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The Impact of Sex and Age Factors on Morphological Characteristics in Children: A Case Study from Kyrgyzstan

Impacto de los Factores de Sexo y Edad en las Características Morfológicas de los Niños: Un Estudio de Caso de Kirguistán

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SUMMARY: This study aimed to investigate the effects of *sex* and age on morphological characteristics in Kyrgyz children. Conducted in 55 primary schools across Bishkek and Chuy regions, the research included boys and girls aged 8 (n=1215), 9 (n=1211), and 10 (n=879). A total of 3315 children participated, comprising 1662 boys and 1653 girls, as part of a talent screening project endorsed by the Kyrgyz Ministry of Sports and the Ministry of Education. The study assessed various characteristics, including anthropometric measurements, to analyze differences based on age and sex. Significant differences were observed in height and body weight across all age groups for both sexes ($p<0.05$). For girls, BMI values showed significant variation across age groups ($p<0.01$). Body fat percentages also revealed significant differences between ages 8 and 10 ($p<0.05$), though no significant differences were noted among other age groups. While there were no notable differences in mesomorphy values between sexes, significant differences were found in endomorphy ($p<0.01$) and ectomorphy ($p<0.05$) values. Specifically, girls aged 8, 9, and 10 had higher endomorphy values compared to boys ($p<0.01$). Ectomorphy and mesomorphy characteristics were similar across all age groups for both sexes. Although there were no significant differences in endomorphy and mesomorphy values for girls, notable differences were observed between boys' endomorphy, ectomorphy, and mesomorphy values, and girls' ectomorphy values. This suggests a proportional increase in height, body weight, body fat percentage, and BMI with age in both boys and girls. This study highlights that morphological characteristics, including height, body weight, body fat percentage, and body mass index, develop proportionally with age in Kyrgyz children, with significant differences observed in endomorphy and ectomorphy values between sexes, especially across different age groups.

KEY WORDS: Morphology; Children; Kyrgyzstan.

INTRODUCTION

Morphological characteristics are qualities that describe the physical structure and form of organisms or objects. In children, morphological characteristics encompass studies aimed at understanding how their physical structures and shapes develop and change. These characteristics are used to assess how children's health status, developmental processes, and environmental factors interact. These assessments are expressed through somatotypes. In children, somatotypes play an important role in understanding their physical structures and developmental processes. Somatotypes are generally assessed through a system that categorizes body types into three main categories: endomorph (round and soft), mesomorph (muscular and athletic), and ectomorph (thin and tall). This system, developed by William Sheldon in the 1940s, is still used in evaluating children's physical characteristics (Sheldon, 1943). Today, various studies are conducted to understand the effects of somatotypes on children's developmental processes, health status, and physical performance.

Sex and age factors have significant effects on children's somatotype characteristics. Research shows that morphological development during childhood varies according to sex and age (Marta *et al*., 2013). While endomorphic and ectomorphic traits differ according to age, mesomorphic traits generally show less variation. The sex

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factor in children can lead to significant differences in somatotype characteristics. For example, endomorphic values may be higher in girls compared to boys, while boys typically have higher mesomorphic values (Krzykala *et al*., 2020). In this context, understanding how somatotype characteristics change with sex and age in children provides valuable information in the fields of physical development, health, and sports sciences. Examining how endomorphy, ectomorphy, and mesomorphy values are influenced by age and sex can aid in assessing children's physical development processes and developing health strategies.

Somatotypes have significant effects on children's motor skills, physical performance, and overall health. Silventoinen *et al*. (2021), have noted that somatotypes are related to physical activity levels and sports performance during childhood. They also found that mesomorphic children generally exhibit better athletic performance, while ectomorphic children tend to have lower muscle mass. The impact of somatotypes on children's health is particularly important in the context of obesity and growth disorders. Koleva *et al*. (2000), have indicated that endomorphic traits during childhood are associated with increased body fat percentage and obesity risks. Additionally, endomorphic children typically have a higher Body Mass Index (BMI) and, consequently, a higher risk of obesity. Somatotypes can also influence children's success in sports and physical education. Shakhanova *et al*. (2016), have shown that mesomorphic children have more muscle mass and strength, making them generally more successful in sports requiring strength and endurance. Ectomorphic children, on the other hand, may perform better in endurance sports. Somatotypes in children can change throughout growth and development processes. Barton & Hunt Jr. (1962), examined changes in somatotypes during childhood and adolescence and the effects of these changes on growth processes. The study illustrates how morphological changes during puberty affect children's somatotypes and the implications of these changes on overall health and physical performance.

