RESEARCH ARTICLE

Assessment of upper to lower body segment ratio and arm span to height difference in school children of Lahore

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Abstract

Objective: To assess upper-to-lower body segment ratio and arm span to height difference in children.

Method: The descriptive, cross-sectional study was conducted in schools of the Raiwind area near Lahore, Pakistan, from November 2021 to May 2022, after approval from the ethics review committee of the Sharif Medical and Dental College, Lahore. The sample comprised children aged 3-14 years whose height fell between the 3rd and 97th centiles on the Centers for Disease Control and Prevention height-for-age chart. Data was analysed using SPSS 23.

Results: Of the 1,836 children, 906(49.3%) were boys with mean age 8.45±3.02 years, mean height 132.54±17.78cm and mean weight 32.0±13.72kg. Besides, there were 930(50.7%) girls with mean age 8.26±3.21 years, mean height 130.41±18.03cm and mean weight 31.09±13.88kg. The mean upper-to-lower body segment ratio in boys was 1.06±0.15 at age 3 years, 0.96±0.08 at age 7 and 0.94±0.08 at age 10. The mean upper-to-lower body segment ratio in girls was 1.08±0.08 at age 3 years, 0.98±0.07 at age 7, and 0.92±0.10 at age 10. The mean arm span to height difference in boys was -1.81±5.83 and in girls -4.09±5.77.

Conclusion: Upper-to-lower body segment ratio and arm span to height difference may help paediatricians in the evaluation of disproportionate short stature.

Key Words: Upper to lower body segment ratio, Body proportions, Children, Arm span to height difference, Pakistan. (JPMA 73: 1043; 2023) **DOI: 10.47391/JPMA.7482**

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Introduction

Anthropometry, the measurement of size and proportion of the human body, is a fundamental component of growth assessment in paediatrics. Anthropometric measures generally used in clinical practice are height, weight, head circumference and mid-arm circumference.[1] Once the height (or length) has been accurately measured and plotted on the growth chart, the next step is measuring body proportions to see if the height deviates from the normal centiles.[2] Body proportions include upper segment-to-lower segment (US/LS) ratio and arm span-height difference.

Several factors, including age, gender, ethnicity, genetics and environment, influence the growth of the body.[3] There are intricate interactions between genetics and the environment that influence body proportions, and the environment has a stronger influence on the growth of extremities than genes.[4] In addition to these factors, malnutrition and recurring illnesses are major contributors to morbidity, and significantly impact growth of children living in developing countries.[5]

The progression of changes in body proportions during development is predictable. At birth, the head and trunk are longer than the limbs, but the extremities get progressively longer over time. The growth rate of the upper and lower body segments is the same until the age of 5, following which the growth rate of the LS exceeds that of the US, and then reverses during puberty[6,7]. Similarly, arm span is greater than height before puberty, but this relationship reverses during puberty.[8]

According to the standard textbook of paediatrics, US/LS ratio is 1.7 at birth, 1.3 at 3 years, and 1.0 after 7 years.[9] The clinical use of these ratios and deviations from the norm may indicate the presence of a number of diseases. In children with achondroplasia, the extremities fail to lengthen, but the trunk is normal in size; consequently, US is longer than LS, and their ratio is typically 2.0.[10] Similarly, arm span measurement is an important anthropometric measure in connective tissue disorders, like Marfan syndrome and Ehlers Danlos syndrome, as the arm span is greater than height.[11]

In Pakistan, data on body proportions is generally not explored. The current study was planned to fill the gap by assessing US/LS ratio and arm span to height difference in children.

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Subjects and Methods

The descriptive, cross-sectional study was conducted in schools of the Raiwind area near Lahore, Pakistan, from November 2021 to May 2022. After approval from the ethics review committee of the Sharif Medical and Dental College, Lahore, the sample size was calculated using WINPEPI software[12] at 5% significance level and 80 % power on the basis of data reported earlier in a study done in Turkiye.[13]

The sample was raised from among students of 3 randomly selected local schools using cluster sampling approach after taking permission from the respective principals. The birth dates of children were verified from their school records. Those included were children aged 3-14 years whose height fell between the 3rd and 97th centiles on the Centers for Disease Control and Prevention (CDC) height-for-age chart.[14] Children whose parents refused consent were excluded.

