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Body proportions of 6–18-year-old children in Merida, Mexico

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ABSTRACT: The purpose of this study was to find out the differences in body physique and its proportions between children from Creole, Maya and Mestizo ethnic groups living in Merida, Mexico. The study was conducted between 1996–1999 and comprised of 4636 children and youth aged 6–18 years from three ethnic groups: Maya, Mestizo, and Creole. There were 1362 boys and 1314 girls from Creole group and 803 boys and 857 girls from the pooled Maya/Mestizo group. Anthropometric measurements included body height, arm and leg length, shoulder and hip width. The following indexes were calculated: leg length-to-body height, upper-to-lower limb, shoulder-to-body height, hip-to-body height, and hip-to-shoulder. Two-way analysis of variance (two-way ANOVA) was used to test the main effect and the interaction effects of age and ethnicity on height, leg length and body proportions, separately for boys and girls. All statistical analyses were performed using Statistica software version 13.1. All *p*-values lower than 0.05 were considered significant. Results of this study revealed that average values of body height, leg length and upper-to-lower limb and shoulder width proportions were statistically significantly different between ethnic groups. Creole children were taller and longer-legged than their Maya/Mestizo peers, and the greatest difference was noted after puberty. Maya/Mestizo children had relatively longer arm as compared to Creoles. Results of two-way ANOVA revealed that age and ethnicity were combined (interaction effect) factors for variation in body height both in boys and girls, and upper-to-lower limb proportion in boys, shoulder-to-body height proportion in girls. Ethnicity was the main effect factor for leg length both in boys and girls, and for the body proportions: upper-to-lower limb in girls and shoulder-to-body height in boys. Age was the main effect factor for upper-to-lower limb proportion in girls, shoulder-to-body height in boys, hip-to-body height in boys and girls, and hip-to-shoulder, both in boys and girls. In conclusion it may be stated that variation in body physique and body proportions during the postnatal growth in different ethnic groups is under the influence of complex interaction between genetic and environmental factors to which the individual is exposed.

KEY WORDS: body physique, ethnicity, age changes

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Introduction

Changes in body proportions during the postnatal growth of an individual are under the influence of complex interaction between genetic and environmental factors to which the individual is exposed (Bogin et al. 2001). Constant and substantial correlation between the height of the children and their mid-parental height, observed from the age of 3 years and onwards, seems to confirm the dominant role of genetic factor in the total phenotypic variance of body height. This is supported by data from multiple studies (Cheng et al. 1996; Malina et al. 1987; Martorell et al. 1988). According to Chatterjee and colleagues (1999), heritability of somatic traits is in the range of 40 to 91 percent of their total phenotypic variance. Studies on monozygotic and dizygotic twins revealed that somatotype might be more sensible to genetic influences, as shown by higher heritability indexes, than the body mass index, BMI (Machado Reis et al. 2007). Body proportions are probably also under the influence of genetic control. It is estimated that about 40 to 75 percent of the difference in selected body indexes between individuals is determined by genetic factors (Livshits et al. 2002).

Family studies have confirmed that the final, adult height is largely genetically determined, however the pathway of this regulation during the postnatal growth in childhood is poorly understood (Sovio et al. 2009). There is also evidence that differences in several somatic traits between various human morphological groups, as for example Afro-Americans who are characterized by longer legs, are genetically controlled (Bogin 1993; 1999).

Beside the genetic factors, each individual has a genetic base with a definite growth potential, a multitude of environmental factors play a role in modulating growth in size and shape/body proportions, as for example growing leg length (Bogin 1993; 1999). One of these factors is socio-economic status (SES) of the family, which frequently refers to availability of proper food or access to better health care (Rao et al. 2012; Siniarska and Wolański 2002). It has been reported that highly processed foods, which become dominated in the present-day diet, affect physical growth and health of Maya children and their families (Bogin et al. 2014). Previous studies indicated that reduced body size might be an adaptive response to poor nutritional conditions. However, even analysis of sib-sib similarities in body dimensions did not prove that adaptation to small body stature is due to genotypic plasticity or genetic adaptation (Little et al. 1986).