The childhood period is a time when physical development and changes in body structure occur rapidly, and these processes can show significant differences based on sex and age. Understanding the effects of sex and age factors on children's body composition, somatotypes, and other anthropometric characteristics can contribute to the development of more effective strategies in health, sports, and education. In developing regions like Kyrgyzstan, collecting such data allows for the shaping of local health policies, sports programs, and educational strategies according to the actual needs of children. Additionally, this study can make significant contributions to both national and international literature by defining the physical development profiles of children in Kyrgyzstan. Such data can aid in designing interventions that support healthy growth and development in children.

The primary aim of this research is to examine the effects of sex and age factors on morphological characteristics in children living in the Bishkek and Chuy regions of Kyrgyzstan. To achieve this goal, the study aims to (i) investigate somatotypes according to sex and age factors and (ii) analyses and interpret anthropometric data. This research not only seeks to understand how children's morphological characteristics change according to sex and age but also aims to reveal the potential implications of this information for local health and education policies.

MATERIAL AND METHOD

Participants. The participants in this study were children selected from 55 primary schools in the Bishkek and Chuy regions of Kyrgyzstan. The study included children aged 8 (n=1215), 9 (n=1211), and 10 (n=879) years, both boys and girls. In total, 3,315 children volunteered for the study, including 1,662 boys and 1,653 girls. The children were selected as part of a talent screening project conducted in schools recommended by the Kyrgyzstan Ministry of Sports and the Ministry of Education. The participants provided various physical and morphological data for the purpose of measuring and analyzing anthropometric characteristics. Before the study, parents and participants filled out informed consent forms. The study was conducted in accordance with the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee of the Kyrgyz State University of Physical Education with decision No. 138.

Anthropometric Measurements. Anthropometric characteristics were assessed through measurements of body fat percentage, body mass index (BMI), somatotypes, as well as circumference and diameter measurements.

Body Mass Index. For the anthropometric measurements, body height and weight were recorded without shoes but with clothing. The weight of the clothing was measured separately for some children, with an average weight of 0.7 kg. On the first day the students were provided with accelerometers, the weight of the clothing (0.7 kg) was subtracted from the measured body weight to determine the net body weight. This net body weight was then used to calculate the Body Mass Index (BMI, kg/m^2) (Inokuchi *et al*., 2021).

Body Fat Percentage (Skinfold). Skinfold thickness was measured to the nearest 0.1 mm using Holtain Skinfold Calipers at the following sites: biceps, triceps, subscapular, suprailiac, chest, and thigh. The formula used for calculating

body fat percentage was (thigh × 0.097) + 3.64 (thigh × 0.097)+3.64 on the right side of the body, following standard procedures as outlined by Lange (Özer, 1993).

Diameter and circumference measurements. Waist circumference (in centimeters) was measured directly on the skin using a non-stretchable tape at the end of a normal expiration. This measurement was taken at the midpoint between the lower edge of the last palpable rib and the top of the iliac crest (hip bone), with the adolescents in a standing position and their arms relaxed at their sides (da Silva *et al*., 2018).

The sagittal abdominal diameter (in centimeters) was measured to the nearest 0.1 cm after a normal expiration, with the adolescent in the supine position on a firm examination table, knees slightly bent, and with the measurement area unclothed. The sagittal abdominal diameter was measured using the Holtain-Kahn Abdominal Caliper (Holtain Ltd, Crymych, UK), a portable sliding-beam caliper. The measurement was taken as the distance between the examination table and the top of the body at the level of the umbilicus, ensuring that the caliper arm lightly touched the abdomen without applying compression (Møller *et al*., 2021).

Somatotype. All subjects were categorized using the Heath–Carter anthropometric somatotype method. This method is reported to be applicable for describing variations in human somatotypes regardless of age, sex, or differences related to climate, diet, genetics, race, health, or physical activity (Carter & Heath, 1990).

The somatotype values of the participants were determined using the Heath-Carter Somatotype Method. According to this method, the formulas for calculating somatotype values were based on measurements of body weight, height, biceps flexion, calf circumference, and femur diameter, as well as skinfold thickness at the triceps, subscapular, suprailiac, biceps, and calf sites. The detailed values and formulas used are shown below (Carter & Heath, 1990).

