

DIFFERENCES IN BODY COMPOSITION OF CHILDREN 12-15 YEARS LIVING AT HIGHLAND AND LOWLAND IN KULONPROGO YOGYAKARTA

Janatin Hastuti, Alwahyulhaq Jati Sasmito, Ari Kurniawati

Department of Anatomy, Embryology and Anthropology
School of Medicine Gadjah Mada University Yogyakarta

ABSTRACT

Background: Body composition changes during growth. From age of 12 to 15 years one of the important growth periods occurs indicated by adolescent growth spurt in the circum pubertal age. Measuring body composition of children necessary, since the different components of body composition vary with age, sex, and maturity status. Many studies showed that high altitude affects morphological and physiological characters of children which are reflected in a different growth pattern.

Objective: The aim of this research was to investigate the differences of body composition of children at age of 12-15 years in Samigaluh highland and Galur lowland in Kulonprogo Regency Yogyakarta Province.

Methods: The research was done on 502 children of 12-15 years old, boys and girls, consisted of 232 children living in Samigaluh highland and 270 children living in Galur lowland. The children were healthy and did not have physical and mental disorder. Some measurements were taken on the children, included weight, and stature, skin fold thickness of triceps, infrascapula, suprailiaca, abdominal, thigh, and calf. The components of body composition were then estimated from those measurements, i.e. Body Mass Index, lean body weight, total fat, and percentage of body fat. Statistical analysis by t-test and Pearson correlation were used in this research.

Results: Body mass index, total fat and percentage of body fat of girls in highland and lowland populations were greater than the boys, but they were smaller on lean body mass. Girls of lowland population were greater on total fat, but they were slight smaller on body mass index except at age of 12 years. Lean body weight and percentage of body fat in girls of both populations were not different except at age of 12 years. Boys living in highland were smaller than their peers in lowland on most of body composition components except total fat.

Conclusions: Estimated body composition of children of highland and lowland in Kulonprogo were different between boys and girls. In comparison to the girls, boys showed greater difference in body composition. However, by the increase of age, growth patterns of body composition components on both populations were similar, except total fat of highland boys.

Keywords: body composition, children, highland, lowland

INTRODUCTION

The physical growth of children living at highland has been observed by a number of researchers. In general, they agree that children living at highland have been found to undergo a delayed growth in body size compared to children living at lowland. The manifestations on the body build, therefore, were shorter and lighter in highland children.^{1,2,3,4,5} On the other hand, highland children have been reported to have, larger lung volumes⁶, chest dimensions^{3,6} and heart volumes relative to body size, greater aerobic capacity⁷, enlarged bone marrow, and higher haemoglobin level. One explanation for those findings is hypoxia, a major stress at high altitude. Nevertheless, hypoxia is not the major factor influencing physical growth of children at highland, since other factors present in environment have been suggested to have relative importance in improving the growth pattern. Some studies demonstrated that nutritional, disease, socioeconomic, genetics, ethnics, physical activity, microclimate,

sociodemographic, and geographic factors play important roles in pattern in physical growth of children living at highland.^{2,3,4,8,9}

Assessment of growth pattern and nutritional status as those reported in highland children were established especially from height and weight measurements. However, a great attention has recently been given to design standards which include measurements of body composition components.¹⁰ The components of body composition are ranging from elements to tissues and organs and are the building blocks that give mass, shape, and function to all living things. The study of body composition is organized into three areas which interconnected to each other i.e., body composition rules and models, methodology, and variation.¹¹ The body composition moves progressively toward the adult constitution as childhood progresses.¹² Hence, body composition measurements can be useful to monitor growth and maturation of children.^{13,14,15} Based on two components models which divide the human

body into fat mass and fat-free mass or lean body mass, therefore, assessment of body composition includes measurements of body mass, body fat and percentage body fat, body water, lean body mass, body density, body volume, and body mineral.^{11,15}

Estimating the body composition of infant, children and adolescents is important, since the different components of body composition vary with age, sex, and maturity status.¹⁶ Some other factors also presumably contribute to the variation in body composition of children i.e., genetic, thermoregulation, physical activity, and diseases.¹⁶ However, assessment of body composition in children is more complicated. Children are chemically immature, fat-free mass components change in the proportions and densities due to growth and development which directly affect overall fat-free mass density.¹⁵

