer. This allowed calculating three components: percentage of fat free mass (PFFM), percentage of fat (PFM) and percentage of water (PTBW) of the total body mass[27]. Body mass index (BMI – body mass in kg/ height in m) was used to eliminate changes of body weight related to increasing stature. The percentage ratio of FFM to FM (FFM/FM), and the absolute and percentage increase in stature (Si%) according to initial data were also calculated (March 2002 – November 2003). The subcutaneous fat tissue was analyzed as the sum of 5 fatfolds. In April and May 2003, the nutritional questionnaire was also used recording the feeding patterns (nourishment) of studied children[9]. During the study girls reported the date of menarche. Only 9 girls started their menstruation before studies and 9 girls after the end of studies. However, the interview was continued each month until the last girls reported the onset of menarche.

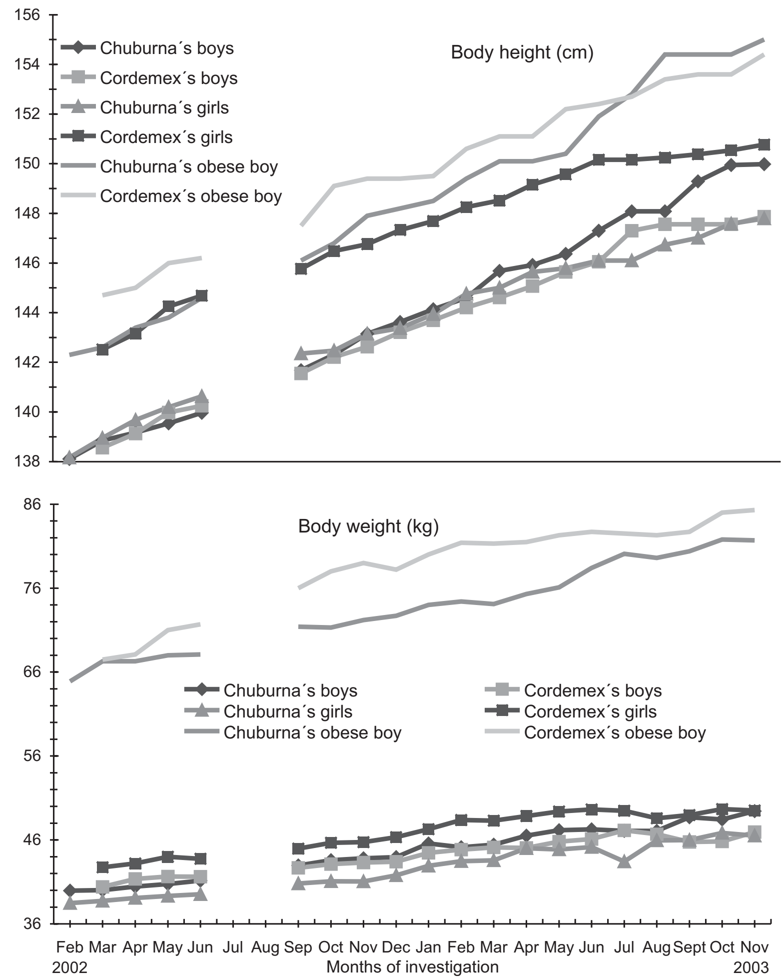

Fig. 2. Mean values of stature in cm and body mass in kg in examined boys and girls and two obese boys from schools in Chuburna and Cordemex since February 2002 (examinated adolescents were in mean 11 years old) till November 2003, with interruption in July and August 2002.

All measurements were taken in the 30 (±2) days intervals in the middle of each month in morning hours (8:00–12:00). Only during vacation time the measurements were sometimes extended till 2 P.M. There was the same team of people taking part in these studies, co-authors of this publication: GV was measuring girls and AR boys.

In our statistical evaluation we did not use specialized statistics (like Periodic Regression & Harmonic Analysis or so) for aligned the individual variations. As presented Hermanussen[16,17] and comment Lampl, Johnson and Frongillo[24,25] they falsify reality as we show in our publications[31,37].

Results

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% for lipids and 52.3% for proteins. 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. There was statistically significant positive correlation between BMI and absolute consumption of nutrients below and above the norm. In the girls it was observed for carbohydrates and lipids (r=0.267) and proteins (r= 0.314), whereas in the boys only for proteins (r=0.249). 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=–0.248), 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 exit for adiposity[9,32].

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).

Changes in means of studied variables in boys and girls

The data for studied sample are presented in the tables 2 and 3. All studied youth, 11–12 years old, are in the phase of puberty. Most of girls from Cordemex are over the adolescent spurt of height, and their mean age at menarche was 11.70 (SD=0.82). It is clearly seen that girls who have already started menstruation were 4 cm taller and the further increase of height have been disappearing than it was observed in girls before menarche (Figure 2). During the whole period under study, girls from Cordemex were taller than boys, and children from Cordemex were taller than from Chuburna. In Chuburna (the poorer district than Cordemex) the mean age at menarche was 11.89 (SD=0.84) but the difference between two schools was statistically insignificant. At the

TABLE 3
STATISTICS OF STATURE FOR THE GROUP OF 25 GIRLS (THE COMPLETE EXAMINATION)

Month and year of examinations	F	Min	Max	Mean	SD
March/02	25	129.8	151.7	141.22	5.81
April/02	25	129.8	152.7	141.87	5.79
May/02	25	130.6	154.0	142.70	5.77
June/02	25	131.2	154.0	143.16	5.89
July/02					
August/02					
September/02	25	133.4	154.0	144.24	5.44
October/02	25	133.7	154.0	144.76	5.41
November/02	25	134.2	154.7	145.16	5.33
December/02	25	134.3	154.7	145.55	5.24
January/03	25	135.4	154.7	145.93	5.06
February/03	25	135.6	154.7	146.27	5.00
March/03	25	136.8	154.7	146.70	4.80
April/03	25	137.5	155.0	147.04	4.71
May/03	25	138.1	155.5	147.38	4.65
June/03	25	138.4	155.5	147.59	4.65
July/03	25	139.5	156.0	148.09	4.50
August/03	25	140.8	157.1	148.44	4.40
September/03	25	140.8	157.8	148.59	4.45
October/03	25	141.1	157.8	148.79	4.44
November/03	25	141.9	158.0	149.06	4.33