The Calculation of Endomorph

- A = triceps + subscapular + suprailiac
- B= (170.18 / height) (coefficient for correction according to height)
- Corrected total X=A.B

Endomorph= -0.7182 + 0.145X - 0.00068X2+ 0.0000014X3

The Calculation of Mesomorph

- H= Humerus epicondyle (cm)
- F= Femur epicondyle (cm)
- BC= biceps circumference - (triceps skinfold /10) (mm)
- CC= calf circumference (calf skinfold /10) (mm)
- B= height (cm)

Mesomorph = 0.858H + 0.601F + 0.188BÇ + 0.161CÇ - 0.131B + 4.5

The Calculation of Ectomorph

- Height is recorded as cm and Weight as kg.
- Ponderal index is calculated by dividing height to cubic root of weight RPI= Height/ Weight (1/3)
- Ectomorph is calculated according to the Ponderal index by using one of the formulas below.
- If RPI ≥ 40.75 via, Ectomorph = 0.732¥RPI - 28.58
- If 38.25 < PI < 40.75, Ectomorph = 0.463× RPI - 17.63
- If RPI ≤ 38.25, Ectomorph = 0.1

Statistical Analysis: For the statistical analysis, SPSS version 18 was used. The normality of the obtained data was tested using the Kolmogorov-Smirnov test. One-way ANOVA was employed to analyse data showing a normal distribution. Pearson correlation analysis was used to determine the relationships between variables. Significance levels were set at 0.05 and 0.01.

RESULTS

The height, body weight, body mass index (BMI), and body fat percentages of the male and female participants were compared across different age groups. Significant statistical differences were found in height and body weight among all age groups for both boys and girls ($p<0.05$). Differences in BMI values were observed across all age groups for girls ($p<0.01$). Additionally, a difference was found between the BMI values of 10-year-old boys and those of 8 and 9-year-old boys, whereas no statistically significant difference was found between the 8-year-old and 9-year-old boys. Finally, comparisons of body fat percentages by age revealed a difference between the 8- and 10-year-old groups, but no differences were noted among other age groups for both boys and girls (Table I).

When comparing somatotype characteristics by sex among the children participating in the study, it was found that while there were no significant differences in mesomorphy values between sexes, girls exhibited higher average values in endomorphy and ectomorphy compared to boys (Table II).

When comparing somatotype characteristics based on sex among children of the same age included in the study, it was found that endomorphy values for girls aged 8, 9, and 10 were statistically higher than those for boys. Additionally, ectomorphy and mesomorphy characteristics showed

statistically similar values for both girls and boys across all age groups (Table III).

When comparing the somatotype characteristics of boys and girls by age groups, it was found that there were no significant differences in endomorphy and mesomorphy values among girls. However, statistically significant differences were observed in endomorphy, ectomorphy, and mesomorphy values among boys, as well as in ectomorphy values among girls. Specifically, for boys, significant differences were found in endomorphy values between ages 10 and 8 and 9, in ectomorphy values between ages 8 and 9 and 10, and in mesomorphy values between ages 8 and 10, with no differences among other age groups. For girls, significant differences in ectomorphy values were observed across all age groups (Table IV).

Table I. Comparison of demographic variables among age groups of boys and girls participants.

	Variables	Age	n	x	SD	F	p
Boys	**Height (cm)**	8	612	128,17[c]	6,78	338,538	0,001**
		9	586	133,49[b]	6,14		
		10	481	138,25[a]	6,00		
	Weight (kg)	8	612	27,85[c]	5,39	117,603	0,001**
		9	586	30,72[b]	6,53		
		10	481	33,69[a]	6,72		
	Body Mass Index (kg/m²)	8	612	16,93[b]	3,02	5,909	0,003**
		9	586	17,14[b]	2,76		
		10	481	17,52[a]	2,55		
	Body Fat Percentage (% kg)	8	612	9,02[b]	1,98	4,308	0,014*
		9	586	9,24[ab]	2,39		
		10	481	9,41[a]	2,27		
Girls	**Height (cm)**	8	616	127,26[c]	5,65	398,743	0,001**
		9	631	132,80[b]	5,94		
		10	419	137,94[a]	6,60		
	Weight (kg)	8	616	26,88[c]	4,85	135,510	0,001**
		9	631	29,88[b]	5,73		
		10	419	32,85[a]	6,84		
	Body Mass Index (kg/m²)	8	616	16,52[c]	2,24	8,450	0,001**
		9	631	16,84[b]	2,38		
		10	419	17,14[a]	2,62		
	Body Fat Percentage (% kg)	8	616	9,70[b]	2,00	2,916	0,054
		9	631	9,83[ab]	2,11		
		10	419	10,06[a]	2,27		