It is generally accepted that growth and development of children and youth is associated with appropriate physical proportions of the body. However, controversy still exists as to whether body proportions are under strict genetic control or can be influenced by environmental stimuli (Bogin et al. 2001; Norgan 1998). Studies conducted in Mexico City in three ethnic groups and within different levels of socio-economic status revealed that skeletal (all height and length measurements) and tissue (all breadth and girth measurements) body measurements and body composition demonstrated statistically significant between-group differences at younger age but not in adulthood, even after adjusting for the socio-economic status (Ramos Rodriguez 1986).

Merida, which is the capital of Yucatan State (Mexico), is inhabited mainly by

three ethnic groups: Creole, Maya and Mestizo. Creoles are fully or partially descended from white European colonial settlers (mainly from Spain), Mayas for centuries have inhabited Central America (Yucatan Peninsula and Chiapas in Mexico, Guatemala, Belize, El Salvador and western Honduras), and Mestizos are the mixture of Mayas with people of European origin.

Given the above, the purpose of this study was to find out whether differences in body proportions across ethnic groups are associated with the ethnicity after controlling for children's chronological age.

Materials and Methods

The study was conducted in Merida, the capital of Yucatan State, Mexico in 1996–1999 (Fig. 1).

Selected somatic characteristics and body proportions were examined in 4636 children and youth aged 6–18 years in three ethnic groups: Maya, Mestizo, and Creole. There were 1362 boys and 1314 girls from Creole group and 803 boys and 857 girls from the pooled Maya/Mestizo group. The subjects came from randomly selected public and private schools of Merida. Ethnic groups were established using two surnames of children from father and mother side (Azcorra et al. 2013). Because there were not statistically significant differences between children from Maya and Mestizo groups in most somatic measurements, and because the names of typical Creoles were also found among the Maya, those two ethnic groups were joined together and the final comparison was done between Creole and Maya/Mestizo groups. This rearrangement enabled us to reduce the double surname error.

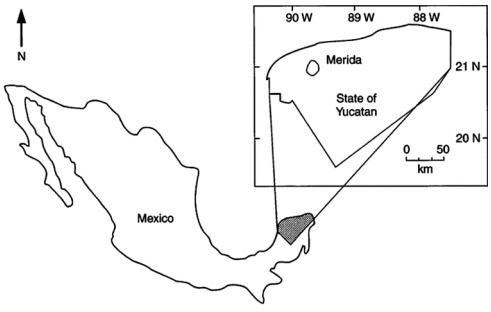

Fig. 1. Location of the Merida city, capital of the Yucatan State in Mexico

For the purposes of this study following somatic characteristics were selected and described in terms of anthropometric landmarks: body height (*B-v*), arm length (a-da_{III}), leg length (*B-sy*), shoulder width (*a-a*) and hip width (*ic-ic*). All these measurements were taken in a standardized way using anthropometer and spreading caliper and with the accuracy to the nearest 0.1 mm (Martin and Saller 1957; Malinowski and Wolański 1988). Children were standing erect with their head in the Frankfurt position.

Based on these measurements, following indexes were calculated for body proportions:

1. Lower limb length-to-body height ratio was calculated by subtracting the person's leg length from his/her total body height and expressed it as a percentage of the total body height:

$$[(B\text{-}sy)/(B\text{-}v)]100.$$

2. Upper-to-lower limb ratio was calculated by subtracting the length of arm from the length of leg and expressed it as a percentage of the lower limb length:

$$[(B\text{-}a) - (B\text{-}da_{III})/(B\text{-}sy)]100.$$

3. Shoulder-to-body height ratio was calculated by subtracting the width of shoulder from the total body height and expressed it as a percentage of the total body height:

$$[(a\text{-}a)/(B\text{-}v)]100.$$

4. Hip-to-body height ratio was calculated by subtracting the width of hip from the total body height and expressed it as a percentage of the total body height:

$$[(ic\text{-}ic)/(B\text{-}v)]100.$$

5. Hip-to-shoulder ratio was calculated by subtracting the width of hip from the width of shoulder and expressed it as a percentage of the shoulder width:

$$[(ic\text{-}ic)/(a\text{-}a)]100.$$

Two-way analysis of variance (two-way ANOVA) was used to test the main effect and the interaction effects of age and ethnicity on height, leg length and body proportions, separately for boys and girls. All statistical analyses were performed using Statistica software version 13.1. All *p*-values lower than 0.05 were considered significant.

