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Article

Differences in growth and development velocity between boys and girls from Kosovo, aged 6-18 years

Diferencias en la velocidad de crecimiento y desarrollo entre niños y niñas de Kosovo, de 6 a 18 años.

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SUMMARY

Background: Human growth and development is a complex process of bio-psycho-social changes in children and adolescents. The evaluation of these two processes is of high importance in clinical and anthropological contexts. The present study aimed to find out and to evaluate the velocity of the biological growth and development during different ages of Kosovo children and adolescents of both genders.

Materials and methods: Body Height, Body Weight, and Ideal Body Weight were measured in 68762 children and adolescents from Kosovo (66264 boys, 2498 girls). Age groups were classified into 13 categories, ages 6.0-18.9 years old. There have been analyzed the systematic differences between males and females in the annual changing of Body Height, Body Weight, and Ideal Body Weight.

Results: Based on the results of the present study growth and development in boys can be divided into three stages that are distinct from one another, compared with the girls' growth and development that can be divided into four stages. Boys have reached the Peak Height Velocity (PHV=7.8cm), respectively the Peak Weight Velocity (PWV=6.6kg) at the age-group of 14 years old, while girls have reached the Peak Height Velocity (PHV=8.4cm) and the Peak Weight Velocity (PWV=12.6kg) at the age-group of 11 years old.

Conclusion: The puberty stage occurs approximately three years earlier in girls (11yrs) compared with the boys (14yrs). Although the boys experience a later achievement of PHV, their growth, and development, with reduced intensity, it continues even after the age of 18th. The girls' body growth and development commence earlier in age, and it reaches the maximal values earlier. This fact suggests that males will grow more during the late stage of the adolescence compared with females; therefore, in general males' morphometric features tend to be larger.

Keywords: Stature, Body-weight, Puberty.

1. Introduction

The process of growth and development means the changes in the body tissues structure, body height, and body weight that occur from conception to the mature phase of the human being (Cossio-Bolanos et al., 2015). In other words, growth is the result of an interaction between the body's endocrine (growth hormone, thyroxine, insulin, corticosteroids, leptin, parathyroid hormone, and calcitonin) and musculoskeletal system (Neinstein, 2002).

The auxologic measurements such as body height and body weight variables measured at different ages of the children and youth are two of the most important anthropometrical variables according to which can be assessed the variability of the growth and development velocity during a fixed period (Cameron, 1978; WHO, 2009). Human beings during their life, pass through different age-periods of the morpho-functional transformations. These distinctive morpho-functional characteristics during different age-periods, occur under dominant influences of the endogenous (genetic factors, a variety of hormones), exogenous (environmental, nutritional, socio-economic factors, ethnicity, etc.), and pathological factors (some diseases, medicaments, "bad habits") (Rosenbloom, 2007). According to Haymond et al. (2013), monitoring of the growth, disturbances are of determinant importance in pediatric health care. While normal growth velocity is a sign of good health, the slow growth velocity is often correlated with the pathological condition of children and adolescents. So, according to these authors, the main reason to study abnormal growth in infants and children is to identify conditions that may threaten good health and life.

The assessment of the body height and body weight of the children is of primary importance for all areas of paediatrics to evaluate their general health condition (Bozzola & Meazza, 2011).

The velocity of the biological growth and development during different ages of children and youth show variable intensity, depending on their life stage. The commencement of the rapid adolescent growth corresponds with the beginning of the puberty stage (Fryar et al., 2012; Granados et al., 2015; Komlos & Breitfelder, 2007; Portella et al., 2017; Stang & Story, 2005;). According to Rogol et al. (2000), since children often have growth spurts, yearly growth velocities are more accurately determined by taking annual measurements of the body height rather than from intervals shorter than one year.

Although a growth spurt (peak growth velocity) in boys occurs between ages 12 and 17, while in girls between ages 9 and 14, according to Neinstein (2002), the Peak Height Velocity (PHV) in females occurs 18-24 months earlier than in males, as for the Peak Weight Velocity (PWV) in females, it occurs 6-9 months after reaching PHV, while in males, it coincides with PHV.

According to Juul et al. (2006), the adolescence stage begins earlier in the US population than in Netherland population.

From the clinical practice aspect, assessment of the growth and development velocity, and the pubertal stage of the child are highly applicable in standard diagnostic or evaluation procedures.

In the absence of these data regarding the Kosovo population, the present study aimed to find out and to evaluate the velocity of the biological growth and development during different ages of Kosovo children and adolescents of both genders.