x: Arithmetic Mean, SD: Standard Deviation, *p<0,05; **p<0,01; a-b-c: Differences between groups are represented by different letters.

Table II. Comparison of somatotype characteristics by sex.

Variables	Sex	n	x	SD	t	p
Endomorphy	Boys	1679	4,07	1,15	-8,859	0,001*
	Girls	1666	4,43	1,14		*
Ectomorphy	Boys	1679	2,83	1,23	-2,182	0,029*
	Girls	1666	2,93	1,28		
Mesomorphy	Boys	1679	4,66	1,58	-0,808	0,419
	Girls	1666	4,71	1,64		

x: Arithmetic Mean, SD: Standard Deviation, *p<0,05;

Table III. Comparison of somatotype characteristics between girls and boys.

Variables	8 Age	x ± SD	t	p	9 Age	x ± SD	t	p	10 Age	x ± SD	t	p
Endomorphy	Girls	4,38±1,10	-6,463	,000**	Girl	4,43±1,12	-5,194	,000**	Girl	4,48±1,24	-3,785	,000**
	Boys	3,99±1,04			Boys	4,08±1,21			Boys	4,17±1,19		
Ectomorphy	Girls	2,72±1,21	-,630	,529	Girl	2,96±1,26	-1,093	,275	Girl	3,19±1,36	-2,466	,014*
	Boys	2,67±1,16			Boys	2,88±1,25			Boys	2,98±1,26		
Mesomorphy	Girls	4,61±1,60	-,674	,500	Girl	4,72±1,60	-,226	,821	Girl	4,85±1,72	-,662	508
	Boys	4,55±1,58			Boys	4,70±1,61			Boys	4,78±1,52		
n	Girls	**616**			Girl	**631**			Girl	**419**		
	Boys	**612**			Boys	**586**			Boys	**481**		

x: Arithmetic Mean, SD: Standard Deviation, *p<0,05; **p<0,01

Table IV. Comparison of somatotype characteristics by age groups for boys and girls.

Sex	Somatotype	Age	n	x	SD	F	p
Boys	Endomorphy	8	612	3,99[b]	1,04	3,503	0,030*
		9	586	4,08[b]	1,21		
		10	481	4,17[a]	1,19		
		Total	1679	4,07	1,15		
	Ectomorphy	8	612	2,67[b]	1,16	8,849	0,001**
		9	586	2,88[a]	1,25		
		10	481	2,98[a]	1,26		
		Total	1679	2,83	1,23		
	Mesomorphy	8	612	4,55[b]	1,58	3,032	0,048*
		9	586	4,70[ab]	1,61		
		10	481	4,78[a]	1,52		
		Total	1679	4,66	1,58		
Girls	Endomorphy	8	616	4,38	1,10	0,891	0,411
		9	631	4,43	1,12		
		10	419	4,48	1,24		
		Total	1666	4,43	1,14		
	Ectomorphy	8	616	2,72[c]	1,21	17,807	0,001**
		9	631	2,96[b]	1,26		
		10	419	3,19[a]	1,36		
		Total	1666	2,93	1,28		
	Mesomorphy	8	616	4,61	1,60	2,702	0,067
		9	631	4,72	1,60		
		10	419	4,85	1,72		
		Total	1666	4,71	1,64		

x: Arithmetic Mean, SD: Standard Deviation, *p<0,05; **p<0,01; abc: Differences between groups are represented by different letters.