Weight was measured in kilograms (kg) using an electronic weighing machine with the child wearing light clothing and no shoes. Wall-mounted mechanical stadiometer was used to measure the height in centimetres (cm). As per the standard protocol, the children were required to stand barefoot against the wall with their heel, buttock and occiput touching the surface. To eliminate head tilt, they were instructed to look straight ahead, bringing the lower edge of the eye socket to the same level as the external acoustic meatus.

The children then stayed in the same position barefoot, but were asked to separate their feet by 5cm to facilitate LS measurement. The pubic symphysis was palpated, and the distance from the top of the pubic symphysis to the floor was measured using a non-stretchable measuring tape, and was recorded as LS. The LS was subtracted from the total height to determine the length of the US.

For the measurement of arm span, the children were made to stand upright against a wall with arms fully extended horizontally. The tips of their middle fingers were marked on the wall, and then the distance between them was measured using a measuring tape. To ensure accuracy, the same investigator repeated measurements more than once, and the final value was determined by taking the average of multiple measurements.

Data was analysed using SPSS 23. Mean and standard deviation (SD) were calculated for variables, such as age, weight, height, US/LS ratio, and arm span-height difference. Independent samples t-test was used to compare the means of variables between the genders. Pearson's coefficient (r) was used to determine the correlation between anthropometric variables after confirming data normality using P-P plots. Correlation graphs among anthropometric measurements were plotted.

Results

Of the 1,836 children, 906(49.3%) were boys with mean age 8.45±3.02 years, mean height 132.54±17.78cm and mean weight 32.0±13.72kg. Besides, there were 930(50.7%) girls with mean age 8.26±3.21 years, mean height 130.41±18.03cm and mean weight 31.09±13.88kg.

The mean US/LS ratio in boys was 1.06±0.15 at age 3 years, 0.96±0.08 at age 7 and 0.94±0.08 at age 10. The mean upper-to-lower body segment ratio in girls was 1.08±0.08 at age 3 years, 0.98±0.07 at age 7, and 0.92±0.10 at age 10 (Table 1). Curves showed negative correlation between age and US/LS ratio in males (r= -0.515) (Figure 1) and females (r= -0.550) (Figure 2).

The length of the US exceeded that of the LS at age 7 years, with the lengths of both segments crossing between ages 6 and 7 (Figures 3-4).

The mean arm span of males and females was 130.72±20.77 and 126.32±19.67, respectively, and the arm span to height difference was -1.81±5.83 and -

Table-1: Upper segment-to-lower segment (US/LS) body ratio among male and female subjects.

Age (in years)	Male			Female			t	p
	Frequency (n)	US:LS		Frequency (n)	US:LS			
		Mean	SD		Mean	SD		
3	26	1.06	0.15	42	1.08	0.08	-.458	0.65
4	88	1.08	0.11	86	1.04	0.13	2.10	0.03
5	46	1.06	0.09	115	1.06	0.11	.045	0.96
6	124	1.03	0.10	96	1.02	0.84	.217	0.82
7	104	0.96	0.08	74	0.98	0.07	-1.72	0.08
8	60	0.95	0.11	84	0.97	0.08	-1.17	0.24
9	110	0.94	0.08	95	0.96	0.10	-1.74	0.08
10	104	0.94	0.08	68	0.92	0.10	1.68	0.09
11	74	0.90	0.07	70	0.90	0.06	-.036	0.97
12	64	0.88	0.11	70	0.90	0.06	-1.33	0.18
13	56	0.88	0.14	94	0.90	0.08	-1.01	0.31
14	50	0.89	0.08	36	0.89	0.07	0.57	0.56

SD: Standard deviation.