Results

Descriptive statistics, arithmetic means and standard deviations, for linear dimensions, the total body height and leg length, by sex, age and ethnic group are presented in Table 1.

Generally, both boys and girls from Creole group, were taller than their Maya and Mestizo peers. The magnitude of the difference between these groups was smallest at the ages 6 and 7 years and increased after puberty. At the age 18 years, the difference was approximately 5 cm in favor of Creoles (Fig. 2).

Similar was found for leg length, although the magnitude of the difference was smaller (approx. 3 cm and 2 cm in boys and girls aged 18, respectively). The smallest difference was found in children aged 6 and 7 and up to the age just before puberty, at 11 years in boys and 9 years in girls (Fig. 3).

Means and standard deviations for body proportions in boys and girls by age and ethnic group are presented in Tables 2 and 3.

The relatively longer upper limb than lower limb (higher value of upper-to-lower limb ratio) were observed in Maya/Mestizo group than in Creole group in almost every age group. The difference diminished in mid-adolescence. Only before puberty, at the ages of 11–12 years, Creole boys had longer arm than their Maya/Mestizo peers (Fig. 4).

The Maya/Mestizo children had wider relative shoulders (shoulder-to-body height ratio) than their Creole peers in almost every age group with greatest discrepancy around the onset of puberty (Fig. 5).

Results of two-way analysis of variance (ANOVA) are shown in Table 4. In this analysis, the dependent variables were the total body height, leg length and body proportions (all indexes). The independent variables were age (13 age groups from 6 to 18 years) and ethnicity (Creole, Maya and Mestizo).

There was a statistically significant interaction between the effects of age and ethnicity on body height in boys ($F=1364.46$, $p<0.001$ for age and $F=117.17$, $p<0.001$ for ethnicity) and in girls ($F=1033.83$, $p<0.001$ for age

and $F=180.83$, $p<0.001$ for ethnicity) and the proportion of upper-to-lower limb in boys ($F=81.01$, $p<0.001$ for age and $F=16.84$, $p<0.001$ for ethnicity), and shoulder-to-body height in girls ($F=7.77$, $p<0.001$ for age and $F=29.25$, $p<0.001$ for ethnicity). It means that the explained variance in the afore-mentioned dependent variables is the combination (interaction) of age and ethnicity where the impact of ethnicity depends on the varying age and the impact of age depends on the category of ethnicity.

Significant difference between ethnic groups regardless of age (the main effect) was found for leg length both in boys ($F=97.22$, $p<0.001$) and girls ($F=109.89$, $p<0.001$), and for the body proportions: upper-to-lower limb in girls ($F=21.10$, $p<0.001$) and shoulder-to-body in boys ($F=10.44$, $p<0.01$). Age was a predictive factor (the main effect

Table 1. Descriptive statistics, means and standard deviations of body height and leg length by sex and age in Creole and Maya/Mestizo samples