DISCUSSION

Anthropometric research continues in many countries today, with results being evaluated in detail. These studies are used to establish norms for healthy growth and development in various communities. Data from these studies are also utilized in fields such as sports and health. For developing physical and motor skills, as well as mental and social abilities during the growth and development phases in children, conducting anthropometric measurements and guiding children based on these results is crucial (Özkoçak *et al*. 2018). Advances in health and sports disciplines are a result of anthropometric measurements. Therefore, performing these measurements and identifying anthropometric characteristics in young children is important. However, methodological issues may arise from inaccurate measurements and analysis in such studies. Due to the lack or limited amount of anthropometric research on children in Kyrgyzstan, this study is important as it provides a resource for other studies.

In our research, it was found that both boys and girls showed statistically significant differences in height and body weight across all age groups, which increased in proportion to age. Despite this increase, no difference was found in BMI values between 8 and 9-year-old boys. However, differences were observed between the BMI values of the 10-year-old boys and the 8-9-year-old boys. In contrast, there were statistically significant differences in BMI values across all age groups for girls. Statistically significant differences were found in body fat percentages between 8-10-year-old boys and girls, but no differences were observed in other age groups (Table I).

The importance of having appropriate levels of fat, muscle, and bone in relation to age during childhood is emphasized (Giese *et al.* 2017). Observing components such as fat body weight, distribution of subcutaneous fat, lean body mass, fat percentage, and muscle percentage is crucial for understanding obesity and evaluating healthy growth and development in children (Lemos & Gallagher, 2017). Literature review shows that many studies, similar to our study, observe statistically significant increases in body weight, height, BMI, and body fat percentage with age in both boys and girls (Vásquez *et al*. 2017). Some studies, however, indicate that height, body weight, BMI, and body fat percentage can be irregular and complex, particularly in boys and girls aged 8-10 (Wong *et al*., 2003).

In our study, while no significant differences were found in mesomorphy values between sexes, it was observed that endomorphy and ectomorphy values were statistically

higher in girls compared to boys. These findings indicate that morphological differences between sexes, particularly in endomorphy and ectomorphy, are pronounced. The more pronounced endomorphic characteristics in girls compared to boys can be explained by hormonal differences, genetic factors, or age-related developmental processes (Hebbelinck *et al.*, 1995). Kabakci & Yucel (2016) noted that mesomorphic characteristics are predominant in girls suited for ballet, while endomorphic characteristics are dominant in those not suited for ballet.

Based on the study findings, it was observed that endomorphy values were statistically higher in girls aged 8, 9, and 10 compared to boys. This suggests that endomorphy criteria, such as body fat percentage and general roundness, may vary based on sex. The results suggest that girls might have more body fat compared to boys, or that sex-specific metabolic differences could influence endomorphy values (Smith & Jones, 2022; Brown, 2023). The similar values of ectomorphy and mesomorphy characteristics across all age groups in both girls and boys highlight the effect of age-related developmental processes on these characteristics (Rahmawati & Hastuti, 2021). The observed sex differences in endomorphy and the similarities in ectomorphy and mesomorphy suggest that morphological characteristics can reflect both genetic and environmental factors influencing sex differences (Wells, 2003).

The differences in endomorphy values among boys, particularly between ages 10 and 8 and 9, suggest that features like body fat percentage and roundness may change with age. This indicates how hormonal and developmental changes affect endomorphy values (Lizana *et al*., 2018). The noticeable differences in ectomorphy values between ages 8 and 9 and 10 suggest that subtle changes in body composition become more pronounced with age, and that ectomorphic characteristics may be more prominent in younger ages (Malacko *et al*., 2015). Differences in mesomorphy values between ages 8 and 10 reflect developmental changes in muscle structure and how these are influenced by physical activities and genetic factors (Miller *et al*., 2015). However, the lack of differences between 8 years and other age groups suggests that mesomorphic characteristics might remain stable during certain developmental periods.

CONCLUSIONS

In conclusion, these findings provide valuable data for evaluating the morphological characteristics of children according to sex and age factors. The results of this study contribute to understanding the physical development processes and sex differences among children, which can aid in the formulation of individualized development strategies in the fields of sports and health. Increasing the number of anthropometric studies that provide information about public health, nutrition, hygiene, and growth and development conditions is essential. Such research will facilitate more practical applications and improve human well-being. However, it is important to note that further advanced studies are necessary to enhance the generalizability of these findings and obtain more comprehensive results.

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DZHANUZAKOV, K.; DEMIRHAN, B.; BAYRAKDAR, A.; ISIK, Ö.; ABDYRAKHMANOVA, D. & GERI, S. Impacto de los factores de sexo y edad en las características morfológicas de los niños: un estudio de caso de Kirguistán. *Int. J. Morphol., 43(1)*:141-147, 2025.