2. Material and method

Research design

This study as a part of the project "The exploration of the anthropological status of Kosovo population" was carried out at the Institute of Sports Anthropology in Prishtina, Kosovo, during the period 2007-2016. Part of the data from this study which has to do with male entities have been previously published in two other of our researches, which are also part of the same project (Rexhepi et al. 2011; Rexhepi, et al. 2018).

By its nature, this research is an observational and cross-sectional descriptive study.

Site of study and sampling

Two morphometric variables (Body Height and Body Weight) were measured in 68762 children and adolescents from Kosovo (2498 girls and 66264 boys). Ages were grouped into 13 categories from age 6 to 18.9 years. Groups were allocated at 1-year-age-intervals. The measurements were done during the period 2007-2016. The examined entities were chosen randomly, always respecting the rule that their psycho-physical condition was in the normal range.

Analysing the systematic differences between males and females in annual changing of the Body Height (BH), Body Weight (BW) and Ideal Body Weight (IBW), derives the differences in growth and development velocity between males and females.

Measuring tools and data collection

In conformity with the International Biological Program (IBP) the following morphometric variables were measured:

- Body Height (BH) – indicates the distance from the standing surface to the vertex of the head, with subject's body position in a standard erect posture, without shoes, and with the head position in Frankfort horizontal plane. Stature was measured with a classical anthropometer (expressed in mm);
- Body Weight (BW) – was measured with a digital weighing scale (expressed in kg);
- Ideal Body Weight (IBW) – using the Vanderval equation this measurement was calculated for each group of the examined entities.

The statistical analyses were performed with the IBM SPSS Statistics software package, version 20. The obtained data were analyzed in term of the descriptive statistical parameter - Mean value.

Ethical considerations. This project was approved by the Ethics Committee of the Institute of Sports Anthropology.

3. Results and discussion

Data of table I show general information regarding the number of examined entities, their group ages, the mean values of the growth and development velocity, and the ideal body weight calculated for each age group.

Table I.

Age groups, Number of estimated entities, Body Height (BH), Body Weight (BW) and Ideal Body Weight (IBW) for boys and girls

	Boys				Girls			
Age (yr)	Nr of examined entities	Mean BH (cm)	Mean BW (kg)	Mean, IBW (kg)	Nr of examined entities	Mean BH (mm)	Mean BW (kg)	Mean IBW (kg)
6	117	120.3	22.1	22.7	57	119.1	20.2	22.1
7	347	125.1	24.2	25.0	138	123.2	21.5	24.1
8	657	130.6	27.5	28.4	156	128.0	24.3	26.8
9	1278	136.0	30.8	31.6	194	134.9	27.9	31.9
10	2227	140.8	34.1	34.5	101	140.3	33.6	34.2
11	4722	145.5	37.0	37.0	72	149.4	46.2	40.1
12	7714	150.4	40.4	40.1	93	153.7	46.4	43.1
13	9127	156.8	45.5	47.8	157	158.1	49.0	49.1
14	9196	164.6	52.0	55.6	245	162.0	53.0	54.1
15	9223	171.0	58.4	61.0	337	163.2	55.3	56.2
16	8365	174.8	63.2	64.8	367	163.4	57.1	56.4
17	7205	176.7	66.1	66.7	315	163.8	57.4	56.8
18	6086	177.7	68.2	67.7	266	163.5	58.2	56.5

According to the results of the present study, although the body growth and development velocity in boys continues through all ages in variable intensity, the body height and body weight show a similar intensity of growth during childhood and adolescence (Tables I, II).

Growth and development in boys can be divided into three stages that are distinct from one another:

- The first stage includes age groups of 6-12 years old. In this stage, body height growth of 4.7 to 5.3 cm can be observed. Meanwhile, body weight growth from 2.1 to 3.4 kg.
- The second stage includes age groups of 12-13, 13-14, and 14-15 years old. This stage distinct from other stages with the rapid increase of the body height growth velocity (6.5cm, 7.8cm, 6.3 cm) and the body weight growth velocity (5.1kg, 6.6kg, 6.4 kg), reaching the Peak Height Velocity (PHV=7.8cm), respectively Peak Weight Velocity (PWV=6.6kg). This stage of growth and development in boys can be referred to as the early stage of adolescence, respectively the rapid stage of puberty;
- The third stage includes age groups of 15-16, 16-17, and 17-18 years old, and characterised with the dropping of the intensity in BH and BW growth. The body height growth velocity drops to 3.9 cm, 1.9 cm, and even to 1 cm to age groups of 17-18 years old, while the body weight growth velocity drops to 4.7 kg, 2.9 kg, and 2.1 kilograms of the corresponding age groups. Both of these anthropometric parameters (BH, BW) in boys do not show a stagnation of values but only a decrease in intensity, which means that growth and development, even though with reduced intensity, continue increasing even after the age of 18 (Tables I, II). This stage can be referred to as the stage of the relative stability of boys' growth and development.