During growth, the relative contribution of water to body mass decreases, but the relative contributions of protein, mineral, and fat to body mass increase. In relation to fat-free mass during growth, the relative contributions of protein and mineral to it increase, whereas the contribution of water declines. Sex differences in the relative composition of fat-free mass are less during infancy and become apparent in early childhood. The estimated relative composition of fat-free mass indicates less water and more protein as well as mineral in boys after the age of three years. Thus, water constitutes a little greater percentage of fat-free mass in girls. The estimated potassium content and density of fat-free mass are greater in boys than girls, which probably reflect the sex difference in muscle mass and bone mineral¹⁶. However, this advantage is much greater at puberty. Examination of age-related changes in lean tissue or fat-free mass can be done in terms of total lean body mass, cross section of individual muscles, and histological changes.¹³

Some problems generated from the background above are:

1. Were there any differences of body composition between boys and girls at age of 12-15 years living at highland and lowland in Kulonprogo Yogyakarta?
2. Were there any differences of body composition between highland and lowland children at age of 12-15 years regarding sex?

The aims of this research were to investigate the differences in body composition of children at age of 12-15 years living at highland and lowland in Kulonprogo Yogyakarta Province. Hopefully, this research would improve knowledge and give addition to growth and developmental data of Indonesian children. Further, it could be utilized as such a reference to regional development consideration and planning especially for public health and human resources development.

MATERIALS AND METHODS

Subjects of the study came from students of junior high schools, boys and girls, age of 15 to 18 years who were born and lived in Samigaluh and Galur Districts, Kulonprogo Regency, Yogyakarta Province. Subjects involved in this research must meet the inclusion criteria: arriving at the day of measurements, are healthy, not having physical and mental disorder, and accepting the agreements written on the letter of informed consent. A number of 462 students were needed to participate in this study; calculated based on the preliminary research using formula of Colton to predict sample number for comparison of two populations.^{17, 18} However, as many as 502 students were examined in this research, divided into 232 children (111 boys and 121 girls) from Samigaluh highland and 270 children (140 boys and 130 girls) from Galur lowland.

Before taking the measurements, the participants had to fill out the questions on the questionnaire list and signed the letter of informed consent. All participants were then measured for weight, height, and skin folds thickness at triceps, biceps, infrascapular, suprailiac, abdomen, thigh, and calf. Instrumentations used therefore, were weighing scale, anthropometer, and skin fold calliper. The measurements were taken according to procedures recommended by Weiner and Lourie.¹⁹ Thereafter, data were collected. Body composition components i.e., total fat or total body fat (BF), percentage of body fat (%BF), and lean body weight (LBW) were estimated using the formulas as reported in Norton and Olds.²⁰ Body mass index was calculated based on measurements of weight and height.

Statistical analysis (t-test) was performed to find out the significant difference of body composition of children between boys and girls, as well as between

Samigaluh and Galur children regarding sex. Relationships between age and body composition and between body mass index and components of body composition were analysed using Pearson correlation of product moment. All analytical procedures were performed using computer.

RESULTS

The data have collected from July to August in 2005 on school children of junior high school in Samigaluh (representing highland) and Galur (representing lowland). Both regions are administratively parts of Kulonprogo Regency Yogyakarta Province. Nevertheless, both regions are

very different in geographical characteristic. Samigaluh has hilly topography and lies at high altitude with some areas lie over 1 000 meters up from sea level. In contrast, Galur lies at lowland close to the Indian Ocean with some areas are at the coast line.

Tables 1 and 2 represent means of body mass index, lean body weight, total body fat, and percentage of body fat of Samigaluh and Galur boys and girls at age of 12-15 years. Generally, girls show greater value on most of all measurements. Galur children also tend to have greater value on all measurements except total body fat and body fat percentage of the boys.

Table 1. Means and Standard Deviations of Body Composition Estimations of Boys and Girls at Age of 12-15 Years in Samigaluh Highland

		Age (years)							
		12		13		14		15	
		Boys N= 18	Girls N= 29	Boys N= 35	Girls N= 33	Boys N= 37	Girls N= 50	Boys N= 21	Girls N= 9
1. Body mass index	\bar{X} sd	15.57 2.45	16.75 2.56	16.13 1.89	17.40 2.87	16.91 1.47	18.16 2.66	16.69 1.57	18.26 2.23
2. Lean body weight	\bar{X} sd	26.35 3.49	28.09 3.03	28.74 3.33	30.01 4.04	32.41 3.25	31.92 3.36	32.00 3.88	32.24 2.67
3. Total fat	\bar{X} sd	4.23 3.62	6.00 3.42	5.51 2.86	7.41 4.53	7.47 2.57	8.83 4.22	7.14 2.93	9.04 3.52
4. Body fat percentage	\bar{X} sd	14.09 2.42	13.71 3.63	13.28 3.42	13.14 4.91	11.98 2.74	13.63 4.13	11.03 2.78	13.77 4.17

Table 2. Means and Standard Deviations of Body Composition Estimations of Boys and Girls at Age of 12-15 Years in Galur Lowland.

