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Research Article
Differences in Somatotype Between Boys and Girls in Arfak Subsistence Population

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Abstract

Background and Objective: A difference in fat, muscle and other body composition was observed in children in each population. Culture and physical environment may influence the development of body shape. The present study aimed to investigate body shape of Arfak children through somatotype assessment. **Materials and Methods:** A cross-sectional study of ten anthropometric measurements was conducted on the Arfak children consisting of 164 boys and 144 girls aged 7-19 years in Manokwari West Papua Province, Indonesia. Somatotype components were measured using the Heath-Carter method. **Results:** Based on age and sex, the somatotype of Arfak children showed a different trend for each component. Sexual dimorphism of somatotype appears in endomorphy (relative fatness) and mesomorphy (musculoskeletal). Arfak children show changes in the somatotype component at the onset of puberty at the age of 8-9 years for girls and 9-10 years for boys. The distribution of somatotype categories for boys was changed from endomorphic mesomorph, balanced mesomorph, ectomorphic mesomorph, to endomorphic mesomorph, while in girls these distributions were central, mesomorph-endomorph and mesomorphic endomorphic. Based on these somatotype categories for various age groups, Arfak boys showed more musculoskeletal in all age groups, while Arfak girls tend to have more fatness. **Conclusion:** The body shape of Arfak children in the subsistence populations differs from previous studies which showed lean body mass.

Key words: Anthropometric measurement, Arfak children, body composition, ectomorphy, endomorphy, mesomorphy

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

A difference in fat, muscle and other body composition was observed in Arfak children. Somatotype is a method of describing the differences in morphological and structural characteristic of the human body composition. Somatotype expressed by three-number ratings, which are endomorphy, mesomorphy and ectomorphy, which provide information on relative fatness, muscularity and linearity, respectively. The rating of somatotype components is plotted on a somatochart which describe the distribution of those components or can be calculated directly using equations given by Carter[1] based on ten anthropometric measurements, that is height, weight, triceps skinfold, subscapular skinfold, supraspinale skinfold, calf skinfold, humerus biepicondylar breadth, femur biepicondylar breadth, bicep girth and calf girth.

The study of somatotype has been applied in the field of sport[2,3], child growth[4-7], physical anthropology, human biology and disease[8-10]. It has been used to study population variation, age and sex variation[11] and puberty-related changes in somatotype components[12]. The size and composition of the body changed during childhood and adolescence, in particular, fat and muscle mass changed significantly during puberty. In puberty, girls experienced secondary sexual development such as the fat development of breasts but tocks and thighs, while boys were marked by muscle and bone density development[13] and secular trends[14]. An assessment of somatotype and age at menarche showed these changes. Rahmawati *et al.*[15] found the value of endomorphy which described that fat mass was greater in earlier menarche, moreover, they found the value of ectomorphy which described that leanness was lower. Increasing endomorphy component and decreasing ectomorphy component reveal the principle of ontogenetic allometry which described the trade-off between investment to growth and sexual maturity[16].

Apart from genetic, age and sex, several factors such as culture, physical activity, occupation, social economic, nutrition, diet, altitude and climate affect the somatotype of each population[14,17-27]. Distribution of somatotypes in Mina, Bhil, Sahariya, Garasia, Damor and Kathodi tribal groups of Rajasthan, India in both boys and girls show that the value of somatotypes lies in mesomorphic ectomorph or endomorphic ectomorph region in all age groups[24]. Culture and physical activity may influence behavior in different populations. In general, farmers and laborers engaged in strenuous physical work, highlighting more ectomorphic and smaller body size. Moreover, physical activity can regulate body weight and specifically fatness[20].

Papua (Papua and West Papua) is famous for the diversity of tribes and cultures. Approximately 269 languages are found in Papua[28], so it is estimated that Papua has 269 tribes with different socio-cultural backgrounds and cultures. Except for the study of Heath and Carter[7], no intensive studies of somatotype in Papuan children had been carried out in the last four decades. Therefore, it is important to study the variation of body shape and composition in each tribe, including the Arfak tribe. Arfak is a traditional tribe that inhabits Manokwari West Papua Province. Papuan people are a popular name for them and they are belonging to Australoid race. They are semi-nomadic people with a semi-permanent residence. They live in hunting, gathering and subsistent farming with shifting cultivation system[29,30]. In general, body shape of traditional population tend to have lean physique[31]. The present study aimed to investigate whether the body shape of Arfak children also reflects the typical body shape based on somatotype assessment.