Table II.
The annual changes of the height growth velocity (HGV) and weight growth velocity (WGV) of males and females

	Males		Females	
Ages (yr)	HGV (cm)	WGV (kg)	HGV (cm)	WGV (kg)
6-7	4.7	2.1	4.1	1.3
7-8	5.6	3.3	4.8	2.8
8-9	5.3	3.3	6.8	3.6
9-10	4.9	3.3	5.4	5.7
10-11	4.7	2.9	9.1	12.6
11-12	4.9	3.4	4.3	0.2
12-13	6.5	5.1	4.4	2.7
13-14	7.8	6.6	3.8	4.0
14-15	6.3	6.4	1.2	2.3
15-16	3.9	4.7	0.1	1.7
16-17	1.9	2.9	0.4	0.4
17-18	1.0	2.1	-0.3	0.8

Girls compared with boys show the different intensity of the body growth and development that can be divided into four stages:

- The first stage includes age groups of 6-7, and 7-8 years old and is characterised by a slight increase in height growth velocity (4.1-4.8cm) and weight growth velocity (1.3-2.8kg);
- The second stage includes age groups of 8-9, 9-10, and 10-11 years old. During this stage, a high increase of height growth velocity (6.8cm, 5.4cm, and 8.4cm) and weight growth velocity (3.6kg, 5.7kg, and 12.6kg) for the corresponding age groups can be noticed. This stage is characterized by reaching of the Peak Height Velocity (PHV=8.4cm) and the Peak Weight Velocity (PWV=12.6kg) - it can be referred to as the rapid stage of puberty;
- The third stage includes 11-12, 12-13, and 13-14 years old. Comparing to the second stage, at this stage can be noticed a gradual decrease of height growth velocity (4.3cm, 4.4cm, and 3.8 cm) and weight growth velocity (0.2kg, 2.7kg, and 4.0kg) for the corresponding age groups. This stage can be referred to as the calm stage of puberty;
- The fourth stage includes age groups of 14-15, 15-16, 16-17, and 17-18 years old. This stage is characterized by almost complete stability of height growth velocity (1.2cm, 0.1cm, 0.4cm, and -0.3cm) and weight growth velocity (2.3kg, 1.7kg, 0.4kg, and 0.8kg) for the corresponding age groups. A relative stabilisation is achieved at the age groups of 17-18 years (BH = 163.8 cm; BW = 58.2 kg) (Tables I, II, Figures 1, 3).

The Ideal Body Weight (IBW) value is related closely to Body Height; therefore the increase of BH has a significant impact in IBW too (Table I). Analysing attained data from measuring the BW of Kosovar adolescents, can be concluded that the BW of the examined boys and girls is relatively close with their IBW, with the tendency of gaining more weight after the age of 18th. It is of importance

to mention that the greater quantitative differentiation of the IBW is observed when the highest PHV occur (boys aged 14th; girls aged 11th) (Table I).

According to the gained results of this study, the Peak Height Velocity (PHV) coincides with the Peak Weight Velocity (PWV) in both groups (boys and girls). The PHV and PWV in boys occur during the 14th year of their life, while in girls during the 11th year of their life. So, the maximum growth velocity of the body height and body weight in the group of boys occur approximately three years later compared with the group of girls (Table I, II, and Figure 2), unlike the results of Neinstein (2002) where this difference is 1.5 - 2 years. Also, the PHV in boys from Kosovo is averaging 1.3 cm less than in girls, compared with the results of Neinstein (2002) and Fryar et al. (2012) where PHV in boys from the USA is averaging 2 cm more than in girls.

It is also of great importance to note that the decrease of height growth velocity and weight growth velocity in boys are realised after the age of 15, whereas in girls after the age of 14 (Table I, II, and Figure 2).