TABLE 2
STATISTICS OF STATURE FOR THE GROUP OF 26 BOYS (THE COMPLETE EXAMINATION) AND FOR 2 OBESE BOYS

Month and year of examinations	f	Min	Max	Mean	SD	Obese boy	
						no 17	no 72
March/02	26	125.5	151.2	138.52	5.50	142.6	144.7
April/02	26	126.5	152.0	138.96	5.53	143.4	145.0
May/02	26	126.9	153.3	139.56	5.72	143.8	146.0
June/02	26	127.5	153.9	140.00	5.75	144.6	146.2
July/02							
August/02							
September/02	26	128.7	157.8	141.51	5.96	146.1	147.5
October/02	26	129.0	157.8	142.19	5.94	146.8	149.1
November/02	26	129.0	158.1	142.68	6.01	147.9	149.4
December/02	26	129.5	158.2	143.30	5.99	148.2	149.4
January/03	26	130.2	158.3	143.76	6.06	148.5	149.5
February/03	26	130.8	159.4	144.24	6.09	149.4	150.6
March/03	26	130.8	160.2	144.92	6.21	150.1	151.1
April/03	26	131.3	161.3	145.39	6.31	150.1	151.1
May/03	26	131.3	161.3	145.84	6.29	150.4	152.2
June/03	26	131.3	162.3	146.51	6.45	151.9	152.4
July/03	26	132.4	162.6	147.48	6.41	152.8	152.7
August/03	26	132.4	162.7	148.06	6.34	154.4	153.4
September/03	26	132.4	162.9	148.26	6.35	154.4	153.6
October/03	26	133.1	162.9	148.76	6.25	154.4	153.6
November/03	26	133.1	163.1	149.35	6.22	155.0	154.4

TABLE 4
STATISTICS OF BODY WEIGHT FOR THE GROUP OF 26 BOYS (THE COMPLETE EXAMINATION) AND FOR 2 OBESE BOYS

Month and year of examinations	f	Min	Max	Mean	SD	Obese boy	
						no 17	no 72
March/02	26	25.0	61.7	39.15	9.36	67.3	67.5
April/02	26	25.2	63.1	39.59	9.71	67.3	68.1
May/02	26	25.2	65.5	39.93	10.107	68.0	71.0
June/02	26	25.6	66.5	40.32	10.52	68.1	71.7
July/02							
August/02							
September/02	26	25.2	66.5	41.58	10.60	71.4	76.0
October/02	26	26.0	68.1	42.11	10.87	71.3	78.0
November/02	26	26.0	68.3	42.38	10.84	72.2	79.0
December/02	26	26.3	67.5	42.45	10.67	72.7	78.2
January/03	26	26.8	70.0	43.70	11.05	74.0	80.0
February/03	26	26.8	70.0	43.78	11.10	74.4	81.4
March/03	26	27.3	70.6	43.93	11.00	74.1	81.3
April/03	26	27.2	70.4	44.46	11.08	75.3	81.5
May/03	26	27.3	71.1	45.11	11.27	76.1	82.3
June/03	26	27.3	71.0	45.47	11.20	78.4	82.7
July/03	26	27.9	74.0	46.11	11.45	80.1	82.5
August/03	26	27.6	70.5	46.34	11.39	79.6	82.3
September/03	26	28.5	70.6	46.70	11.26	80.4	82.7
October/03	26	28.8	71.5	47.44	11.48	81.8	85.0
November/03	26	29.2	72.2	47.86	11.41	81.7	85.3

TABLE 5
STATISTICS OF BODY WEIGHT FOR THE GROUP OF 25 GIRLS (THE COMPLETE EXAMINATION)

Month and year of examinations	f	Min	Max	Mean	SD
March/02	25	26.8	74.5	41.95	11.90
April/02	25	26.8	75.5	42.47	11.97
May/02	25	26.5	76.7	43.01	12.33
June/02	25	26.7	73.5	43.03	12.13
July/02					
August/02					
September/02	25	28.0	71.6	43.86	11.79
October/02	25	28.0	74.3	44.72	12.05
November/02	25	28.4	74.6	44.72	12.16
December/02	25	29.4	75.8	45.20	12.40
January/03	25	30.0	76.5	46.40	12.45
February/03	25	30.6	75.8	46.84	12.40
March/03	25	30.9	78.0	47.17	12.82
April/03	25	32.0	77.5	47.58	12.72
May/03	25	32.6	79.0	48.02	12.74
June/03	25	33.6	79.4	48.17	12.87
July/03	25	34.4	78.2	48.28	12.58
August/03	25	35.0	77.4	48.55	12.47
September/03	25	35.1	76.7	48.55	12.19
October/03	25	35.8	77.9	49.08	11.92
November/03	25	35.9	78.0	49.41	11.81

initial phase of the study girls had almost the same height as boys (Table 4). Even though the age at menarche between girls from Chuburna and Cordemex was very similar, the changes in almost all studied somatic variables during the time of study were different. Grater values of the variables were seen in Cordemex, and it also concerned FFM, FM and initial and final BMI (Table 5).

Boys in Cordemex had greater FM and FFM than boys in Chuburna, but the initial and final BMI were similar in both groups. Girls in Cordemex had greater FM than boys, whereas in Chuburna boys had greater FFM than girls. This may indicates that boys in the poorer district are more physically active or/and are involved in some domestic or »for living« works (e.g. in the supermarkets). Also the increase of height in the Chuburna boys was above 10% greater than in the Cordemex boys (Table 5).

The two, very obese boys (Mestizo no 17 from Chuburna and Creole no 72 from Cordemex) were excluded from some parts of the present analysis for the whole group, but analyzed separately. Their body height was initially similar to that for girls from the better district (Figure 2), but they started to be taller soon. The stature increase in the obese boys during 20 months was 12.5 cm in the boy who was in the pubertal spurt, and 10 cm in another, and finally they exceeded the Cordemex girls by 3 cm. Youth from poorer district showed the height increase equals 11.5 cm (boys) and 9 cm (girls); from the better off district this was 10 cm and 8 cm, respectively. During the study weight of the obese boys was almost double grater (increased in 30% from 65 to 85 kg) than the mean weight for boys and girls under study (increased in 25% from 39 to 49 kg).

The changes in mean values of studied variables during the whole period of 20 months did not show any specific regularity according to the monthly or seasonal changes. However, some the most important changes, which were usually different between boys and girls, should be taken into account. 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 (Figure 3). In boys this rate increased at the beginning of vacation, but decreased during vacation and at the beginning of the school year. The greatest height increase in boys was observed between June and July and then between February and March; whereas in girls between January and February, March and April and August and September. The weaker height increase in girls took place during the vacation time. 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 (Figure 3). 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 maybe 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 greatest increase of BMI in both sexes was observed between December and January, in girls between March and April, and in boys between April and May, when the stature increase was rather small. The first increase of BMI occurred in the season of north winds, mostly because the increase in adiposity, but not in subcutaneous fat tissue (Figure 6). 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 (Figure 3), 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