MATERIALS AND METHODS

In this study, 164 boys and 144 girls aged 7-19 years were selected from Arfak community. A cross-sectional study of ten anthropometric measurements was conducted from September 2010 to April 2011. Data were obtained from schools (elementary schools, primary schools and high schools) and residences surrounding Manokwari West Papua Province. A detailed description and objectives of this study were explained to each subject and they were only included as a sample if they understood and agreed to participate, they were asked to sign the letter of informed consent.

Ten anthropometric measurements (Stature, weight, biepicondylar breadths of the humerus and femur, calf and upper arm circumferences, skonfolds at triceps, subscapular, supraspinale and calf) were obtained on the right side for each subject according to Carter-Heath method[1]. The three somatotype components, (endomorphy, mesomorphy and ectomorphy) of each individual were calculated according to the Carter and Heath method[1] using the following equations in Table 1.

At each age group, 50th percentiles were used to present somatotype components of boys and girls. Percentiles were determined using generalized additive models for location scale and shape (GAMLSS)[32] implemented in the R program version 2.15.2[33]. The median values of somatotype components of each age group ware plotted on a two-dimensional somatochart using X and Y coordinates[1]. Sex differences in somatotype components were determined using a student t-test.

Table 1: Formula for anthropometric somatotypes

Somatotype components
Endomorphy = -0.7182+0.1451 (X) -0.00068(X^2) +0.0000014 (X^3)
where X = (sum of triceps, subscapular and supraspinale skinfolds) multiplied by 170.18/height (in cm)
Mesomorphy = 0.858×humerus breadth+0.601×femur breadth+0.188×corrected arm girth+0.161×corrected calf girth-height×0.131+4.5
Ectomorphy = HWR×0.732-28.58 (if 40.75≤HWR)
Ectomorphy = HWR×0.463-17.63 (if 38.25<HWR<40.75)
Ectomorphy = 0.1 (if HWR≤38.25)
Height weight ratio (HWR) is height divided by the cube root of weight

RESULTS

The median value of somatotype components of Arfak children aged 7-19 years showed age changes and sexual dimorphism (Fig. 1 and 2). The endomorphy component in boys is relatively stable and increases after the age of 15. In girls, endomorphy component also decreased at the age of 7-8 years but thereafter increased and were most dominant among other components.

In boys, the mesomorphy component is the most dominant in all age groups, while in girls, it is dominant between the ages of 7-10. In boys, the pattern of the mesomorphy component decreased at the age of 7-9, after that it increased, while in girls it was fluctuated. At the age of 7 years, the ectomorphy component of boys and girls had the lowest value and gradually increased until age of 10 years (boys) and 8 years (girls) after which they decreased. Overall, at the younger age, Arfak children are more mesomorphy, while at older ages Arfak girls are more endomorphy and boys are more mesomorphy.

Somatotype scores of Arfak boys and girls in each age group were plotted to the somatochart as shown in Fig. 3 and Table 2. Boys are generally classified as endomorphic mesomorphs at age 7 years, balanced mesomorphs at age 8 years and at age 14-17 years, ectomorphic mesomorphs at age 9-13 years and endomorphic mesomorphs at age 18-19. All these categories showed that Arfak boys tend to have a musculoskeletal body shapes.

According to age, Arfak girls change their somatotype category (Fig. 2 and Table 3). At the juvenile stage (7-10 years of age), the distribution of somatotype categorizes lies in the middle, which means all three components are equal. In the adolescent phase (between 11-19 years of age) changes in body shape occur that are mesomorph-endomorph. The body shape showed fatness and musculoskeletal dysfunction between 11-15 years of age. More fatness is associated with mesomorphic endomorphs between 16-19 years of age.