Age (years)	Body height *B-v* (cm)						Leg length *B-sy* (cm)					
	Boys			Girls			Boys			Girls		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Creoles												
6	180	113.08	4.84	159	112.56	5.15	180	53.51	3.45	159	54.48	3.44
7	90	118.22	4.95	94	118.99	5.37	90	58.05	3.82	94	58.95	3.54
8	81	124.43	6.28	94	124.88	5.75	81	62.40	5.07	93	63.00	3.78
9	88	129.48	4.98	82	128.81	6.62	88	65.50	3.28	81	65.83	4.21
10	97	134.30	6.76	70	136.29	7.63	97	69.46	4.88	70	70.15	5.56
11	88	140.03	6.59	74	144.10	6.89	87	72.31	4.04	74	74.55	4.74
12	109	144.31	8.28	76	147.16	6.52	109	75.39	5.31	76	75.92	3.94
13	136	151.31	7.90	128	150.02	6.27	136	79.33	4.50	128	77.21	4.32
14	136	157.25	8.67	126	153.01	5.44	136	82.02	4.92	126	78.50	3.71
15	80	163.37	6.54	141	153.84	6.59	80	84.67	4.29	141	78.61	4.46
16	98	165.19	6.31	87	154.18	6.27	98	85.98	4.09	87	79.34	4.07
17	93	167.47	7.02	120	153.86	6.42	93	86.87	4.55	120	79.04	5.07
18	86	167.82	7.78	63	154.39	6.10	86	87.40	7.16	63	79.41	4.50
Maya and Mestizos												
6	149	111.38	5.21	154	110.14	5.36	149	52.43	3.50	154	52.71	3.28
7	46	116.85	4.70	45	116.62	5.68	46	57.13	3.55	45	57.91	3.99
8	38	120.38	5.99	65	121.34	6.54	38	59.43	4.11	65	60.97	4.77
9	52	125.82	6.30	49	127.11	7.89	52	63.59	4.57	49	65.48	5.88
10	56	129.72	6.42	41	132.28	7.61	56	66.14	4.44	41	68.34	5.11
11	41	137.81	6.06	62	138.53	7.64	41	71.55	4.43	62	71.57	4.85
12	53	139.82	7.05	70	144.64	7.05	53	73.12	5.07	70	74.71	4.27
13	83	149.08	7.98	94	146.24	6.14	83	78.16	4.93	94	75.01	3.84
14	62	153.38	7.88	68	147.73	5.59	62	80.11	4.90	68	75.31	3.24
15	53	156.97	5.76	57	147.96	6.10	53	81.89	4.56	57	74.87	4.34
16	65	157.99	6.29	52	149.53	7.23	65	83.03	6.09	52	77.03	4.78
17	62	161.33	5.06	60	149.77	4.81	62	84.24	3.51	60	76.77	4.63
18	43	163.01	7.25	40	149.78	5.23	43	84.81	4.70	40	77.51	3.68

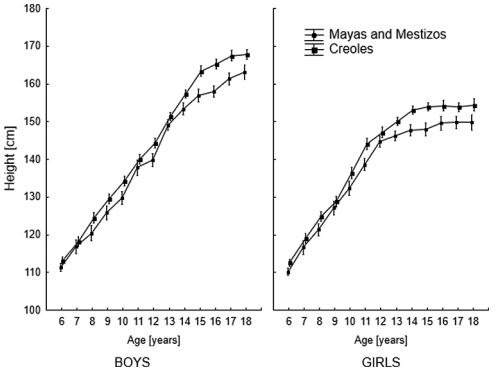

Fig. 2. Graphic representation of means and standard deviations of body height adjusted for age and ethnic group in boys and girls

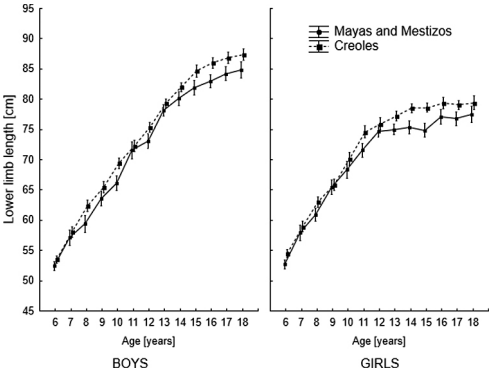

Fig. 3. Graphic representation of means and standard deviations of lower limb length adjusted for age and ethnic group in boys and girls

Table 2. Descriptive statistics, means and standard deviations of selected body proportions in Creole and Maya/Mestizo boys