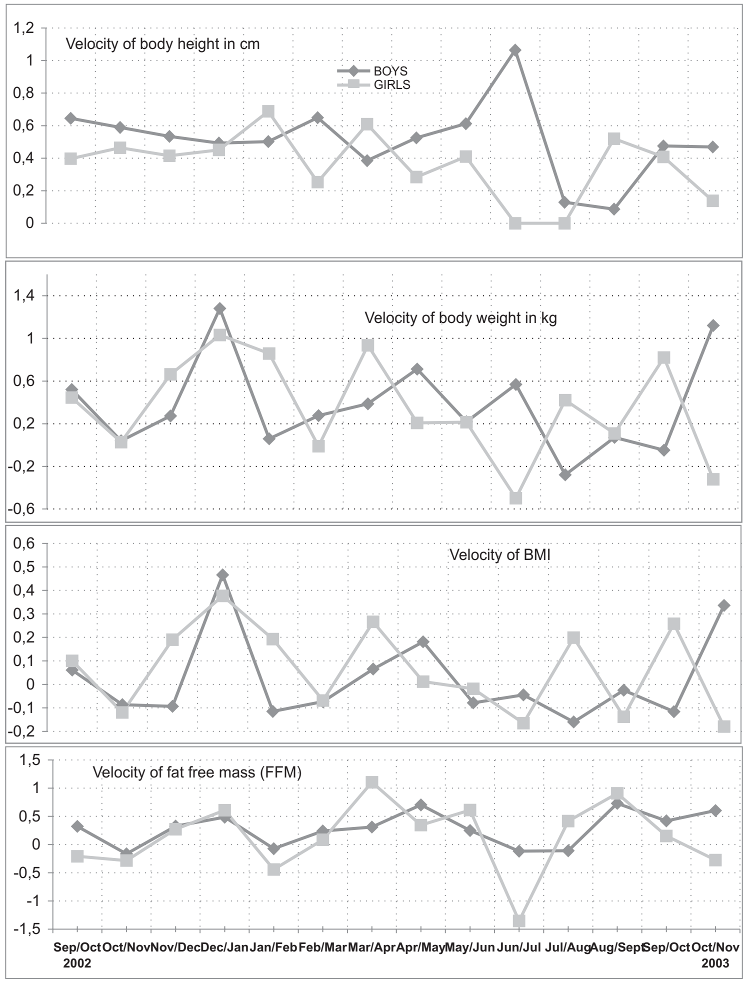

Fig. 3. Monthly changes in body height and mass, Body Mass Index (BMI), and Fat Free Body (FFM) in adolescents in age 11–12 year old from Merida (Yucatan, Mexico). Examined were the same boys and girls in two Merida districts, from rather poor families of Maya, Creoles and Mestizos). On figures were presented data since September 2002 till November 2003.

December and January) the contribution of fat component was more marked, whereas during the dry season the contribution of the fat free component dominated (Figure 3 and 6).

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 (Figure 3 and 4). 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).

Changes in the subcutaneous fat tissue were a little different in various parts of the body (Figure 5). 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.

Almost all monthly changes in body components (FFM, FM [adiposity] and TBW), presented in the percent of total body mass, were greater in girls than in boys (Figure 6). The general tendency showed the increase of intensity of changes between December and February (north wind season) and between June and September (rainy season). This showed that between February and

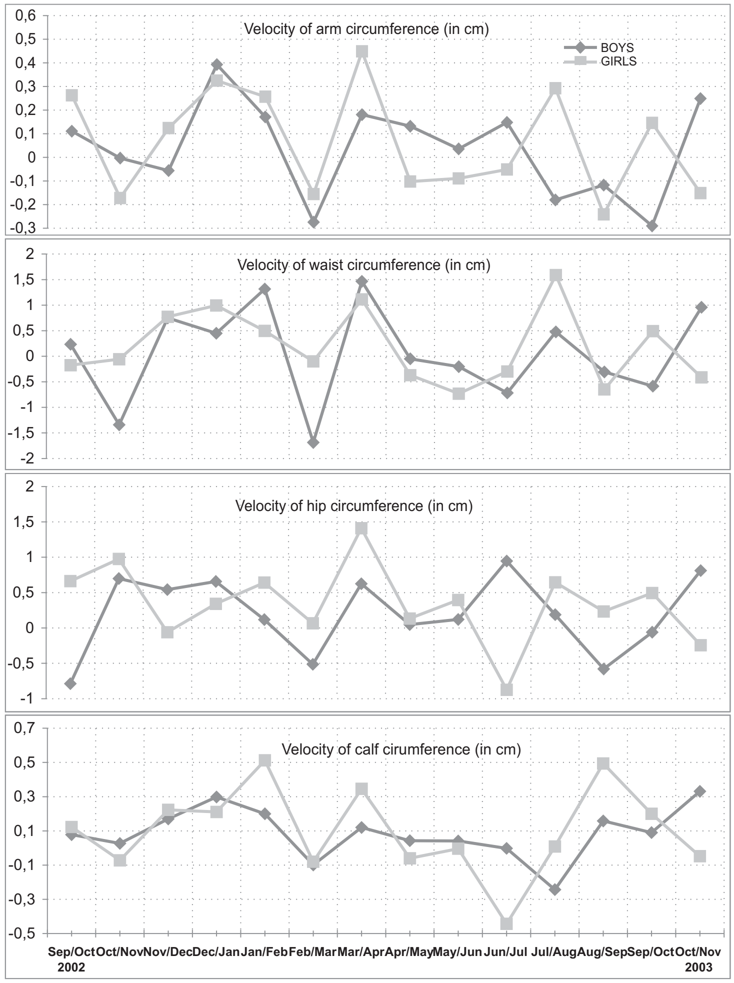

Fig. 4. Monthly changes in arm, waist, hip and calf circumferences in adolescents in age 11–12 year old from Merida (Yucatan, Mexico).

June, but especially in the dry season, the FFM component increased but the FM decreased, and this also occurred during vacations, especially in boys, and in a smaller extent between November and December. The TBW component showed fluctuations similar to described for the FFM.

The increase of FM component (adiposity) dominated between December and February, June and July and, in a smaller extent, between September and November. The peak velocity was seen between June and July what is a little odd, because at the same time in boys the increase and in girls the decrease in height were observed. Additionally, the decrease in BMI, total and relative FFM and TBW were also seen. In both sexes, the greatest decrease in the % of FM in TBW was observed at the end of vacations and at the beginning of school year. The rainy season may be of secondary importance in this phenomenon. The decrease in the FM component was also observed in the whole dry season (February–June), whereas the stabilization was manifested between November and December (on the turn of rainy to north wind seasons).

The above considerations show the complexity of the whole processes of growth. It probably depends on individual style of live, nutritional patterns and school workload. However, it also points out that there is lack of any clear relation between the cyclic changes in means of studied variables for the whole group.

The range of variation measured by standard deviation (SD)

The next problem being considered is the range of changes in dispersion measured by SD. The analysis of changes of studied variables revealed that boys entered pubertal period at the end of the present study, whereas girls started this period just before the beginning of the study (62% of girls reported their menarche during the studies). The mean age at menarche for the whole group is 11.78 (SD=0.82). Because the mean age of all the girls at the beginning of studies (March 2002) was 11.01, the mean age at menarche took place 0.77 of a year (9 months) after study begun (Table 6).