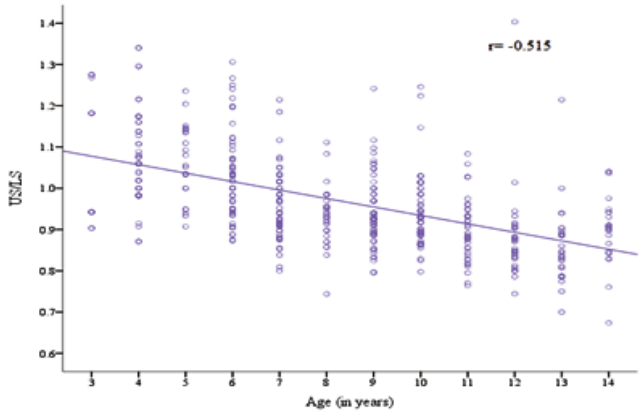

Figure-1: Correlation between age and Upper segment-to-lower segment (US/LS) body ratio in males.

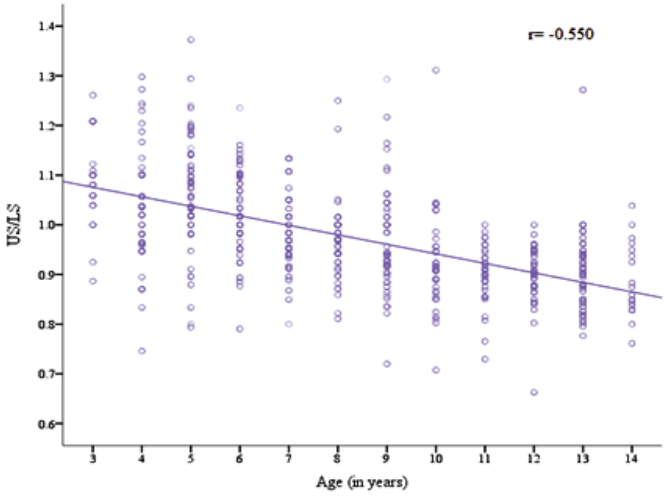

Figure-2: Correlation between age and Upper segment-to-lower segment (US/LS) ratio in females.

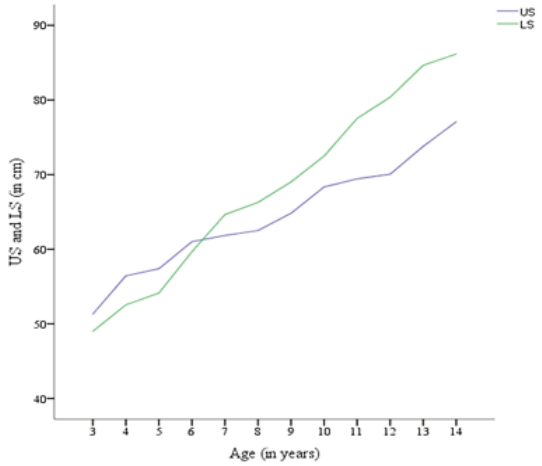

Figure-3: Comparison between the growth of upper segment (US) and lower segment (LS) with age in males.

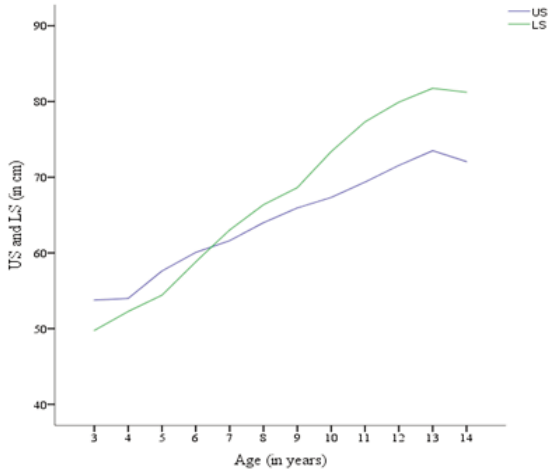

Figure-4: Comparison between the growth of upper segment (US) and lower segment (LS) with age in females.