Age (years)	n	Lower limb length-to-body height ratio		Upper-to-lower limb ratio		Shoulder-to-body height ratio		Hip-to-body height ratio		Hip-to-shoulder ratio	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Creoles											
6	179	47.37	1.67	93.59	4.40	22.06	0.89	16.67	1.11	75.31	4.40
7	88	49.13	1.68	89.52	5.33	21.90	0.97	16.38	1.14	74.89	5.07
8	80	49.92	1.69	89.36	4.29	22.14	1.05	16.44	1.25	74.30	4.98
9	88	50.58	1.47	88.56	3.87	22.12	1.12	16.42	1.07	74.32	4.66
10	96	51.52	1.39	87.51	3.25	21.94	1.06	15.97	1.38	72.84	5.77
11	87	51.59	1.53	87.23	3.37	22.04	1.14	16.52	1.41	74.98	5.33
12	109	52.22	1.60	86.54	3.23	21.85	1.03	16.29	1.35	74.56	5.51
13	136	52.43	1.32	86.68	3.18	21.76	1.11	16.24	1.20	74.86	5.15
14	136	52.16	1.23	87.70	2.91	21.88	0.94	16.36	1.05	74.97	4.47
15	79	51.90	1.15	87.80	2.96	22.10	0.94	16.16	0.89	73.18	3.97
16	98	52.05	1.37	87.02	2.62	22.17	0.98	16.15	0.88	72.92	4.14
17	93	51.86	1.25	87.30	2.67	22.42	1.15	16.35	1.00	73.03	4.96
18	85	51.72	1.47	87.05	3.10	22.55	0.97	16.29	0.77	72.33	4.01
Maya and Mestizos											
6	149	47.05	1.67	94.74	4.33	22.24	0.91	16.77	1.09	75.50	4.81
7	46	48.87	1.70	91.90	4.37	21.94	0.80	16.33	1.05	74.52	5.25
8	38	49.35	1.93	90.73	5.04	22.14	1.19	16.41	1.36	74.17	5.01
9	52	50.52	2.10	89.60	4.53	22.28	1.19	16.34	1.61	73.40	6.35
10	56	50.95	1.43	89.09	3.63	22.08	1.09	16.20	1.49	73.60	6.29
11	41	51.90	1.57	86.45	3.69	21.93	0.78	16.12	1.39	74.07	6.10
12	51	51.89	1.66	86.02	3.40	22.12	1.03	16.36	1.13	74.03	4.41
13	83	52.42	1.33	87.99	3.33	21.93	1.02	16.23	0.99	74.43	5.43
14	61	52.11	1.38	88.64	3.23	22.16	1.00	16.41	0.87	74.12	3.69
15	52	52.26	1.43	87.61	3.23	22.27	1.09	16.55	0.71	74.38	3.44
16	64	52.14	1.36	87.57	3.38	22.57	0.89	16.41	0.85	72.80	4.42
17	62	52.21	1.19	87.17	2.85	22.70	0.96	16.35	0.83	72.10	4.00
18	43	52.01	1.10	87.66	2.23	22.57	0.96	16.55	1.09	73.41	4.81

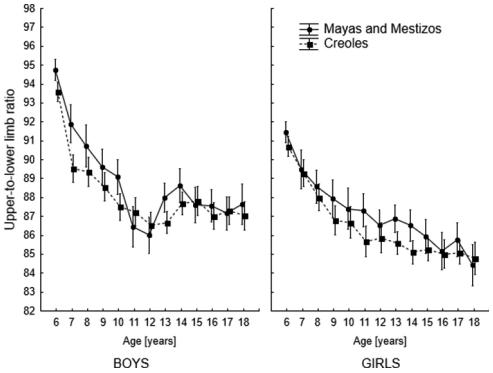

Fig. 4. Graphic representation of means and standard deviations of upper-to-lower-limb ratio adjusted for age and ethnic group in boys and girls

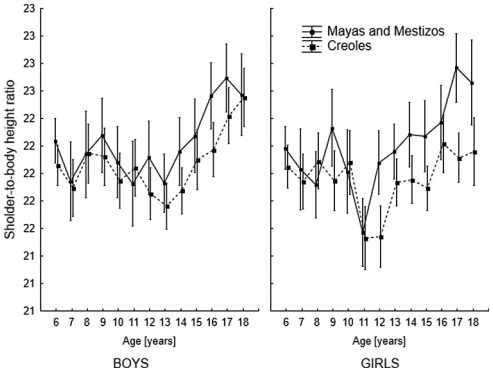

Fig. 5. Graphic representation of means and standard deviations of shoulder–to-body height ratio adjusted for age and ethnic group in boys and girls