Around 14-19 years of age, there were statistically significant differences between sexes in endomorphy (Table 4). Sex differences in endomorphy can be interpreted

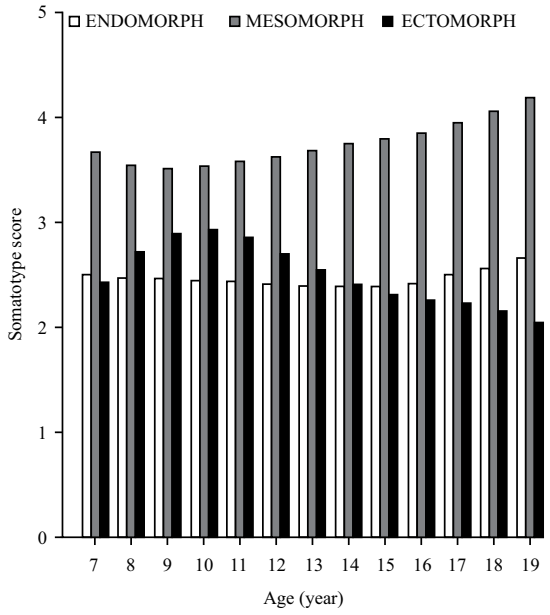

Fig. 1: Median value of somatotype components of Arfak boys aged 7-19 years

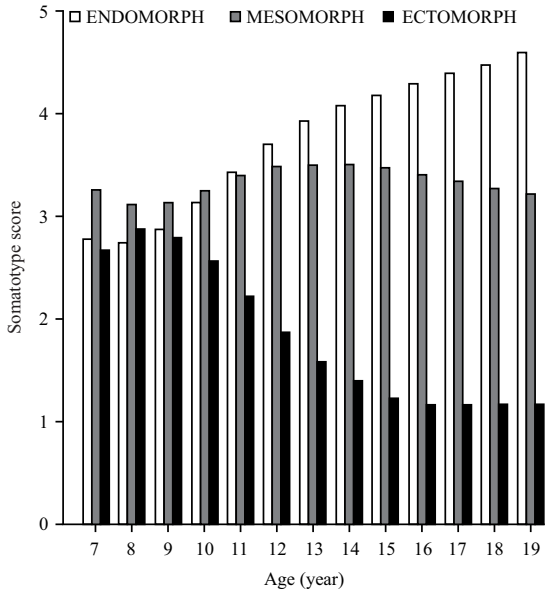

Fig. 2: Median value of somatotype components of Arfak girl aged 7-19 years

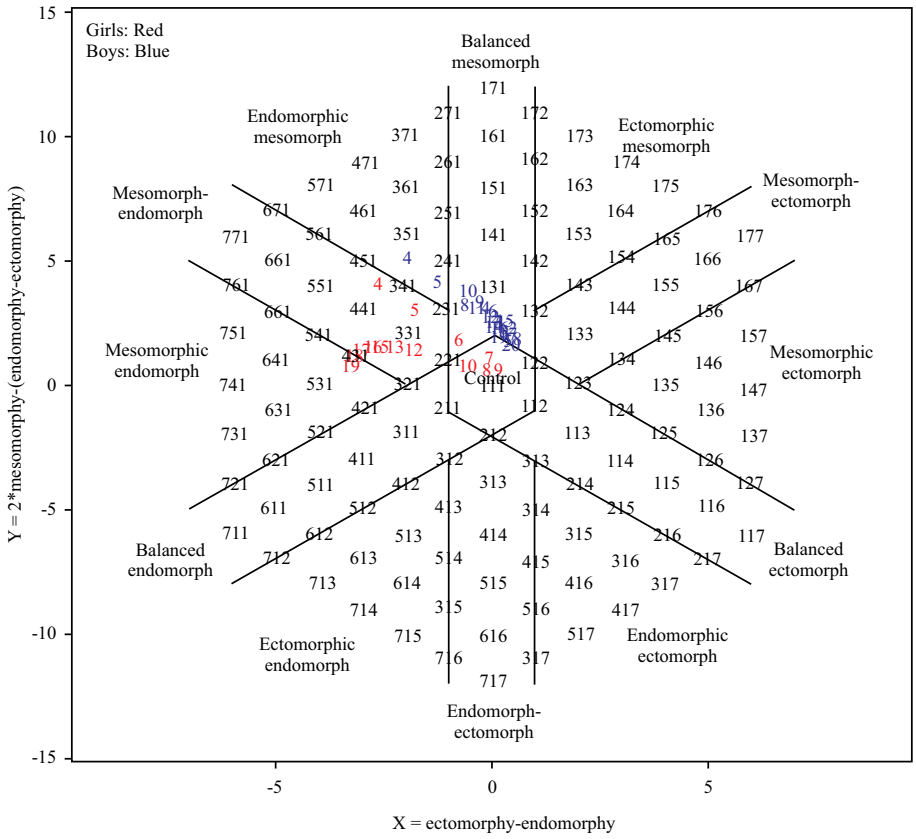

Fig. 3: Somatochart of Arfak children

Table 2: Median somatotype and somatotype category of Arfak boys

	Boys	
Age group (y)	Median somatotype	Somatotype category
7	2.5-3.7-2.4	Endomorphic mesomorph
8	2.5-3.5-2.7	Balanced mesomorph
9	2.4-3.5-2.9	Ectomorphic mesomorph
10	2.4-3.5-2.9	Ectomorphic mesomorph
11	2.4-3.6-2.8	Ectomorphic mesomorph
12	2.4-3.6-2.7	Ectomorphic mesomorph
13	2.4-3.7-2.5	Ectomorphic mesomorph
14	2.4-3.7-2.4	Balanced mesomorph
15	2.4-3.8-2.3	Balanced mesomorph
16	2.4-3.9-2.3	Balanced mesomorph
17	2.5-3.9-2.2	Balanced mesomorph
18	2.6-4.0-2.1	Endomorphic mesomorph
19	2.7-4.2-2.0	Endomorphic mesomorph

Table 3: Median somatotype and somatotype category of Arfak girls

	Girls	
Age group (y)	Median somatotype	Somatotype category
7	2.7-3.2-2.6	Central
8	2.7-3.0-2.8	Central
9	2.8-3.0-2.7	Central
10	3.1-3.2-2.5	Central
11	3.3-3.3-2.2	Mesomorph-endomorph
12	3.6-3.4-1.8	Mesomorph-endomorph
13	3.8-3.4-1.5	Mesomorph-endomorph
14	4.0-3.4-1.3	Mesomorph-endomorph
15	4.1-3.4-1.2	Mesomorph-endomorph
16	4.2-3.3-1.1	Mesomorphic endomorph
17	4.3-3.2-1.1	Mesomorphic endomorph
18	4.4-3.2-1.1	Mesomorphic endomorph