		Age (years)							
		12		13		14		15	
		Boys N= 14	Girls N= 23	Boys N= 28	Girls N= 31	Boys N= 65	Girls N= 54	Boys N= 33	Girls N= 22
1. Body mass index	\bar{X} sd	16.36 1.78	17.37 3.74	16.41 3.11	17.21 1.99	17.42 2.34	17.97 3.51	17.38 2.17	17.25 1.41
2. Lean body weight	\bar{X} sd	27.66 3.45	29.74 4.08	30.83 4.85	30.44 2.75	34.13 4.24	31.78 2.88	35.83 3.84	31.72 2.36
3. Total fat	\bar{X} sd	5.55 2.74	7.26 5.48	6.51 5.40	7.19 3.05	8.77 4.27	8.36 3.97	9.27 3.96	7.62 2.23
4. Body fat percentage	\bar{X} sd	10.12 1.78	15.62 4.83	10.35 4.75	15.23 2.53	10.90 3.99	16.85 3.18	10.56 3.65	16.46 2.34

Body mass index shows a general tendency to increase gradually across the age period in boys and girls of both populations as clearly showed in Figure 1 and reach the peak at age of 14, however it decreases slightly at age of 15 years. Girls found to have greater values compare to the boys at all ages. Comparison between highland and lowland children shows some difference. Samigaluh boys at all ages are weaker than their peers in Galur, on the other hand Samigaluh girls are healthier than Galur girls according to body mass index at most of ages except 12 years. This finding is somewhat different from lean body weight estimation as presented in Figure 2. Regarding sex, girls do not show a greater value than the boys as in body mass index. Lean body weight of boys increases fairly by age, whereas for girls there is a limited increase. Compare to Galur girls, their peers in Samigaluh saw a very slight difference.

Patterns of total body fat and body fat percentage change with age are illustrated in Figures 3 and 4 respectively. Growth of body fat demonstrated that among children in Samigaluh highland and Galur lowland regarding sex, girls are fatter and have a tendency to increase in body fat with age. Among the others, Galur boys have the least body fat and also tend to increase with age. Surprisingly, Samigaluh boys show a different pattern of body fat change which is a decline with age from the highest at 12 years to the lowest at 15 years, although they are still fatter compared to the ones in Galur. Growth patterns of body fat percentage in both populations are similar to those of body mass index. As it is shown in Figure 4, girls have a greater body fat percentage than boys. Regarding place, Samigaluh boys have a rather marked lower body fat percentage than the ones of Galur, whereas there is only a slight difference in girls of both populations.

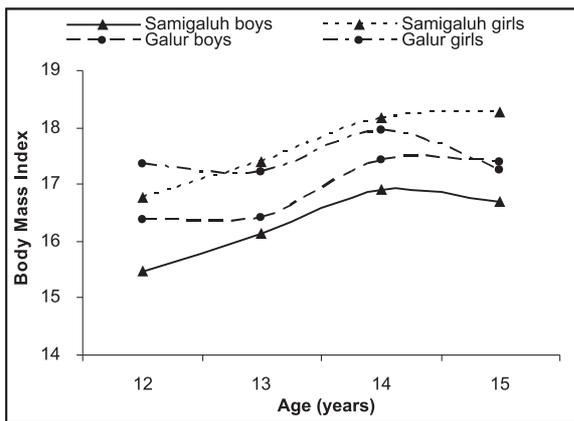


Figure 1. Body Mass Index of Boys and Girls Age of 12-15 Years In Samigaluh Highland and Galur Lowland

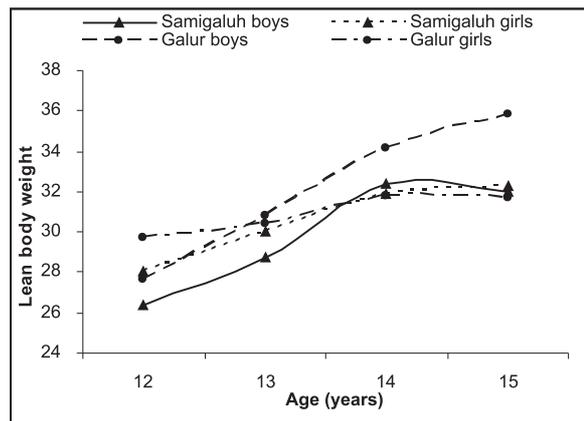


Figure 2. Lean Body Weight of Boys and Girls Age of 12-15 Years In Samigaluh Highland and Galur Lowland