Figure 1.
Annual body height growth attained for Kosovo boys and girls

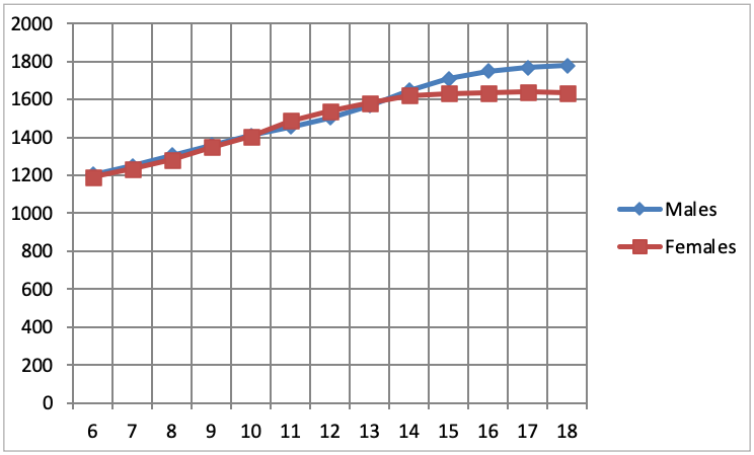


Figure 2.
Annual growth differences in body height for Kosovo boys and girls

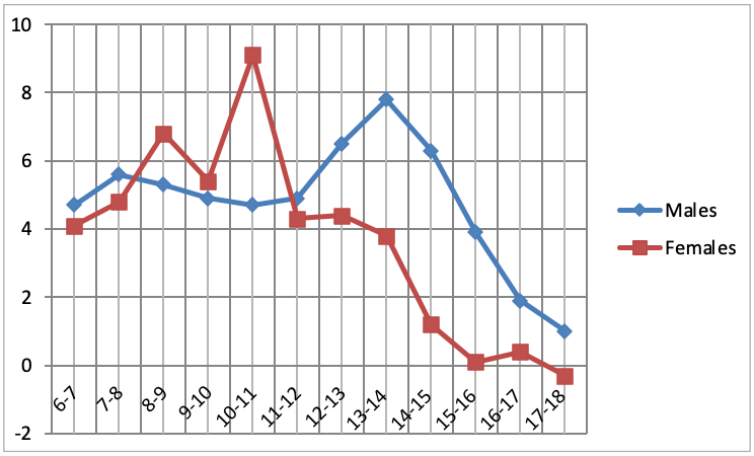


Figure 3.
Annual body weight growth attained for Kosovo boys and girls

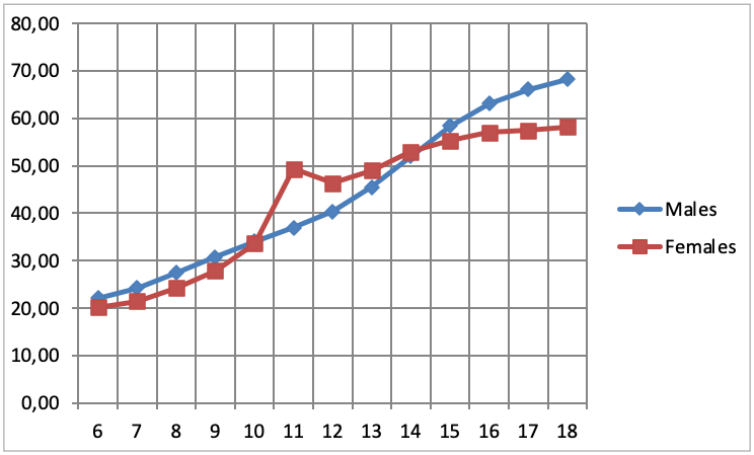
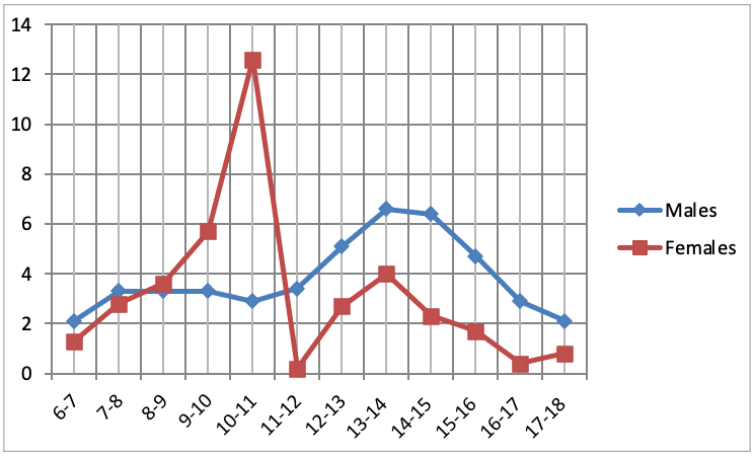


Figure 4.
Annual growth differences in body weight for Kosovo boys and girls



For comparison reasons on Table III are shown values of the PHV for boys (14 years old) and girls (11 years old) from Kosovo, USA (non-Hispanic and non-Asiatic population) and Netherland.

