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ORIGINAL ARTICLE

Using ulna lenght measure compared to forearm measure, for height estimate of previously healthy children at a pediatric hospital

Livia Souza de Oliveira Johansson[1], Izabela Mara Fogiato[2], Pedro Henrique Viscotti[2], Gabriela Oliveira[2], Jocemara Gurmini[3]

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Abstract

In aim to facilitate the use of replacement measures of body segments for monitoring the child's growth, the calculation of medication doses and the organic function rates, this study selected previously healthy children from 5 to incomplete 18 years of age, at a pediatric hospital, and measured their height, ulna's length and the forearm length. An amount of 120 patients were selected, 61 female and 59 male. From these, 77 declared their color as white, 40 as brown and 3 as black. The respective averages were 9.5 years of age, 135 cm in height, 36.2cm in forearm length and 20.9 cm in ulna's length, with a statistically significant difference between the two genders (p<0.05). The ulna's and the forearm length were reproducible, with low coefficient of variation. There were no statistical significance when evaluated if the replacement measure could underestimate or overestimate the height. At the Wilcoxon test, there were more errors on predicting the height through ulna's length on females, and more errors through forearm length on males (p<0.05). At a T Student statistical evaluation, for the whole sample of the study as for the stratified evaluation of each gender and ethnicities, there were no significant statistically difference between the estimated height through the forearm length and the measured height (p=0.28). Tough, the estimated height through the ulna's length compared with the measured height had a statistical significance difference (p<0.05). That said, we have concluded the estimated height through the forearm length as the better replacement measure for height.

[1] Pequeno Principe Children's Hospital, Medical Residency in Pediatrics - Curitiba - Paraná - Brazil.
[2] Pontifical University Catolica do Parana , Academic in Medicine - Curitiba - Parana - Brazil.
[3] Pequeno Principe Children's Hospital , Head of the Nutrology Service - Curitiba - Parana - Brazil.

Correspondence to:
Lívia Souza de Oliveira Johansson.
Pequeno Príncipe Children's Hospital. Rua Desembargador Motta, 1070 - Água Verde, Curitiba - PR, Brazil. CEP: 80250-060. E-mail: livias.oliveir@gmail.com

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INTRODUCTION

The estimation of height by other body segments is of paramount importance in patients with neuromuscular impairment, with contractures in wrists, elbows, hips, knees and ankles, with spinal deformities or who are critically ill in an ICU bed[1,2]. It is also important in monitoring development, calculation of medications and rates of organic functions.

Studies have already been carried out to estimate length and height from body segments. Gauld et al and Forman et al, showed the effectiveness of replacement measures in previously healthy children, with ulna length[3] and wingspan[4] being the ones that were best related to height. Miller et al, in addition to previously healthy children, evaluated those with contractures and muscular dystrophies[1]. Children with significant contractures had a better correlation with ulna length; previously healthy ones, with the forearm[1]. Spender et al studied the applicability of several replacement measures in children with cerebral palsy and observed that, with the use of the anthropometer in black children, the arm measurement (acromial to radial point) would be preferable. In the case of white children and in the absence of an anthropometer, leg measurement (tibial point to malleolar point) would be a good option[5]. Another study, in previously healthy adults, showed a better correlation between ulna length and height[6].

There is no standardized or widely studied formula in Brazil. We carried out a study in previously healthy children without deformities, aged between 5 and 18 years, with the aim of evaluating the applicability and similarity of some of the replacement measures (of the forearm and ulna) with height.

METHODS

Participants. Children and adolescents between 5 and 18 years of age, with no sign of seriousness, treated in the emergency department of a pediatric hospital, were included in the research, through prior screening by the nursing team.

Prematurity (gestational age less than 37 completed weeks), growth disorders, patients with neurological, cardiac or renal comorbidities, those with neuromuscular, osteoarticular impairment, alteration of tone, significant contractures, spinal deviation, comorbidities or chronic use of medication that could impair growth, were not selected for the study.