RESUMEN: Este estudio tuvo como objetivo investigar los efectos del sexo y la edad en las características morfológicas de los niños kirguisos. La investigación se llevó a cabo en 55 escuelas primarias en las regiones de Bishkek y Chuy, e incluyó a niños y niñas de 8 (n = 1215), 9 (n = 1211) y 10 (n = 879) años. Un total de 3315 niños participaron, incluidos 1662 niños y 1653 niñas, como parte de un proyecto de detección de talentos respaldado por el Ministerio de Deportes y el Ministerio de Educación de Kirguistán. El estudio evaluó varias características, incluidas las mediciones antropométricas, para analizar las diferencias en función de la edad y el sexo. Se observaron diferencias significativas en la altura y el peso corporal en todos los grupos de edad para ambos sexos ($p < 0,05$). Para las niñas, los valores de IMC mostraron una variación significativa entre los grupos de edad ($p < 0,01$). Los porcentajes de grasa corporal también revelaron diferencias significativas entre las edades de 8 y 10 años ($p < 0,05$), aunque no se observaron diferencias significativas entre otros grupos de edad. Si bien no hubo diferencias notables en los valores de mesomorfia entre ambos sexos, se encontraron diferencias significativas en los valores de endomorfia ($p < 0,01$) y ectomorfia ($p < 0,05$). Específicamente, las niñas de 8, 9 y 10 años tuvieron valores de endomorfia más altos en comparación con los niños ($p < 0,01$). Las características de ectomorfia y mesomorfia fueron similares en todos los grupos de edad para ambos sexos. Aunque no hubo diferencias significativas

en los valores de endomorfia y mesomorfia para las niñas, se observaron diferencias notables entre los valores de endomorfia, ectomorfia y mesomorfia de los niños y los valores de ectomorfia de las niñas. Esto sugiere un aumento proporcional de la altura, el peso corporal, el porcentaje de grasa corporal y el IMC con la edad tanto en niños como en niñas. Este estudio destaca que las características morfológicas, incluida la altura, el peso corporal, el porcentaje de grasa corporal y el índice de masa corporal, se desarrollan proporcionalmente con la edad en los niños kirguisos, con diferencias significativas observadas en los valores de endomorfia y ectomorfia entre sexos, especialmente entre diferentes grupos etarios.

PALABRAS CLAVE: Morfología; Niños; Kirguistán.

REFERENCES

Barton, W. H. & Hunt Jr., E. E. Somatotype and adolescence in boys: a longitudinal study. *Hum. Biol., 34(4)*:254-70, 1962.

Carter, J. L. & Heath, B. H. *Somatotyping: Development and Applications.* Vol. 5. Cambridge, Cambridge University Press, 1990.

da Silva, C. C.; Vasques, A. C. J.; Zambon, M. P.; Camilo, D. F.; De Bernardi Rodrigues, A. M.; Antonio, M. Â. R. G. M.; Geloneze, B. & Brazilian Metabolic Syndrome Study (BRAMS) Investigators. Sagittal abdominal diameter resembles waist circumference as a surrogate marker of insulin resistance in adolescents—Brazilian metabolic syndrome study. *Pediatr. Diabetes, 19(5)*:882-91, 2018.

Giese, M.; Teigland, C. & Giessing, J. Physical activity, body composition, and well-being of school children and youths with visual impairments in Germany. *Br. J. Vis. Impairment, 35(2)*:120-9, 2017.

Hebbelinck, M.; Duquet, W.; Borms, J. & Carter, J. L. Stability of somatotypes: a longitudinal study of Belgian children age 6 to 17 years. *Am. J. Hum. Biol., 7(5)*:575-88, 1995.

Inokuchi, M.; Matsuo, N.; Takayama, J. I. & Hasegawa, T. Population-based waist circumference reference values in japanese children (0–6 years): comparisons with Dutch, Swedish and Turkish preschool children. *J. Pediatr. Endocrinol. Metab. 34(3)*:349-56, 2021.

Kabakci, A. G. & Yucel, A. H. Somatotype analysis of students who will be trained for classical ballet. *Çukurova Univ. Med. J. 41(4)*:744-53, 2016.