The peak velocity of the body height growth is reached in the same adolescent age-group of three different nationalities. While the boys of three different nationalities have shown similar values of PHV, the girls from Kosovo have shown the higher value of the PHV compared with the girls of two other nationalities (Komlos & Breitfelder, 2007).

Table III.
Peak Height Velocity (PHV) and for adolescents from Kosovo, USA, and Netherland

Boys = 14 yo Girls = 11 yo	Kosovo		USA		Netherland	
	Boys	Girls	Boys	Girls	Boys	Girls
PHV	7.8 cm	9.1 cm	7.1 cm	6.8 cm	7.3 cm	6 cm

The highest values of body height (BH) and body weight (BW) for boys and girls (aged 18th) from Kosovo, USA (non-Hispanic and non-Asiatic population) and Netherland are shown in Table IV.

Table IV.

Maximum values of Body Height for adolescents from Kosovo, USA, and Netherland

Boys = 18 yo	Kosovo		USA		Netherland	
Girls = 18 yo	Boys	Girls	Boys	Girls	Boys	Girls
Body Height	177.7	163.8	177.7	164.2	182.9	170

Based on the data obtained from Table IV, it can be concluded that Kosovar boys and girls of age 18 have similar growth rate with the American coevals. Meanwhile, Dutch adolescents of the same age have shown higher values of the body height compared to same-age coevals from Kosovo and USA (Komlos & Breitfelder, 2007).

Future Research

Given the importance of the clinical practice of adolescent normative values of PHV, PWV, BH and BW, the importance of future studies to involve a larger number of entities from all age groups increases proportionately.

Practical Application

The gained results may be used and applied in clinical and anthropological contexts.

4. Conclusion

According to the results of this study, it can be concluded that the boys' Peak Height Velocity and the Peak Weight Velocity have been achieved at the age group of 14 years old, while in girls at the age group of 11 years old. Since, the commencement of the rapid adolescent growth corresponds with the beginning of the puberty stage, according to the results of this study it can be concluded that this stage of life occurs approximately three years earlier in girls (aged 11 years) compared with the boys (aged 14 years).

Although the boys experience a later achievement of PHV and PWV, their growth and development, even though with reduced intensity, it continues even after the age of 18. Meanwhile, the girls' body growth and development commence earlier in age, and it reaches the maximal values more prior. This fact suggests that males will grow more during the late stage of the adolescence compared with females; therefore, in general males' morphometric features tend to be larger.

Conflict of interest

The authors declare no conflict of interest and no financial or commercial benefits for the performing of this study.

REFERENCES

Bozzola, M. & Meazza, C. (2011) Handbook of Growth and Growth Monitoring in Health and Disease. Chapter 180: Growth Velocity Curves: What They Are and How to Use Them. DOI 10.1007/978-1-4419-1795-9_180

Cameron N. (1978) The Methods of Auxological Anthropometry. In: Falkner F., Tanner J.M. (eds) Human Growth. Springer, Boston, MA. Available at: https://link.springer.com/chapter/10.1007/978-1-4684-2622-9_3 (Accessed: 11.02.2019)

Cossio-Bolanos M. et al. (2015) Physical growth, biological age, and nutritional transitions of adolescents living at moderate altitudes in Peru. Int J Environ Res Public Health. 12:12082–12094. doi: 10.3390/ijerph121012082 Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4626956/ (Accessed: 17.02.2019)

Fryar CD., et al. (2012). Anthropometric reference data for children and adults: United States, 2007–2010. National Center for Health Statistics. Vital Health Stat 11(252).

Granados A, et al (2015) . Relationship Between Timing of Peak Height Velocity and Pubertal Staging in Boys and Girls. *J Clin Res Pediatr Endocrinol*. 7(3):235-7.