Anthropometric measurements. Standardization, training in anthropometric measurement techniques and quality control are important prerequisites for consistent and high-quality data collection[7].

Height was evaluated with a portable stadiometer , whose measurement was extended to 210 cm, graduated at 0.1 cm, with the head positioned in the Frankfurt plane and the heels in contact with each other and against the wall (Figures 1 and 2A). The length of the ulna and forearm was evaluated with a bone caliper, whose measurement extended to 60 cm, graduated at 0.1 cm (Figures 2B and 2C).

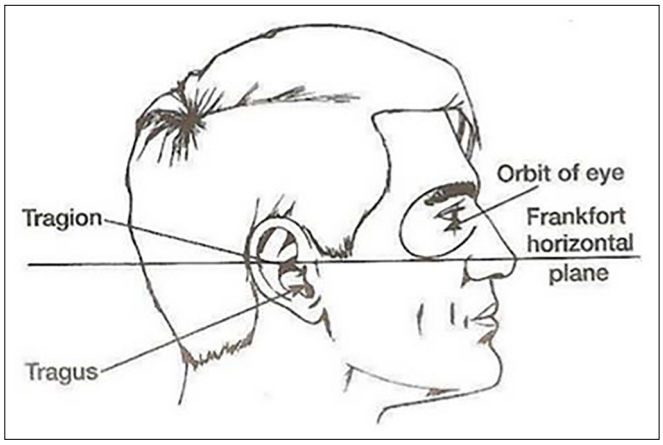


Figure 1. Frankfurt Plan.

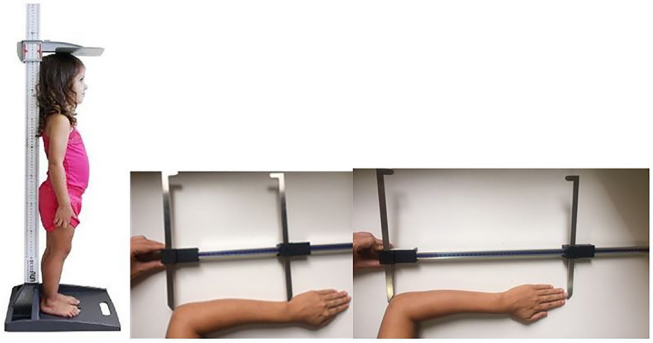


Figure 2. A) Portable stadiometer. B) Bone caliper measuring the length of the ulna. C) Bone caliper measuring forearm length.

The participants after selection kept themselves with light clothes, without socks and shoes and without hair accessories. The ulna and forearm measurements were performed with the child sitting and with the left upper limb placed on the table in a comfortable position. The palm of the hand was positioned downwards, with fingers extended and touching each other.

For the length of the ulna, the elbow was flexed between 90º and 110º. The proximal end (olecranon) and the styloid process of the ulna were palpated. For forearm length, the measurement extended from the tip of the third finger to the proximal end of the ulna (olecranon). Two previously trained researchers performed the measurements. Measurements were approximated to the nearest 0.1 cm. In case of disagreement in the measurements, a third measurement was performed.

The measurements of the length of the ulna were placed in the formula described by Gauld et al for estimating height[3]:

Male children: H = 4,605U + 1,308A + 28,003
Female children: H = 4,459U + 1,315A + 31,485
(H, height; H, age; U, length of the ulna)

Forearm length measurements were calculated using a formula published by Snyder et al in 1975, and also applied by Miller & Koreska, for comparison with height[3,8]:

$$Y = (0.28596.X) - 2.74377, \text{ then } X = (Y + 2.74377) / 0.28596$$

(Y, forearm length; X, height).

The height values estimated by the length of the ulna and by the length of the forearm were compared to the values of measured heights, sex and ethnicity and applied to statistical evaluations.

Statistical analysis. The data were organized in Microsoft Excel spreadsheets, the analysis was performed in the SPSS program version 22.0. Qualitative variables were described in frequencies and percentages, quantitative variables in mean, median, minimum and maximum values and standard deviation and used for statistical calculations. The coefficient of variation was calculated to assess the homogeneity of the measured data, in addition to Pearson's correlation coefficient for some variables. The Wilcoxon test was applied to classify the measurement error between the replacement measurements and the patient's height.