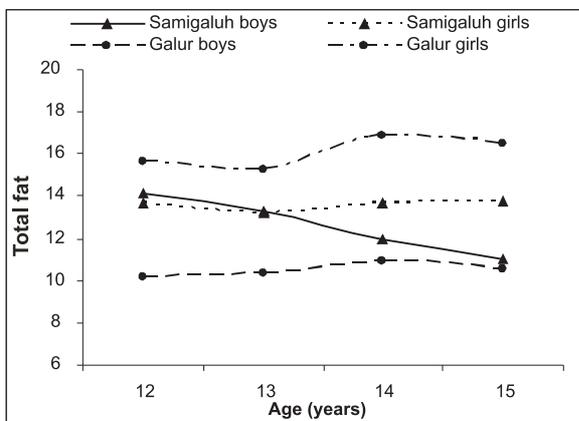


Figure 3. Total Fat of Boys And Girls Age of 12 -15 Years in Samigaluh Highland and Galur Lowland

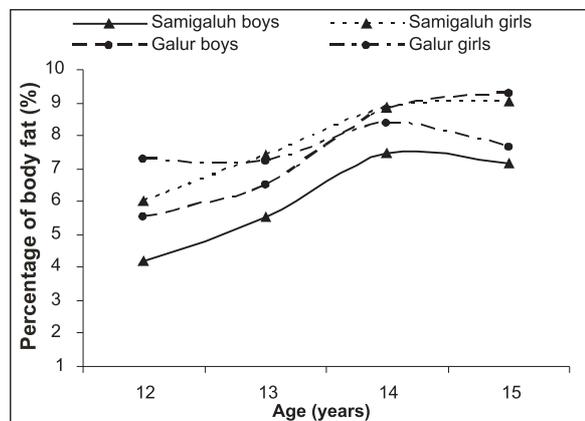


Figure 4. Percentage of Body Fat of Boys and Girls Age of 12-15 Years In Samigaluh Highland and Galur Lowland

The result of t-test analyses among children in Samigaluh and Galur are summarized in Tables 3 and 4. Concerning these results, differences in body composition estimations among populations vary widely with ages both between boys and girls as well as between Samigaluh and Galur children with the same sex.

Pearson correlation of product moment was carried out to find the relationships between age with body composition components and between body mass index with the other body composition components. The results as illustrated in Tables 5 and 6 shows that age is significantly correlated with body mass index, lean body weight, and body fat in most of Samigaluh and Galur children, except with body mass index in Galur children.

Whereas, relationship between age and body fat percentage is not significant in both populations. Relationships between body mass index and the other body composition compartments are significant in both populations, with the exception of body fat percentage in Galur children.

DISCUSSION

Growth of body mass index, lean body mass, and percentage of body fat of children of both populations show similar patterns, starting with the lowest point at age 12 and reaching the highest point at age 14 before slowing (? falling a little) at age 15. Between the age of 12 and 15 years, Samigaluh boys growing up at highland in Kulonprogo Regency Yogyakarta Province have the least body mass index, lean body mass, and percentage of body fat. However, statistically the differences are not significant, except on percentage of body fat. Body mass index of girls in both populations is greater than of the boys. However, the values are lesser in comparison to ones of children in Yogyakarta city and Bantul Regency who are different in socioeconomic conditions.²¹ Due to a delay in linear growth in children residing at high altitude as noted in Han children in Western China³ and in Peruvian children⁵, body mass index of Samigaluh and Galur are much lesser than girls from Lima Peru (lowland) and a little bit lesser than girls from Cerro de Pasco Peru (highland, 4340 m).