Haymond, M., et al. (2013) Early recognition of growth abnormalities permitting early intervention. *Acta Paediatr*. 102(8):787-96. doi: 10.1111/apa.12266 Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3738943/ (Accessed: 15.02.2019)

Juul, A., et al. (2006) Pubertal development in Danish children: Comparison of recent European and US data. Int J Androl, 29:251-252. doi:10.1111/j.1365-2605.2005.00556.x Available at: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2605.2005.00556.x (Accessed: 21.02.2019)

Komlos, J., & Breitfelder, A. (2007) Are Americans shorter (partly) because they are fatter? A comparison of US and Dutch children's height and BMI values, *Annals of Human Biology*, 34:6, 593-606. DOI: 10.1080/03014460701730032

Neinstein, L.S. (2002). Adolescent Health Care: A Practical Guide, 4th edition. Lippincott Williams & Wilkins. USA

Portella, D.L., et al. (2017)Physical Growth and Biological Maturation of Children and Adolescents: Proposed Reference Curves. Ann Nutr Metab. 70:329–337. DOI: 10.1159/000475998

Rexhepi, A., et al. (2011). Physical characteristics at different ages. Int. J. Morphol, 29 (1), 105-111.

Rexhepi, A. M., et al. (2018). Normative values of some morphometric variables for Kosovo Albanian population aged 06-> 70 years old. Int. J. morphol, 36 (2), 592-7.

Rogol, A.D., et al. (2000) Growth and pubertal development in children and adolescents: effects of diet and physical activity. *The American Journal of Clinical Nutrition.*, 72(2,1):521S–528S. Available at: https://doi.org/10.1093/ajcn/72.2.521S (Accessed: 10.02.2019)

Rosenbloom, A.L. (2007) Physiology of growth. Ann Nestle (Engl), 65:97-108. Doi: 10.1159/000112232 Available at https://www.karger.com/Article/Pdf/112232 (Accessed: 09.02.2019)

Stang, J. & Story, M. (2005) Guidelines for Adolescent Nutrition Services. Chapter 1: Adolescent growth and development. Center for Leadership, Education and Training in Maternal and Child Nutrition, pp. 1-7. Available at: https://pdfs.semanticscholar.org/b0e4/7622b41a6f31179ab15970f069bd66c74255.pdf (Accessed: 07.02.2019)

WHO Child Growth Standards. (2009) Growth velocity based on weight, length and head circumference. Methods and development. Pp:1-3.

RESUMEN

Antecedentes: el crecimiento y desarrollo humano es un proceso complejo de cambios biopsicosociales en niños y adolescentes. La evaluación de estos dos procesos es de gran importancia en contextos clínicos y antropológicos. El presente estudio tuvo como objetivo descubrir y evaluar la velocidad del crecimiento y desarrollo biológicos durante diferentes edades de niños y adolescentes de ambos sexos de Kosovo.

Materiales y métodos: se midió la altura y el peso corporal y se estimó el peso corporal ideal en 68762 niños y adolescentes de Kosovo (66264 niños, 2498 niñas). Los grupos de edad se clasificaron en 13 categorías, con edades entre 6.0-18.9 años. Se analizaron las diferencias entre hombres y mujeres en el cambio anual de altura y peso corporal y peso corporal ideal.

Resultados: Según los resultados del presente estudio, el crecimiento y el desarrollo en los niños se pueden dividir en tres etapas que son distintas entre sí, en comparación con el crecimiento y el desarrollo de las niñas que se pueden dividir en cuatro etapas. Los niños han alcanzado la Velocidad de Altura Máxima (PHV = 7.8cm), respectivamente, la Velocidad de Peso Máximo (PWV = 6.6kg) en el grupo de edad de 14 años, mientras que las niñas han alcanzado la Velocidad de Altura Máxima (PHV = 8.4cm) y la velocidad máxima de peso (PWV = 12.6 kg) en el grupo de edad de 11 años.

Conclusión: la etapa de la pubertad ocurrió aproximadamente tres años antes en las niñas (11 años) en comparación con los niños (14 años). Aunque los niños experimentan un incremento posterior de PHV, su crecimiento y desarrollo, con intensidad reducida, continúa incluso después de los 18 años. El crecimiento y el desarrollo corporal de las niñas comienzan más temprano en la edad y alcanzan los valores máximos antes. Este hecho sugiere que los hombres crecerán más durante la etapa tardía de la adolescencia en comparación con las mujeres; por lo tanto, en general, las características morfométricas de los hombres tienden a ser más grandes.

Palabras clave: estatura, peso corporal, pubertad.