Student 's t-tests for paired samples, thus assessing whether the mean height differences estimated by both the forearm measurement and the ulna measurement were similar to the height of the same patient. A significant T test (p<0.05; observed T > critical T) is considered to be one whose difference from the mean of the paired samples is different from zero (in the case of the study, the estimated heights are different from the actual height). A non-significant test (p>0.05) shows that there is no difference in the mean of the paired samples (in the study, the estimated heights are similar between them). Thus, for the study, the non-significant samples to the test (p>0.05), are those that show us similarity of the replacement measure with height.

Ethics committee approval. This study was submitted and approved by the Ethics and Research Committee in human beings of the Pequeno Príncipe Children's Hospital, Curitiba / PR, under number 2,590,575.

RESULTS

A total of 120 previously healthy patients aged between 5 and 18 years had their height, forearm and ulna lengths measured. Of these, 50.8% were female (n=61), 49.2% were male (n=59), 62.2% were white, 33.3% brown and 2.5% black.

The mean age was 9.5 years, height 135 cm, forearm length 35.7 cm and ulna length 20.9 cm. All the cited means had statistical significance between the different sexes (p<0.05). (table 1)

Height estimated by the forearm (EEA). Height estimated by the ulna (EEU).

Forearm length measurements were reproducible in females and males, with a coefficient of variation of 0.14 and 0.15, respectively. The length of the ulna was also reproducible, with a coefficient of variation of 0.15 for males and 0.14 for females.

In the present study, the forearm measurement tended to underestimate height by 0.2 cm in girls (p=0.97) and by 0.74 cm in boys (p=0.97). The ulna measurement tended to overestimate height by 2.47 cm in girls (p=0.95) and by 1.61 cm in boys (p=0.98). None of these data obtained statistical significance. The mean forearm length in females was 36.1 cm (CI = 34.8 – 37.4) and in males it was 35.3 cm (CI = 33.9 – 36.7). The mean length of the ulna in females was 21 cm (CI = 20.2 – 21.9) and in males it was 20.7 cm (CI = 19.9 – 21.5). All the average lengths of the body segments fit into their respective confidence intervals (Figures 3 and 4).

As for the measurement error classifications between the replacement measurements and the patient's height, the Wilcoxon test showed that in the entire sample (n=120) the error of height for the length of the ulna was greater than that for the length of the forearm in 54% of patients, data without statistical significance (p=0.2). In females, the error of height by ulna length was approximately 82%, with statistical significance (p<0.05). In males, the error of height by forearm length was higher (74.5%), also with statistical significance (p<0.05).

In the entire sample (n=120), when the Student's T test was applied to evaluate the average of the differences, in the comparison of the height estimated by the length of the forearm with the height, the test presented (for 119 degrees of freedom) a T lower than the critical T, which shows the absence of statistical significance between the forearm replacement measure (p=0.28). As for the length of the ulna for estimating height, the test showed statistical significance between the mean of the differences (p<0.05). The same pattern of significance was repeated when the sample was stratified both by sex and for most ethnicities. Black ethnicity

Table 1. Means for height, segment length and estimated height by sex (p<0.05). Height estimated by the forearm (EEA). Height estimated by the ulna (EEU).