Table 3. Descriptive statistics, means and standard deviations of selected body proportions in Creole and Maya/Mestizo girls

Age (years)	n	Lower limb length-to-body height ratio		Upper-to-lower limb ratio		Shoulder-to-body height ratio		Hip-to-body height ratio		Hip-to-shoulder ratio	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Creoles											
6	159	48.38	1.64	90.70	4.31	22.05	0.85	16.76	1.00	76.07	4.34
7	93	49.44	1.39	89.29	4.00	21.94	0.86	16.57	1.18	75.59	5.48
8	93	50.44	1.41	88.01	3.56	22.09	1.14	16.54	1.50	74.20	5.36
9	81	51.09	1.67	86.81	3.59	21.95	1.08	16.50	1.18	75.26	5.20
10	69	51.24	1.67	86.68	3.52	22.08	1.07	16.43	1.33	74.49	5.95
11	74	51.72	1.63	85.69	3.29	21.53	1.10	16.84	1.48	78.23	5.78
12	76	51.59	1.25	85.87	3.02	21.54	0.86	17.42	1.34	80.93	5.95
13	127	51.51	1.32	85.60	2.67	21.93	0.94	17.74	1.38	80.93	6.22
14	126	51.30	1.27	85.12	2.56	21.96	0.92	17.85	1.42	81.36	6.50
15	140	51.22	1.28	85.24	2.80	21.89	0.87	18.02	1.32	82.35	5.66
16	87	51.45	1.41	85.01	2.76	22.22	0.93	18.29	1.29	82.38	5.18
17	119	51.50	1.50	85.10	2.57	22.11	1.02	18.71	1.25	84.66	5.07
18	63	51.42	1.70	84.78	3.19	22.16	1.04	18.48	1.46	83.43	6.03
Maya and Mestizos											
6	154	47.85	1.55	91.44	4.43	22.19	0.94	16.93	0.86	76.42	4.58
7	45	49.62	1.44	89.50	4.10	22.03	1.18	16.08	1.14	73.44	5.34
8	65	50.20	1.98	88.57	4.25	21.92	1.05	16.58	1.44	75.38	5.30
9	48	51.19	1.79	87.94	4.41	22.33	1.13	16.82	1.34	75.32	4.98
10	40	51.33	1.82	87.41	2.71	22.01	1.25	16.22	1.51	73.79	6.67
11	62	51.64	1.53	87.31	3.72	21.57	1.16	16.56	1.17	76.85	5.16
12	70	51.66	1.50	86.53	3.65	22.08	0.94	17.60	1.51	79.78	6.57
13	94	51.28	1.22	86.88	2.66	22.16	0.70	17.78	1.26	80.24	5.30
14	68	50.98	1.09	86.53	3.08	22.28	1.00	18.08	1.39	81.27	6.27
15	57	50.58	1.28	85.94	2.50	22.27	1.01	18.15	1.27	81.48	5.82
16	52	51.50	1.54	85.17	3.03	22.37	0.84	18.98	1.40	84.87	5.66
17	59	51.52	1.55	85.77	2.82	22.77	1.02	19.01	1.46	83.52	5.91
18	40	51.75	1.47	84.43	2.85	22.66	0.94	18.73	1.31	82.67	5.17

Table 4. Results of the analysis of variance (two-way ANOVA) for boys and girls separately, with age and ethnicity as independent variables and body height, lower limb length, and body proportions as dependent variables