19	4.5-3.1-1.1	Mesomorphic endomorph

as girls reserve more fat than boys for secondary sexual development. In the younger age, the difference in endomorphy components of the two sexes was not significant. There was no statistically significant differences in the mesomorphy component according to age group, except at 11, 15 and 17 years of age. Although, boys and girls were not different in mesomorphy, boys may be taller and stronger in muscle mass than girls. There was no statistically significant difference in ectomorphy or linearity between boys and girls, except at 12, 15 and 18 years of age. It can be interpreted as the boys are not more lean than girls.

Table 4: Sex differences in somatotype components: Student t-test

	Endomorphy		Mesomorphy		Ectomorphy	
Age group (y)	p-value	Significance	p-value	Significance	p-value	Significance
7	0.2473	Non-Sign	0.8115	Non-Sign	0.7998	Significant
8	0.7584	Non-Sign	0.3654	Non-Sign	0.3833	Significant
9	0.527	Non-Sign	0.839	Non-Sign	0.1623	Significant
10	0.2015	Non-Sign	0.07601	Non-Sign	0.9305	Significant
11	0.3688	Non-Sign	0.02697	Non-sign	0.5419	Significant
12	0.0001284	Significant	0.06856	Significant	0.01224	Non-sign
13	0.05641	Non-Sign	0.7267	Non-Sign	0.3481	Significant
14	0.0002544	Significant	0.6993	Non-Sign	0.1147	Significant
15	3.639e-05	Significant	0.01857	Significant	0.04453	Non-sign
16	6.924e-05	Significant	0.0677	Non-sign	0.08045	Significant
17	0.0003670	Significant	0.009559	Non-sign	0.07378	Significant
18	0.0009373	Significant	0.3827	Significant	0.0371	Non-sign
19	0.0006687	Significant	0.3713	Non-Sign	0.9975	Significant