61	59	120
9.9	9.1	9.5
136.1	133.9	135
36.1	35.3	35.7
21	20.7	20.9
135.9	133.1	134.5
138.6	135.5	137.1

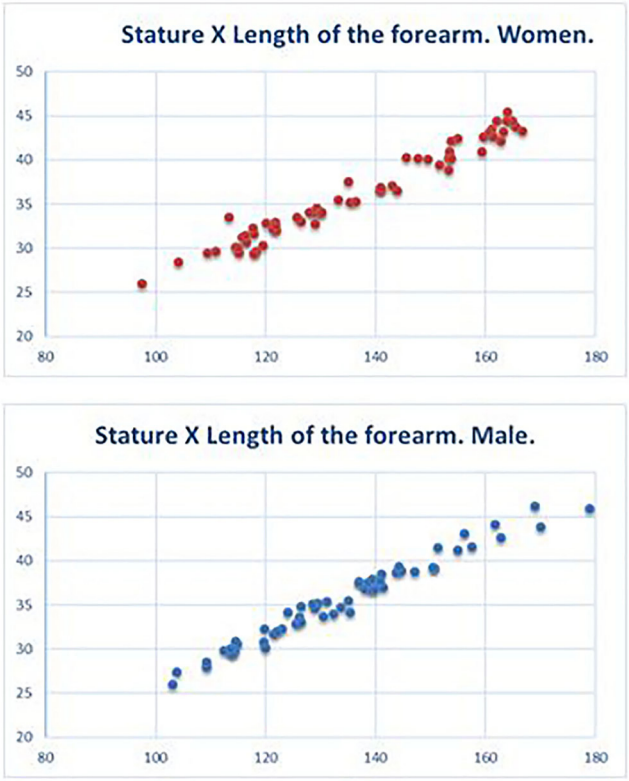


Figure 3. Scatter plots: relationship between forearm length and height, by sex (CI = 95%).

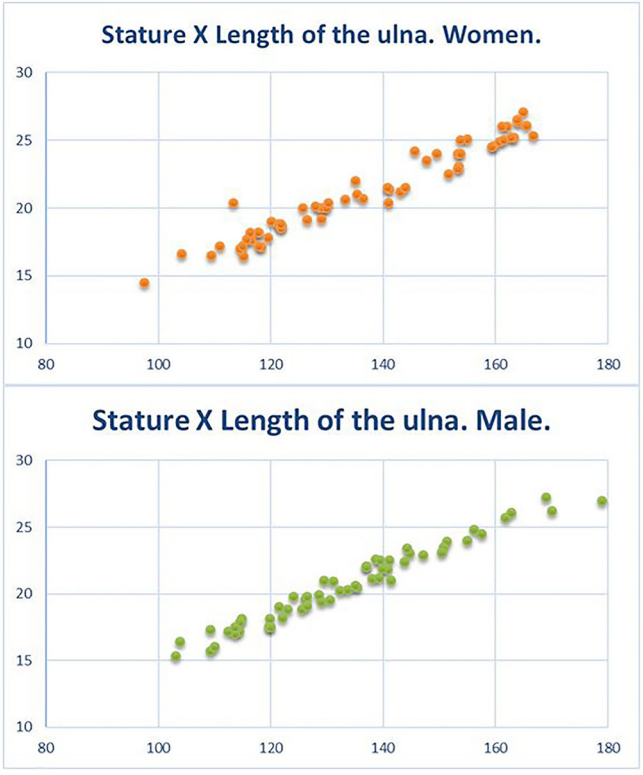


Figure 4. Scatter plots: relationship between ulna length and height, by sex (CI = 95%).

was not statistically significant for any of the substitution measures (p>0.05), however the sample of this population was small (n=3) (Table 2).

Measures with statistically significant difference if p<0.05.

DISCUSSION

The present study used a bone caliper to measure the ulna and forearm, and other ways of measuring the segments were not attempted. One study compared measurements performed on the upper limbs using an anthropometer, with measurements made using a metal or plastic ruler. The values obtained were, on average, 1 cm higher than the anthropometric measurements (p=0.002). Due to the significant difference, it was recommended that such rulers not be used to measure the length of the ulna[5].

In this study, forearm length tended to underestimate height and ulna length to overestimate it, with a small difference between them and no statistically significant difference in both sexes (p>0.95). For Forman et al, the length of the ulna also tended to overestimate height[4]. A systematic review of studies examining the accuracy of lengths has identified a general tendency in the population to overestimate height when referred, probably reflecting social appreciation of height[9]. In another study, measurements of body segments were compared with measurements on radiographs and showed that such measurements slightly overestimate the bone measurement[10]. Therefore, the replacement measures may be even more discrepant if compared to the height referred to.