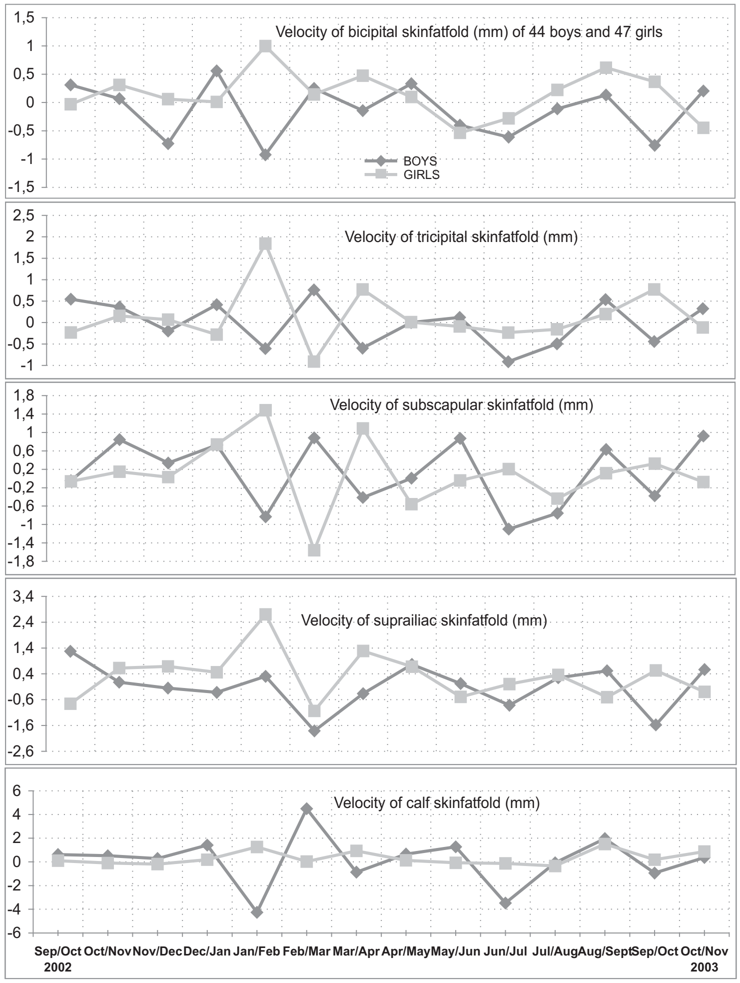

Fig. 5. Monthly changes in subcutaneus fat tissue in 5 places of the body in adolescents in age 11–12 year old from Merida (Yucatan, Mexico).

Standard deviation (SD) of height in boys was showing increasing tendency with age from 5.6 to 6.7 cm, whereas in girls this was a decreasing tendency from 6.4 to 4.9. Seasonal changes were not clearly seen (Figure 7a). In girls, during the first three months of studies SD of height was decreasing, then it was increasing, and at the end of study the stabilization was observed. In boys, SD started to decrease three months before the end of studied.

The greater SD of height existed together with the beginning of acceleration of growth processes (pubertal spurt[36]). The height of youth individuals at that period was highly differentiated because some of them were before the spurt (most of boys at the beginning of studies), others were during this process, and the third group was over it (girls at the end of investigations). The greatest differentiation of height can be located at the middle of pubertal period (at least – pubertal spurt). However, because the girls' pick of variation occurred before the first vacations, the exact evaluation of this phenomenon was rather impossible. The pick of height variation was observed at the age of 12.50 years in boys, and 11.33 years in girls. This difference (1.17 of a year) corresponded probably to the biological age which differentiated both sexes at the puberty period.

TABLE 6
AGE AT MENARCHE OF MERIDA GIRLS

	F	Minimum	Maximum	Mean	SD
Chuburna	22	10.19	13.76	11.8857	0.8376
Cordemex	25	9.84	13.27	11.6959	0.8162
All	47	9.84	13.76	11.7848	0.8228

The total group of 47 girls showed greater variation in height than the group of 25 girls, who have the complete data. This points out that the studied sample was not random. The difference within the sample of boys (49 boys versus 26 with the complete measurements) was fortunately less marked (Figure 7a).

The picks of variation measured by SD (different for both sexes) were moved to the common point (September 2003 for boys and June 2002 for girls, 1.25 of a year). Af-

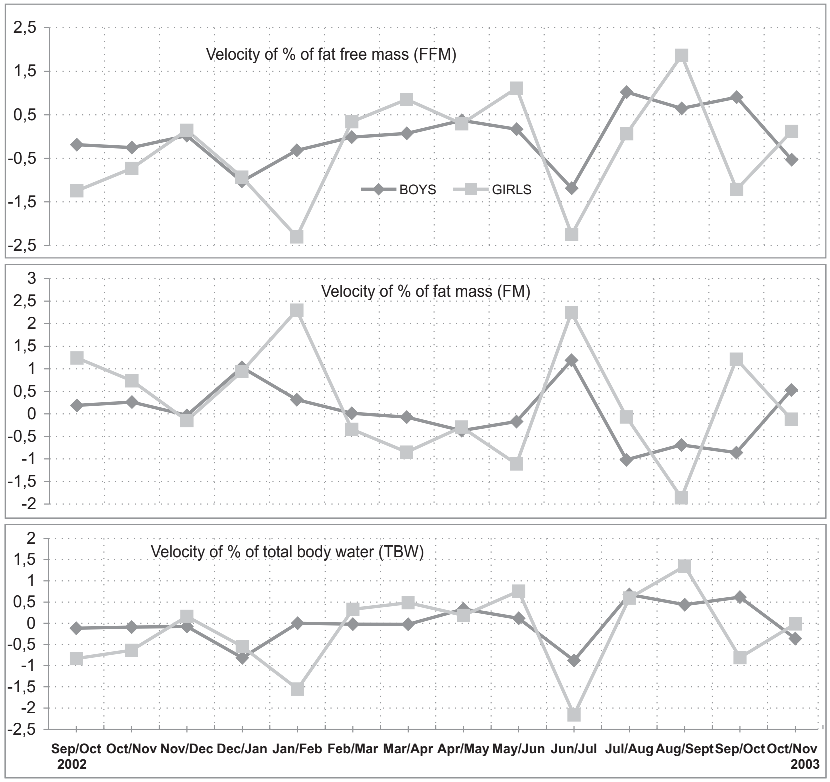

Fig. 6. Monthly changes in percentage of body components: Fat Free Mass (PFFM), Fat Mass (PFM) and body water (PTBW) in total body mass in adolescents in age 11–12 year old from Merida (Yucatan, Mexico).

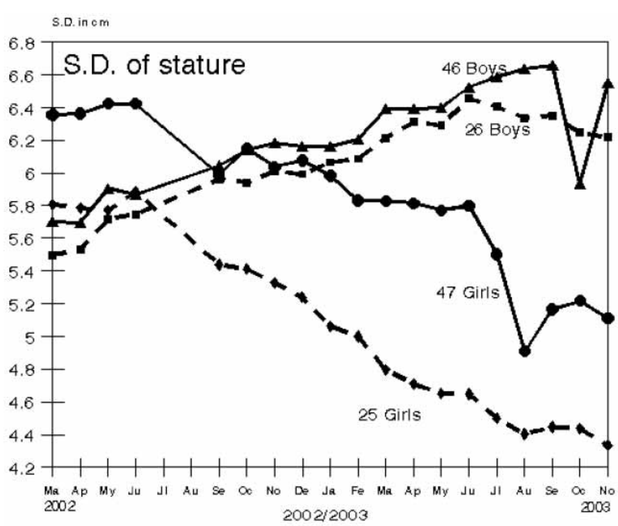

Fig. 7a. Changes of standard deviation of body height in boys and girls in groups of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), by year and month of measurements.