Variable	Boys		Girls	
	F	*p*-value	*F*	*p*-value
Height (cm)				
Age (years)	1364.46	<0.001	1033.83	<0.001
Ethnicity	117.17	<0.001	180.83	<0.001
Interaction	3.16	<0.001	1.79	<0.05
Lower limb length *B-sy* (cm)				
Age (years)	1127.38	<0.001	775.44	<0.001
Ethnicity	97,22	<0.001	109.89	<0.001
Interaction	1.42	NS	1.67	NS
Upper-to-lower limb ratio				
Age (years)	81.01	<0.001	60.09	<0.001
Ethnicity	16.84	<0.001	21.10	<0.001
Interaction	1.96	<0.05	0.91	NS
Shoulder-to-body height ratio				
Age (years)	7.61	<0.001	7.77	<0.001
Ethnicity	10.44	<0.01	29.25	<0.001
Interaction	0.57	NS	2.20	<0.01
Hip-to-body height ratio				
Age (years)	3.18	<0.001	72.95	<0.001
Ethnicity	1.78	NS	3.58	NS
Interaction	1.01	NS	1.63	NS
Hip-to-shoulder ratio				
Age (years)	5.42	<0.001	63.14	<0.001
Ethnicity	0.77	NS	2.21	NS
Interaction	0.90	NS	1.54	NS

Age, 6–18 years; Ethnicity, Creole and Maya/Mestizo groups.

factor regardless of ethnic category) for body proportions: upper-to-lower limb in girls ($F=60.09$, $p<0.001$), shoulder-to-body height in boys ($F=7.61$, $p<0.001$), hip-to-body height in boys ($F=3.18$, $p<0.001$) and girls ($F=72.95$, $p<0.001$), and hip-to-shoulder in boys ($F=5.42$, $p<0.001$) and girls ($F=63.14$, $p<0.001$).

Discussion

The distinctive features of the Maya physique have been described in hitherto studies indicating their extremely short stature, stocky and robust body and distinctive proportions: long arms, broad shoulders and long trunks (Starr 1902; Gann 1918; Steggerda 1932, 1936, 1941).

The present results indicate that Maya/Mestizo children differ from Creole ones not only in body height and leg length (stands for the lower segment of the body) but also in the body proportions: upper-to-lower limb and shoulder-to-body height ratios. It means that Maya/Mestizo children and youth are shorter, with shorter legs and are characterized by relatively longer upper limbs than legs and relatively (to height) wider shoulders as compared to their peers from the Creole group.

It is worth mentioning that Creole people live on higher standard due to their higher socio-economic status than that of Maya/Mestizos (Siniarska 1999; Siniarska and Wolański 1999a). However, data on socio-economic status were not analyzed in the present work. Some other studies also reported that Maya had quite a shorter stature and shorter leg length (Gann 1918; Balam-Pereira et al. 1997; Bogin et al. 1992). Moreover, there are studies indicating that the growth of leg length is under strong control of environmental conditions (Bogin et al. 2002; Frisancho 2007). Another evidence for that is derived from the study of Maya subjects in Mexico showing that leg length was more sensitive to the quality of environmental conditions than height (Azcorra et al. 2013; Azcorra et al. 2015). Data on Maya children born and living in Guatemala and Mayas living in the USA corroborate well to the above mentioned (Bogin et al. 2002). Those living in the USA are currently 11.54 cm taller and 6.83 cm longer-legged, on average, than their peers living in Guatemala (Bogin et al. 2002). The values indicate that about 60% of the increase in body height is due to longer legs. Similar results were found in two tribes of Maya in Guyana, where the difference in height between those groups were mostly due to legs length. Both tribes were characterized by low SES, but the quality of their living conditions significantly varied (Dangour 2011). At this point we should clarify that the data used to compare the length of the lower extremities were measured using different methods (sitting height and *B-sy)*. Certainly these measurements are associated with different accuracy and the statistical analysis of raw data cannot be performed. But a general reference to the size of the body height can be done, because two methods estimate the length of the lower extremities and their relative proportion to the body height.

Maya/Mestizo children had wider shoulders than their Creole peers at almost every age group. Smaller values of this index describe narrow-shouldered posture in relation to height (Malinowski and Wolański 1988). This specific dimension as well as hip width have not changed for decades, as indicated by research on the secular trend between 1928–1976 (Siniarska and Wolański 1999b).