Table 3. The Result of T-Test Analysis of Children at Age of 12-15 Years in Samigaluh Highland and Galur Lowland Regarding Sex

	t							
	12 years		13 years		14 years		15 years	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
1. Body mass index	-0.91	-0.67	-0.58	0.31	1.54	0.31	-1.36	1.51
2. Lean body weight	-0.69	-1.62	-2.09	-0.49	-2.20*	0.21	-3.55**	0.51
3. Total fat	-0.84	-0.97	-0.75	0.23	-2.93**	0.58	-2.26*	1.12
4. Body fat percentage	5.46**	-1.58	2.75**	-2.12*	-0.33	-4.47**	0.53	-2.29*

* P< 0.05; ** P<0.01

Table 4. The Result of T-Test Analysis of Children at Age of 12-15 Years in Samigaluh Highland and Galur Lowland Regarding Place

	t							
	12 years		13 years		14 years		15 years	
	S	G	S	G	S	G	S	G
1. Body mass index	-1.72	-1.38	-2.13*	-1.01	-2.56*	-0.97	-1.92	0.27
2. Lean body weight	-1.74	-2.14*	-1.42	0.50	0.69	3.45**	-0.19	4.48**
3. Total fat	-1.66	-1.62	-1.72	-0.46	-1.74	0.53	-1.42	1.78
4. Body fat percentage	0.44	-4.04**	0.13	-4.93**	-2.10*	-9.05**	-1.81	-7.29**

* P< 0.05; ** P<0.01; G= Galur; S = Samigaluh

Table 5. Pearson Correlation of Age to Body Composition Estimations of Children in Samigaluh And Galur

	r	
	Samigaluh	Galur
1. Body mass index	0.19**	0.06
2. Lean body weight	0.49**	0.41**
3. Total fat	0.29**	0.18**
4. Body fat percentage	-0.12	-0.02

* P< 0.05; ** P<0.01

Table 6. Pearson Correlation of BMI to Body Composition Estimations of Children Students in Samigaluh and Galur

	r	
	Samigaluh	Galur
1. Lean body weight	0.72**	0.58**
2. Total fat	0.98**	0.94**
3. Body fat percentage	0.64**	0.65**

Lean body weight is increase by the increase of age as found among children from Illinois America²² and children from Central Spain.¹⁰ Compared with Spanish children of the same age, children from Samigaluh and Galur have much lesser lean body weight. Comparison between boys and girls show significant differences among Galur children. Boys tend to have greater lean body weight especially at older age in Galur boys as found in Spanish children. Whereas, lean body weight in girls show similar means in both populations and attain slightly greater at an increased age. Body fat or fat mass is increase by age changes in most of groups. Body fat of these children is somehow much lower compared to Spanish children in the same age. Average body fat of Samigaluh and Galur children of age 12 is about 4 – 7 kg, whereas Spanish children have about 9 – 11 kg of body fat. Body fat percentage of Samigaluh boys is slightly decrease by age as found in Spanish boys, but in Galur boys and girls of both populations tend to increase. Percentage of body fat in girls is greater than in boys in relation to the onset of puberty. However, the average of body fat percentage of Samigaluh and Galur children are much lower in comparison to Spanish children in the same age, who have about 17% - 20% body fat percentage of boys and about 25% - 26% of the girls. According to table of recommended percent body fat levels for children from Lohman, Houtkooper, and Going in 1997¹⁵, Samigaluh and Galur children are in the low level of with an exception of Samigaluh boys who have greater percent body fat than their peers in Galur and are in the mid level.

Based on the result of statistical analysis by Pearson correlation, age has a significant contribution to body composition components except percentage of body fat in both populations. However, in comparison between age and body mass index as factors which contribute to body compositions, body mass index has greater correlation to all body composition components in both populations. Statistical analyses of nonmetrical data including parental backgrounds (education, occupation, and income of father and mother), physical activity, distance of housing to school, and pattern of food consumption of the children. The result showed significant differences in most of those compartments, except father's occupation and food consumption. More than 70% of the fathers in both populations were farmers. Out of school sport activity,

highland children do more activities (approximately 45%) than lowland children (about 28%). They were also differed significantly on the way to go to school. Approximately 71% of highland children go to school on foot, in contrast with lowland children who about 90% go to school by bicycle. In addition, more than 28% children of highland housing have more than 6 km in distance to their school, while there only about 1% in lowland children. Based on those observations we presumed that the difference in physical activities and geographical conditions give more contribution to the patterns of body composition of children in both populations.

CONCLUSION

Body composition of children in highland and lowland in Kulonprogo were different between boys and girls. Girls tend to have greater body mass index, total fat, and percentage of body fat. Boys living in highland were smaller than their peers in lowland on most of body composition compartments except total fat. In comparison to the girls, boys showed greater difference in body composition. However, by the increase of age, growth patterns of body composition compartments for both populations were similar, except total fat of highland boys.

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