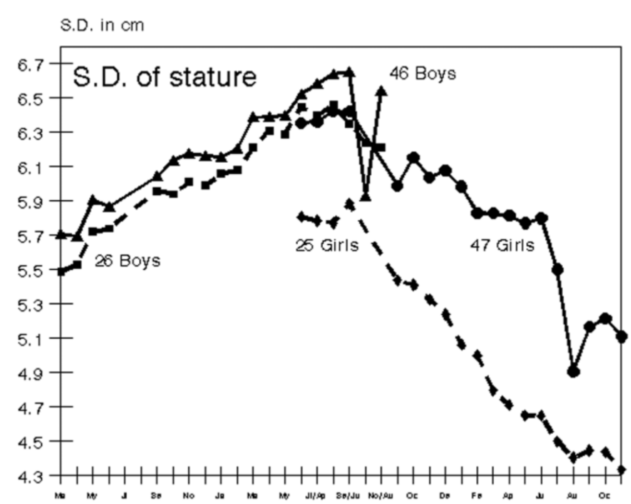

Fig. 7b. Changes of standard deviation of body height in boys and girls in groups of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), with correction (move) of curves for the same month in which peak values of SD were observed.

ter that, the curve of SD for height made the logical course (Figure 7b). It showed that till the time when the half of studied boys reached height pick velocity (probably girls, as well), the increase in SD variation was observed and after that the decrease started. The figure 3 presents the pick height velocity which occurred 1.5 months before the pick of SD variation.

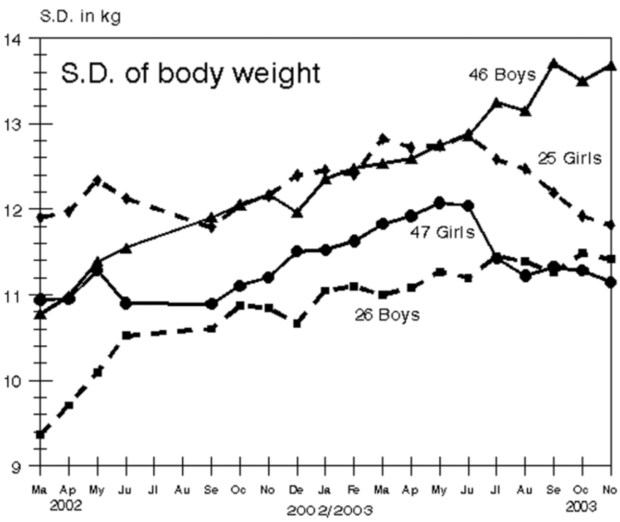

Fig. 8a. Changes of standard deviation of body mass in boys and girls in groups of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), by year and month of measurements.

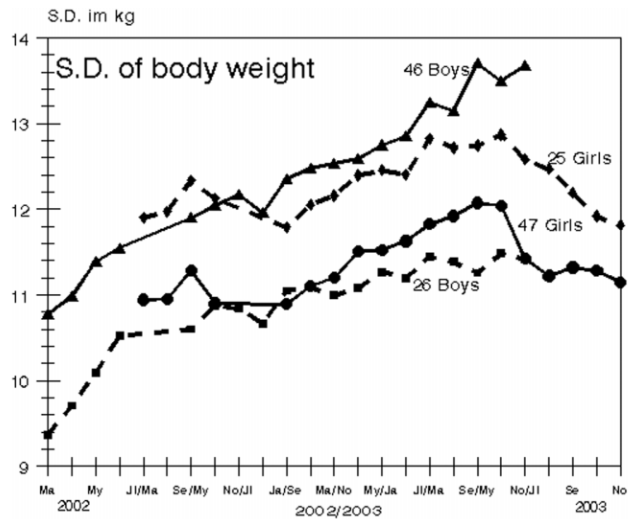

Fig. 8c. Changes of standard deviation of body height in boys and girls in group of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), with correction (move) of curves for the same month in which peak values of SD were observed.

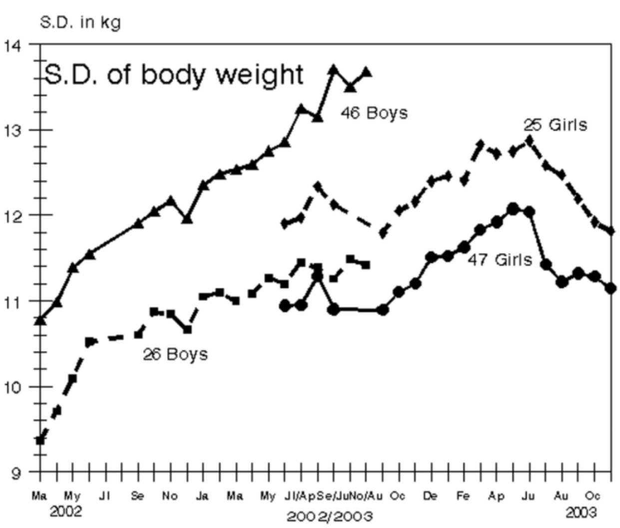

Fig. 8b. Changes of standard deviation of body height in boys and girls in group of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), with correction (move) of curves for the some number of months as in Fig. 7a.

Because the first menstruation (menarche) in girls occurs usually in the year following pubertal spurt, and the pollution in boys takes place the year before this spurt, these both phenomena characterizing physiological age, may occur at the same calendar age. The menarche in Merida girls occurred 3 months (0.25 a year) after the greatest SD variation in height, which identified the beginning of pubertal spurt.

In the group of boys, SD of weight oscillated between 9.4 and 13.7 kg, and the increasing tendency with age was observed. In girls, SD fluctuated between 10.8 and 2.8 kg, the increasing tendency occurred between May–June 2003, and then the decrease of the SD variation with age was observed (Figure 8a, b, c). There was lack of seasonal fluctuations.

In boys, the pick of SD variation of weight occurred just at the end of studies, whereas in girls it was notified 5–6 months before the end of studies. If the picks of SD variation for weight was established at the month in which the same phenomenon occurred for height (Figure 8a, b), the curves would be at the different levels. However, if the both picks of SD were placed according to weight (Figure 8c), the curves would have more similar course, and the difference was only 3–4 months (Figure 8a, b, c).

Discussion

There is rather hard to observe the impact of seasonal changes on human somatic characteristics in the tropical conditions. According to opinions of other researchers[8,30] regions with the seasonal difference in temperature about 20°C and more, have greater influence on growth processes. Together with the decrease in temperature difference the seasonal fluctuations in height diminish. This hypothesis has been proved by the present studies located in Yucatan, where the mean monthly difference in temperature is only 9°C (Fig.1).

In general, the increase in height is not followed by the proportional increase in weight, however if the increase in weight is more manifested the growth processes of long bones will be slowed down. Those changes are irregular for height and weight, but more marked (defined) for BMI and FFM.