Studies on Mexican Americans (Mestizos, described as descendants of admixture of American Indians and southwest Europeans), revealed that when compared to Whites and Blacks from San Antonio, they were characterized by small shoulder width (Malina et al. 1986). Other studies conducted between 1928–1931 and compared young Mexican Americans (Mestizos) in El Paso and Laredo (Manuel 1943, cited in Malina et al. 1986), San Antonio (Whitacre 1939, cited in Malina et al. 1986) and Brownsville (Dodd 1930, cited in Malina et al. 1986) indicated general similar mean heights and weights. Also shoulder and hip widths did not differ in children from El Paso, Laredo and San Antonio. Can we therefore hypothesize that certain body dimensions or even proportions have their genetic determination?

It is also worth to mention that for some dimensions there are observed certain fluctuations during the growth process. The leg length differences between two ethnic groups are rather small in childhood and before puberty in both sexes (in 11 year old boys and 9 year old girls). The shoulder-to-body height ratio shows greater differences in youth (the later phase of adolescence), whereas the

upper-to-lower limb ratio diminishes their differences between compared ethnic groups with age. Prepubertal period (from 6–7 to 10–12 years) is characterized by the decrease in growth rate, but at the same time there are intense hormonal changes prior to puberty. Puberty is a specific period of growth when genetic factors begin to dominate (Bogin 1999; Wolański 2012).

Numerous studies suggest that genes have a crucial impact on body physique and stature (Eveleth and Tanner 1990; Malina et al. 1987; Martorell et al. 1988; Pathmanathan and Prakash 1994). On the other hand, environmental factors are those that are frequently quoted as contributing to increase of body height (Bogin et al. 2002). Still, there are no unambiguous results explaining this phenomenon.

This study has some limitations. The first and foremost is cross-sectional design which limits observations of individual growth pattern. However, this design helps us to study large sample of children from different ethnic groups.

There is also controversy regarding anthropometric measurement techniques, namely that of lower extremity length (LEL) measured as basion- symphysion height. However, this measurement is much more accurate than LEL calculated as the difference between body height and sitting height. Basion-symphysion height has been usually done by touching the measured person at the upper edge of pubic symphysis, which is quite embarrassing. Each examined person in this study was asked to find yourself the *sy* landmark under a special instruction and keep the finger on it. The examiner approached with anthropometer and measured the distance *B-sy* without touching this point.

Another week point of this study is the method of assignment subjects to ethnic group of the Merida population. It is often established using two surnames of children from father and mother side, two Spanish names indicate Creole, two Maya names indicate Maya, one Maya and another Spanish indicate Mestizo (Azcorra et al. 2013). Two authors of this work (AS and NW) have been working in Yucatan for 15 years (1990–2005). The division into three ethnic groups of Merida inhabitants using two of their surnames is not easy and is not fully correct. We have to remember that in the turn of the century (the 19th and 20th) in some places of Maya land (especially in Yucatan), Maya inhabiting communities were under supervision of owners of sisal or other plantations' haciendas and Maya people received the surname of the owner (as a gift). It is the case of a small Maya community Dzeal located near Pisté (Yucatan Peninsula) investigated in 1986 and 2000 (Fernández del Valle 2011). For years many people from this community and others as well have migrated to Mérida city with the "Spanish names". Their descendants were included into the group of Mestizo or Creole, depending on the name of spouses. In many cases they should be classified as Maya, especially that they looked like Maya. Independently, relatively pure Creole people remained a separate group due to their higher SES (relatively well paid jobs and better living conditions). Majority of Maya indigenous population of the Yucatán Peninsula, live in low soil fertility areas, which often forces them to abandon their lands and undertake low paid manual work in the cities, e.g. in Merida (Siniarska 1999; Siniarska and Wolański 1999a.)

Summing up this discussion it can be stated that both genetic and environmen-

tal factors may have the decisive influence on between ethnic group differences in body proportions during the childhood growth process. It seems that some differences may originate from environmental stimuli such as various lifestyle and nutritional habits rather than from genetic determination, especially that these differences are not observed among adults. The far-reaching conclusion however, needs further genetic studies.

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Authors' Contributions

AS was the lead researcher for the grant project, conceived and wrote the first draft of the manuscript; JN-D searched for the literature and contributed to the writing of the discussion; SK performed statistical analysis and interpreted the results; NW was project manager and revised the work critically for important intellectual content. All authors discussed the results, commented each successive version of the manuscript and approved the final manuscript for publication.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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