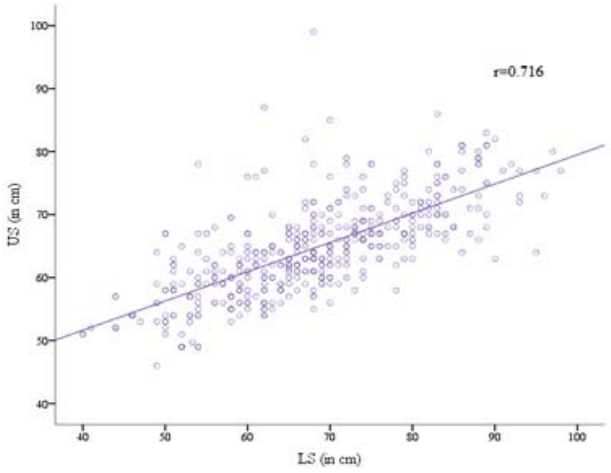

Figure-5: Correlation between upper segment (US) and lower segment (LS) in males.

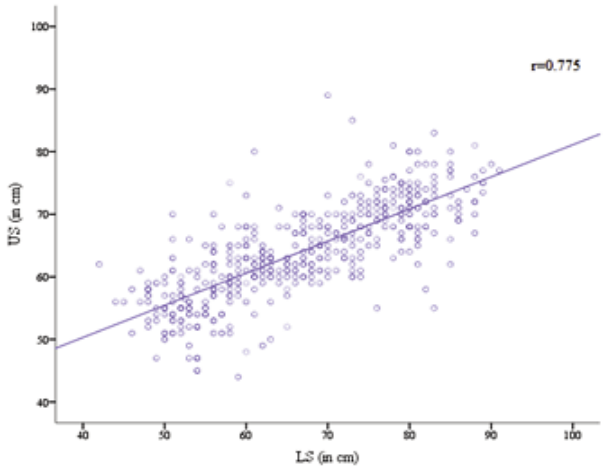

Figure-6: Correlation between upper segment (US) and lower segment (LS) in females..

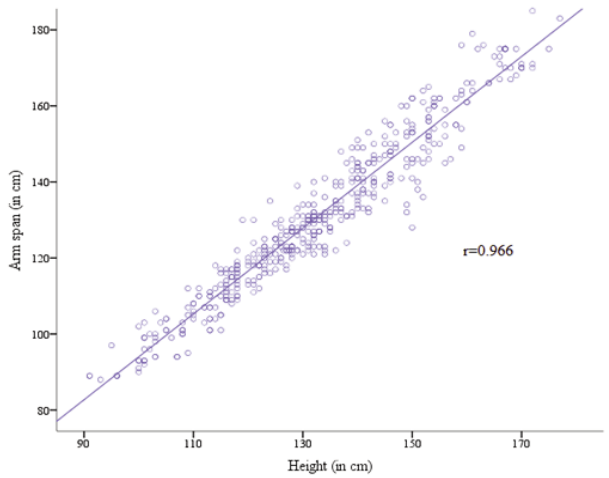

Figure-7: Correlation between height and arm span in males.

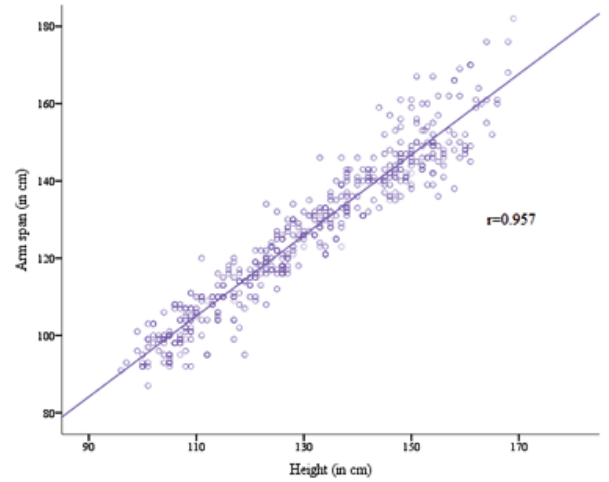

Figure-8: Correlation between height and arm span in females.