The attention should be paid in case of the drastic difference in the height increase between sexes during vaca-

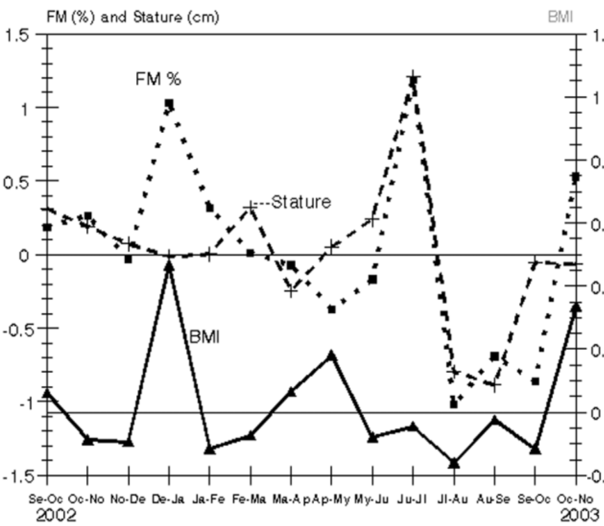

Fig. 9a. Comparision of monthly changes in percent of fat mass (PFM), body height and body mass index (BMI) in boys from Merida.

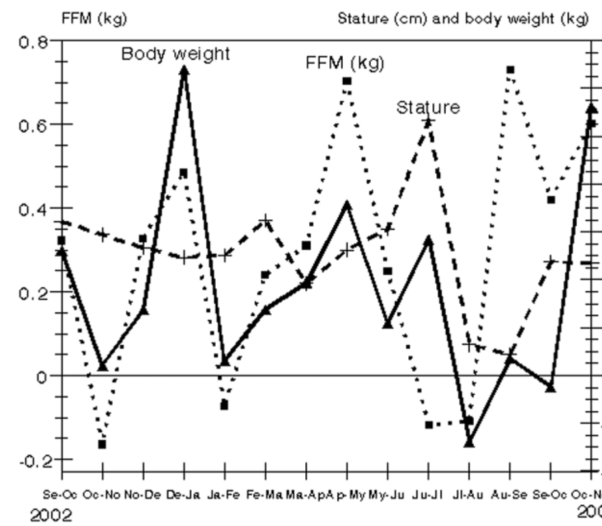

Fig. 10a. Comparision of monthly changes in fat free mass (FFM), body height and body mass in boys from Merida.

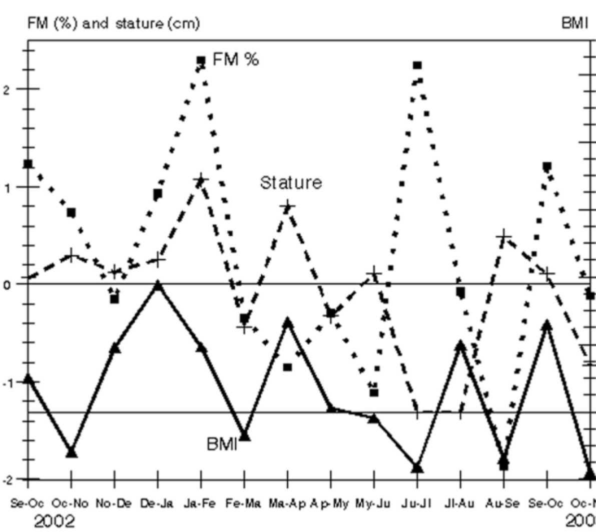

Fig. 9b. Comparision of monthly changes in percent of fat mass (PFM), body height and body mass index (BMI) in girls from Merida.

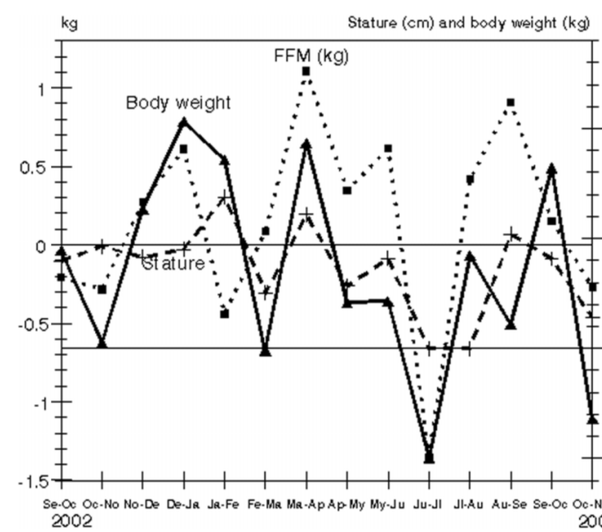

Fig. 10b. Comparision of monthly changes in fat free mass (FFM), body height and body mass in girls from Merida.

tions. This might be related to different reactivity of boys' and girls' organisms, who are in the various stage of development or to the different style of life (the level of physical activity) between two genders during vacation time than during the school year. It is also worth to mention that the greatest weight increase in both sexes are observed at the end of the year what could be related to the rather long-lasting Christmas vacations and changes in life style at that time.

There were different periods of changes for hip and calf circumferences than for arm and waist circumferences. This was probably related to different elements of tissue compositions, responsible for these changes, which depend on nutritional patterns and style of life (type of physical activity), and finally resulted in different energetic balance.

In boys, between June and July there was observed greater increase in height, but less in weight. The intensive weight increase was however observed between December and January simultaneously with greater increase of fat (Figure 9a, b). In girls the increase in weight and height took place close to each other, between December and January for weight and between January and February for height. The increase in fat occurred in girls between June and July and it was accompanied by very little increase of weight, height and FFM. It points out that the secretion of leptine, greater together with the increase in fat tissue is rather hardly related to the stimulation of growth processes.

The growth processes of bone tissue may be stimulated by a strong insolation which causes the production of cholecalciferol (vitamin D3) and occurs mostly between June and July. This phenomenon was observed in boys but not in girls. During the most sunny months in Yucatan there was observed in both sexes the intensive increase of FFM (Figure 9a, b and 10a, b), and it also occurred between August and September and between December and January (the end of summer vacations and at the time of winter holidays). It suggests that the increase in FFM occurs mostly during free of school workload periods when the physical activity may be greater. During summer vacations the PFM seemed to not increase, however there was observed the increase of the FFM and the PFM during winter holidays in boys and the PFM a month later in girls.

The figures presenting arithmetic means for the whole group did not show any clear regularity. Also the description of the observed changes was very complicated and was hard to find any connection between them and seasonal conditions. Comparing both sexes, besides similarities, there were observed differences in direction and intensity of changes in growth processes. The lack of relations between growth processes and seasonal periods is probably caused by the tropical climate. There are three seasons with very little difference in temperature. The relation was rather observed between growth processes and style of life connected to school and free of school periods.

Because the first menstruation (menarche) in girls occurs usually in the year following pubertal spurt, and the pollution in boys takes place the year before this spurt, these both phenomena characterizing physiological age, may occur at the same calendar age. The menarche in Merida girls occurred 3 months (0.25 a year) after the greatest SD variation in height, which identified the beginning of pubertal spurt.