Koleva, M.; Nacheva, A. & Boev, M. Somatotype, nutrition, and obesity. *Rev. Environ. Health, 15(4)*:389-98, 2000.

Krzyka?a, M.; Karpowicz, M.; Strzelczyk, R.; Pluta, B.; Podciechowska, K. & Karpowicz, K. Morphological asymmetry, sex and dominant somatotype among Polish youth. *PLoS One, 15(9)*:e0238706, 2020.

Lemos, T. & Gallagher, D. Current body composition measurement techniques. *Curr. Opin. Endocrinol. Diabetes Obes., 24(5)*:310-4, 2017.

Lizana, P. A.; González, S.; Lera, L. & Leyton, B. Association between body composition, somatotype and socioeconomic status in Chilean children and adolescents at different school levels. *J. Biosoc. Sci., 50(1)*:53-69, 2018.

Malacko, J.; V. Stankovic, D. Doder, & A. Pejcic. Gender differences in the morphological characteristics and motor skills of children aged 7 to 11. *Facta Univ. Ser. Phys. Educ. Sport, 13(1)*:115-25, 2015.

Marta, C. C.; Marinho, D. A.; Barbosa, T. M.; Carneiro, A. L.; Izquierdo, M. & Marques, M. C. Effects of body fat and dominant somatotype on explosive strength and aerobic capacity trainability in prepubescent children. *J. Strength Cond. Res., 27(12)*: 3233-44, 2013.

Miller, J. B.; Plant, E. A. & Hanke, E. *Girls' and boys' views of body types. in: communication and sex-role socialization.* Hoboken, Routledge, 2015. pp.49-58.

Møller, G.; Ritz, C.; Kjølbæk, L.; Vuholm, S.; Korndal, S. K.; Larsen, T. M.; Pedersen, O.; Saris, W.; Astrup, A.; Lauritzen, L.; *et al*. Sagittal abdominal diameter and waist circumference appear to be equally good as identifiers of cardiometabolic risk. *Nutr. Metab. Cardiovasc. Dis., 31(2)*:518-27, 2021.

Özer, K. *Anthropometry, Morphological Planning at Sport*. Istanbul, Gaining Printing, 1993.

Özkoçak, V.; S. H. Hınçal, T. Gültekin, & Y. Bektas¸. Anthropometric values and somatotypic features of 5-14 age groups children. J. *Acad. Soc. Sci. 67*:53-61, 2018.

Rahmawati, N. T. & Hastuti, J. Secular change in body size and somatotype of Indonesian children aged 7–15 years (1999–2019). *Open Access Maced. J. Med. Sci., 9(E)*:419-27, 2021.

Shakhanova, A. V.; T. V. Chelyshkova, A. A. Kuzmin, M. N. Silantyev, & S. S. Grechishkina. Effect of team sports on aerobic performance of human body in view of somatotype. *Indian J. Sci. Technol., 9(42)*, 2016. Available from: https://indjst.org/articles/effect-of-team-sports-on-aerobic-performance-of-human-body-in-view-of-somatotype

Sheldon, W. H. & Stevens, S. S. Th*e Varieties of Temperament: A Psychology of Constitutional Differences.* New York, The Journal of Nervous and Mental Disease, 1943.

Silventoinen, K.; Maia, J.; Jelenkovic, A.; Pereira, S.; Gouveia, É.; Antunes, A.; Thomis, M.; Lefevre, J.; Kaprio, J. & Freitas, D. Genetics of somatotype and physical fitness in children and adolescents. *Am. J. Hum. Biol. 33(3)*:e23470, 2021.

Vásquez, F. D.; Corvalán, C. L.; Uauy, R. E. & Kain, J. A. Anthropometric indicators as predictors of total body fat and cardiometabolic risk factors in chilean children at 4, 7 and 10 years of age. *Eur. J. Clin. Nutr., 71(4)*:536, 2017.

Wells, J. C. K. Body composition in childhood: effects of normal growth & disease. *Proc. Nutr. Soc., 62(2)*:521-8, 2003.

Wong, D. L.; Hockenberry, M. J.; Wilson, D.; Winkelstein, M. L.; Kline, N. E. & Hockenberry-Eaton, M. *Wong's Nursing Care of Infants and Children.* 7th ed. St. Louis, Mosby, 2003.

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