DISCUSSION

Sexual dimorphism of somatotype can be observed in endomorphy (relative fatness) and mesomorphy (musculoskeletal), reflecting evolution in reproductive biology[25]. Girls had more dominant endomorphy than boys, who had more dominant mesomorphy. The changes in the somatotype component of Arfak children occur in juvenile and adolescent phases. This pattern is similar to that observed in the girls from Magelang and Baduy[12,16], where endomorphy increased before puberty and continuing in older age. Peak height and weight velocity are correlated with increasing adiposity at puberty[14,24,26]. During puberty, girls store fat for future needs such as secondary sexual development, menarche events and reproduction[23,27,32,33]. When girls reach the age of 8, ectomorphy and mesomorphy also begin to change in Arfak children. During puberty, changes in ectomorphy and mesomorphy components was also reported by Widiyani *et al*.[12] and Rahmawati *et al*.[15].

As indicated by a stable endomorphy score of Arfak Boys in adolescence, boys show little or no increase in adiposity during adolescence and young adulthood[24]. Arfak boys have a greater mesomorph (musculoskeletal) component, because fat has little direct association with secondary sexual development and reproduction maturation[14,25]. At the age of 9 years, the secondary sexual development in boys was marked by muscle and bone density development[14], which was reflected by increasing mesomorphy component.

The ectomorphy component of Arfak children showed the same pattern, increasing until the age of 10 years in boys and 8 years in girls thereafter decreasing with age. Similarly, like ectomorphic children in Japan, this trend shows an increase between ages 6-10 years[34]. The endomorphy components of Arfak boy suggest more fatness, after the age of 15 years. This developmental pattern differs from that of Javanese boys from Yogyakarta, Magelang[12], Bekasi[18], who have the better socioeconomic backgrounds and environmental conditions. Modern populations that enjoy an energy-rich environment and low exposure to pathogens commonly exhibited a decrease in fat levels from pubertal to adult stages[27]. In contrast, Arfak children live in comparatively underdeveloped living conditions, with 79% of their parents engaged in hunting, gathering and subsistent farming, also malaria infection is prevalent in the endemic area[18]. The storage of energy in adipose tissue could be a result of selection influenced by shifts in diet and exposure to infectious diseases, especially after the introduction of agriculture and the mediation of adult fat stores by plastic responses to environmental conditions[24,25].

Overall, the distribution of the somatotype category of girls was mainly centered around mesomorphy, endomorphy and centrality, while boys were concentrated at the mesomorphy component in all age group. The physique component of Arfak children showed a slightly increased fat content in adulthood while the mesomorphy component developed in both boys and girls. The mesomorphy component in Arfak boys, which indicates relative musculoskeletal strength, was the highest, possibly due to increased workload. Limited access to transportation and difficult roads caused an increase in physical activity. Moreover, a better musculoskeletal condition also helps them to carry out heavy loads[10].

This finding is in line with a previous study conducted by Rohmatullayaly[16] on the Baduy People, who live as a subsistent farmers (swidden farmer) with similar environmental and socioeconomic conditions but the strategy of somatotype development were different in each population. Agricultural

communities typically engage in high levels of physical activity for extended period, resulting in significant energy expenditure, potentially leading to a more linear body shape and reduced fat deposits[10,35]. Individuals with lower fat mass and weight relative to their stature may find it easier to move around in the field, which is advantageous to perform various agricultural activities[10,31].

CONCLUSION

Arfak children in subsistence populations exhibited a body composition that deviates from previous studies that suggested a leaner physique, characterized by increased musculoskeletal and fatness. This study provides new information related to more fatness of traditional tribes.

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