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. These results are similar to the data from literature showing that menarche occurs a year after 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. This indicates that the calendar age of boys at pollution and girls at menarche is similar. Similar results were also presented by Jaczewski and Pyzuk[18].

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 insolation at that time, accelerating the process of puberty in both sexes. This phenomenon in girls has been already found in earlier studies[38].

The maximal SD variation in weight occurred in boys about 4 months later than in girls. It shows that the gender difference is more than 3 times shorter than in case of height, and suggests the hypothesis that weight might

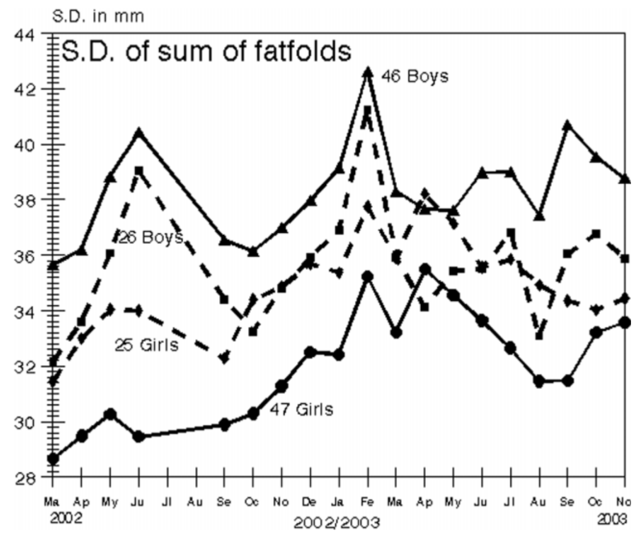

Fig. 11a. Changes of standard deviation of the sum of 5 fatfolds in boys and girls in groups of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), by year and month of measurements.

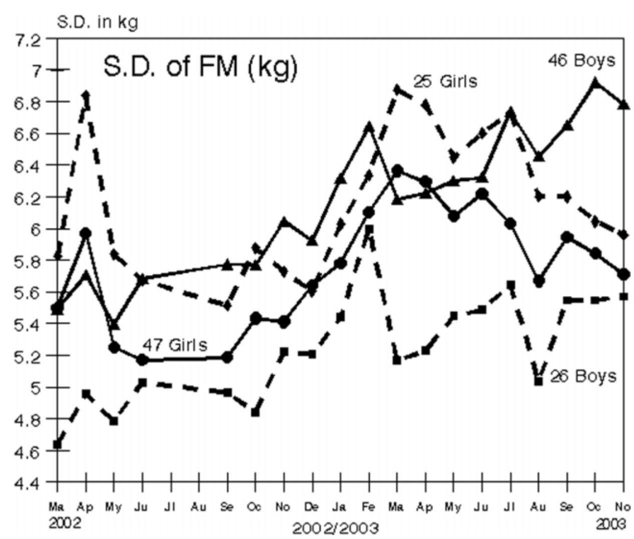

Fig. 11b. Changes of standard deviation of fat mass in kg (FM) in boys and girls in groups of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), by year and month of measurements.

have a different rhythm of growth than height. It may also suggest that the pick weight velocity is closer to the age at pollution and menarche than to the age of pick height velocity. Thus, the question arises whether growth rate of height is under different neuro-hormonal control than growth rate of weight.

The SD variation in sum of subcutaneous fat tissue showed a certain cyclic changes. It was greater in May and June (at the end of dry season of 2002, Figure 11a, b) and in February of 2003 (between rainy and dry seasons). The third phase of greater variation was observed only in boys in September and October (the initial months of school year). It does not show any regularity according to the season of a year, but presents the three-five-month--periods of increase, and similar period of decrease in subcutaneous fat tissue. Logically, the greater variation in adiposity should be when the style of life and physical activity are also more differentiated. This is hard to explain following these changes with the beginning and the end of school year, and the study on energetic balance might be more helpful in this explanation.

The changes of SD variation in FM (kg) were not parallel to the changes in subcutaneous fat tissue. It suggests that the growth processes of these two characteristics might have different origin. The greatest variation in FM in both sexes was observed in April 2002 and in February, March and April of 2003. It occurred at the end of north winter season and in dray season. There is a different role of subcutaneous fat tissue (mostly isolation) comparing with the fat located inside the organism (energetic reserves, internal organs protection). If so, this rather points out that the relation between subcutaneous fat tissue and energetic balance should be more dependent on climatic conditions than in case of the whole FM.

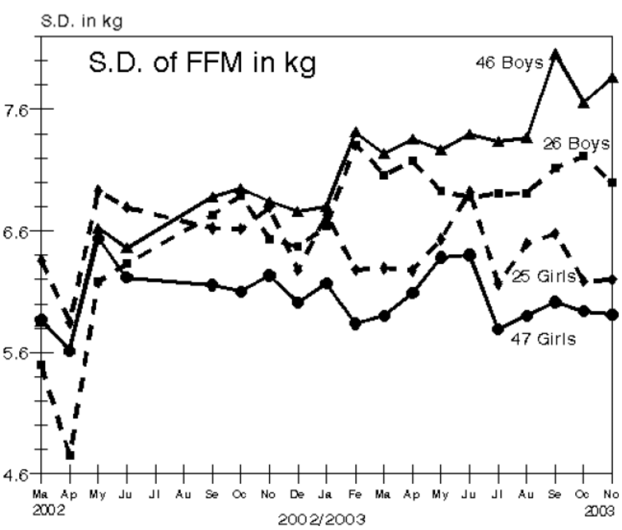

Fig. 12a. Changes of standard deviation of fat free mass in kg (FFM) in boys and girls in groups of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), by year and month of measurements.

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[14]. Because, in the same region the menarche occurs most frequently in April and May[38], 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 (Figure 6 and 9a, b). 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.

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 (Figure 12a). 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 (Figure 12b). It corresponded to the later phase of girls' puberty.

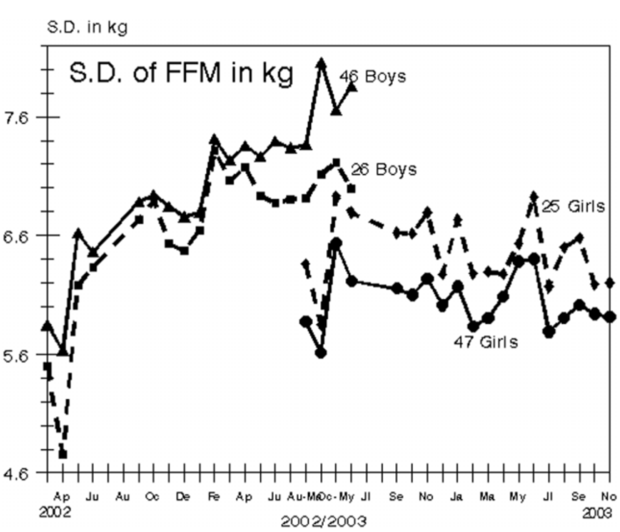

Fig. 12b. Changes of standard deviation of fat free mass (FFM) in boys and girls in groups of complete measurements (25–26 subjects), and with some lack of measurements (47–49 subjects), with correction (move) of curves for the same month in which peak values of SD were observed.