Table-2: Arm span to height difference among male and female participants

Age (in years)	Male Frequency (n)	Male Arm span – Height (cm) Mean	Male SD	Female Frequency (n)	Female Arm span – Height (cm) Mean	Female SD	t	p
3	26	-5.23	3.12	42	-7.14	3.04	2.48	0.01
4	88	-5.43	3.97	86	-5.13	5.48	-.402	0.68
5	46	-3.57	3.95	115	-5.89	4.88	2.88	0.005
6	124	-3.79	4.24	96	-4.41	4.74	1.03	0.31
7	104	-2.61	4.40	74	-3.48	4.03	1.34	0.18
8	60	-3.31	3.39	84	-5.57	4.35	3.18	0.002
9	110	-3.65	4.31	95	-3.88	4.51	0.37	0.71
10	104	-1.88	6.16	68	-1.23	6.03	-.681	0.49
11	74	2.24	6.80	70	-1.84	5.79	3.88	<0.001
12	64	2.71	6.58	70	-3.44	5.91	5.70	<0.001
13	56	2.50	5.94	94	-4.41	7.77	6.12	<0.001
14	50	3.80	5.66	36	0.00	9.42	2.15	0.03

SD: Standard deviation.

4.09±5.77 (Table 2).

Positive correlations were observed between height and US (r=0.890, r=0.915), height and LS (r=0.955, r=0.964), US and LS (r=0.716, r=0.775), and height and arm span (r=0.966, r=0.957) in males and females, respectively. Negative correlations were observed between arm span and US/LS ratio (r= -0.515, r= -0.575), and height and US/LS ratio (r= -0.499; r= -0.517) in males and females, respectively. Correlation curves between anthropometric parameters for both genders were plotted (Figures 5-8).

Discussion

In the current study, US/LS ratio decreased with age, which is consistent with the prior studies.[13,15,16] This decreasing ratio demonstrates that the lower extremities of children grow more than their trunks throughout this period of growth. This was also confirmed in a photogrammetric study conducted in London, revealing that the contribution of the LS to the final height increases as the child ages.[17]

US/LS ratios observed in both genders were comparable to the studies conducted in Turkiye and India. The results are also consistent with a commonly used reference value derived from North American children demonstrating US/LS ratios decreasing from 1.05 at 4 years to 0.92 at 12 years.[18] However, the current findings differ from those of the Dutch and Japanese paediatric populations. The Dutch study showed the ratio was 1.4 in males and 1.35 in females at age 3 and declined to 1.1 for both genders at age 14.[19] The disparity may be attributable to the different method used for measuring body proportions; measuring sitting height and subtracting it from overall height to determine the length of LS. According to the Japanese study, the US/LS ratio for males and females at age 6 was 1.30 and 1.25, respectively, and decreased to about 1.15 by age 14 for both genders.[16] The difference between the findings could be attributed to racial disparities. The results also differed from the values given in traditional textbooks, which could be due to racial differences and the omission of standard deviations.[9] The absence of standard deviation reduces the practicality of these measurements.

The comparative growth analysis of US and LS in the current study

showed that the growth curves for both segments intersected between ages 6 and 7 years for both genders. This is similar to the findings of an Indian study; the modest difference observed in males could be related to racial variations.[15] Similarly, the positive and negative associations observed between anthropometric parameters are consistent with prior research.[13]

The trend of increasing arm span to height difference with age was observed in the current study, which is in agreement with the previous studies.[13,20,21] This increasing difference shows that the arm span of children grows more rapidly than their height. However, the range of mean values was greater and differed from those of other populations, which could have been caused by multiple factors, including race.[13,21] The ethnic differences in arm span and height have also been observed in a study that included nine centres in different countries.[22]

The current study has limitations, like data being limited to a specific geographical area. The sampling technique employed did not distribute the subjects evenly by age. And, the children were not classified based on their socioeconomic background, residence or sexual maturity. To overcome such limitations, it is essential to conduct multi-stage, large-scale studies.

Conclusion

Body proportions are important parameters in the evaluation of short-statured children. Paediatricians should keep an eye on the trend.

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Conflict of Interest: None.

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