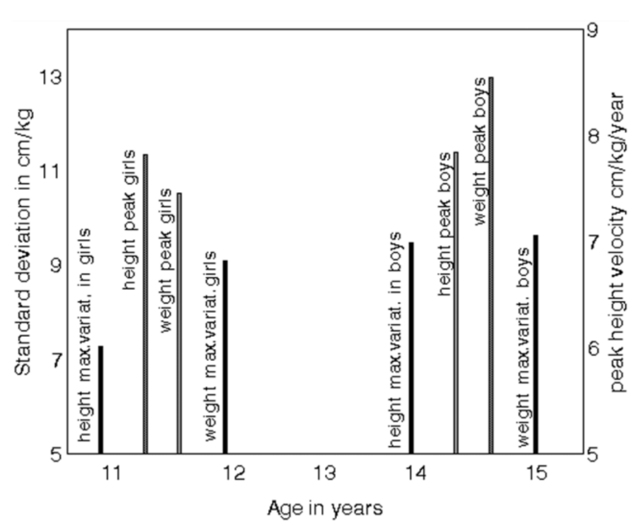

Fig. 13. Age at maximal variation as measured by standard deviation (SD) of body height and mass and age at maximal peak velocity of body height and mass in Warsaw boys and girls (crossectional data from Wolanski 1962).

TABLE 7
INCREASE OF STATURE IN CM IN BOYS AND GIRLS FROM SCHOOLS FROM CHUBURNA AND CORDEMEX

Increase of stature in cm	f	Min	Max	Mean	SD
Boys	46	6.80	17.10	10.41	2.43
Girls	47	3.30	13.30	8.49	3.07
Adolescents from Chuburna	40	3.70	15.10	9.79	2.89
Adolescents from Cordemex	53	3.30	17.10	9.17	2.95
Boys from Chuburna	18	7.50	15.10	11.14	2.14
Boys from Cordemex	28	6.80	17.10	9.94	2.52
Girls from Chuburna	22	3.70	13.30	8.67	2.98
Girls from Cordemex	25	3.30	13.10	8.32	3.19

TABLE 8
INITIAL AND FINAL BODY MASS INDEX (BMI) IN BOYS AND GIRLS FROM SCHOOLS FROM CHUBURNA AND CORDEMEX

Place of studies	f	Min	Max	Mean	SD
Initial BMI					
Adolescents from Chuburna	40	14.20	33.10	20.50	4.53
Adolescents from Cordemex	53	15.36	33.65	21.07	4.30
Final BMI					
Adolescents from Chuburna	40	14.58	34.01	21.68	4.49
Adolescents from Cordemex	53	15.60	35.78	22.20	4.55
Initial BMI					
Boys from Chuburna	18	14.20	33.10	21.23	5.01
Boys from Cordemex	28	15.87	32.24	21.30	4.32
Girls from Chuburna	22	14.93	32.46	19.91	4.12
Girls from Cordemex	25	15.36	33.65	20.82	4.36
Final BMI					
Boys from Chuburna	18	14.58	34.01	22.27	4.82
Boys from Cordemex	28	15.60	35.78	22.24	4.84
Girls from Chuburna	22	16.48	32.48	21.20	4.25
Girls from Cordemex	25	16.00	33.02	22.15	4.30
Initial BMI					
Boys from Chuburna	17	14.20	30.82	20.53	4.17
Boys from Cordemex	27	15.87	28.47	20.90	3.83
Girls from Chuburna	22	14.93	32.46	19.91	4.12
Girls from Cordemex	25	15.36	33.65	20.82	4.36
Obese boy no 17 from Chuburna	1	33.10	33.10	33.10	
Obese boy no 72 from Cordemex	1	32.24	32.24	32.24	
Final BMI					
Boys from Chuburna	17	14.58	30.60	21.58	3.94
Boys from Cordemex	27	15.60	29.64	21.74	4.13
Girls from Chuburna	22	16.48	32.48	21.20	4.25
Girls from Cordemex	25	16.00	33.02	22.15	4.30
Obese boy no 17 from Chuburna	1	34.01	34.01	34.01	
Obese boy no 72 from Cordemex	1	35.78	35.78	35.78	

The results of Polish cross-sectional studies[36] 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 (Figure 13). The greatest variation in height takes place immediately after the pick height velocity, whereas the same phenomenon for body weight is manifested before the pick weight velocity. The last observation needs to be confirmed in the further studies.

It was earlier mentioned that the BMI of girls from Cordemex was greater than in girls from Chuburna, whereas the % of stature increase (Si%) was only slightly greater in girls from Chuburna (Table 7 and 8). It may point out that the Chuburna girls mature a little later or there is the different time relation between menarche and pick height velocity. This problem will be considered in the next paper devoted to the further issues of studies in Yucatan.

Conclusions

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. 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 looks to be independent from climatic conditions, at least, they do not have the cyclic character. 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. The pick of weight variation (measured by SD) occurs a year later than this phenomenon observed in height. 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. Girls that form the better-off-district (Cordemex) are taller than from worse-off-district (Chuburna). However, there is not difference in the age at menarche between girls form those districts, but more fat is observed in the Chuburna girls. Changes in the rate of growth are rather determined by endogenic factors than by exogenic ones.

Acknowledgements

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POSTOJI LI SEZONSKI RAZVOJNI RITAM U TROPSKIM POPULACIJAMA?

SAŽETAK

Cilj je ovog rada odgovoriti na pitanje postoje li generalne pravilnosti u sezonskim razlikama u promjeni visine, težine i tjelesnog sastava tijekom ontogeneze te ovisi li taj fenomen o cikličkim promjenama u prirodi ili je to samo prilagodba na lokalne uvjete i način života. Kako bi odgovorili na ovo pitanje provedena su istraživanja u tropskoj klimi Yucatana nad 49 dječaka i 47 djevojčica u dobi od 11–12 godina majanskog, mestizo ili kreolskog podrijetla. Djeca su pohađala dvije škole smještene u prilično siromašnom okrugu Merida (glavni grad države Yucatan, Meksiko). Istraživanja su počela u veljači 2002. i završila u studenom 2003. Primjenjena je standardna antropometrijska metodologija za mjerenje visine tijela, težinu, opsege ruke, struka, kuka i potkoljenice te 5 potkožnih nabora (bieps i triceps brachii, subskapularni, suprailijačni i potkoljenični). Za mjerenje mase masti, mase bez masti i ukupnu vodu u tijelu korištena je bioimpendancija. Rezultati su pokazali da ne postoje mjesečni ili dulji periodi rasta tijela te povećanja ili smanjenja tjelesne mase. Ne postoje slične pravilnosti u promjenama čak ni u grupama vršnjaka istog spola djece koja dolaze iz istog okruga. Svaka varijabla pokazuje sasvim specifičnu stopu promjene.