The error observed in the error classifications was greater for the length of the ulna in females (p<0.05) and greater for the length of the forearm in males (p<0.05), data compatible with what is observed in the scatter plots. of such measures, by sex (Figures 3 and 4).

For our population, forearm length was the most similar replacement measure to height, where the test showed little statistical significance between the mean of their differences (p=0.28). For Miller & Koreska, in their study with a previously healthy sample of children between 8 and 14 years of age, forearm length showed the highest percentage of measurements with little difference (77% with a difference of less than 5 cm), being the best replacement measure for this population (p=0.96)[1].

In this study, the length of the ulna as a replacement measure obtained statistical significance when compared to height (p<0.05), that is, there was less similarity with height. As for Gauld et al[3], who measured height, weight and used the wingspan, forearm, tibia and legs as replacement measures in a population aged 5 years and 4 months to 19 years and 7 months, the accuracy of the ulna was compared to that of the ulna. the span, as well as the length of the ulna, was accurate in previously healthy children. Madden et al concluded that the ulna measurement was the most accurate, but in a population of previously healthy adults[6]. Miller et al evaluated replacement measures in patients with contracture (wrists, fingers), and the

Table 2. Student 's t test for paired samples and its level of significance. Measures with statistically significant difference if p<0.05.

Student Test : Standing Height X Height by Forearm Length			
Population	**No**	**Detour pattern**	**Significance**
General	120	4.76	=0.28
Feminine	61	3.81	=0.68
Male	59	5.59	=0.31
White	77	5.51	=0.44
brown	40	3.04	=0.41
black	3	3.42	=0.74
Student t test : Standing Height X Height by Ulna Length			
Population	**No**	**Detour pattern**	**Significance**
General	120	3.66	<0.05
Feminine	61	4.28	<0.05
Male	59	2.86	<0.05
White	77	3.98	<0.05
brown	40	3.09	<0.05
black	3	2.10	=0.16

ulna measurement obtained the best result, remaining the best correlation coefficient for the sample (p=0.91). Still in the same study, patients with idiopathic scoliosis and those with Duchenne muscular dystrophy, the measure of the wingspan had the worst correlation coefficient for this population (p=0.47)[1]. The present study did not address children with contractures or neuromuscular impairment as reported in the studies.

It is known that anthropometric measurements, including height, can be affected by a variable of factors, including ethnic differences[11]. Reeves et al showed a better relationship of equality of height and height among white adults than between Asians and black Africans[12]. Equations describing the relationship between ulnar length and height have been published, however details on how they were derived are not reported, leaving the ethnicity of the population used unknown[6]. For Spender et al, there is a difference in the use of certain measures according to ethnicity. They mention that the measurement of the arm is preferable in relation to the measurement of the leg in people of black ethnicity, for overestimating the height in this population[5]. For the length of the ulna among the ethnicities reported, only black women were related to height (p>0.05), while white and brown women were significantly different from height (p<0.05). As for forearm length, all ethnicities were correlated with height (p>0.05). However, for the estimation of height by the length of the forearm and ulna, this sample of black ethnicity was only 2.5%, which widened the confidence interval and raised its standard error of the mean to 12.49 and 11, 71 respectively.

CONCLUSION

Height measurement is important for monitoring development, calculation of medications, rates of organic functions, among other attributions. Previously healthy children, but seriously ill, unable to measure height, or those with a condition that compromises this measurement in serious health or not, need to estimate height based on body segments. When performing the measurements, specific devices such as bone calipers or stadiometers have better accuracy, and the use of rulers is not recommended.

Few studies correlate ethnicity with a better replacement measure. The present study, in addition to addressing a mixed population, had a small black population sample, which made such a correlation unfeasible.

In this study, the length of the forearm and ulna segments, both applicable to the population, were addressed as replacement measures. The length of the ulna tended to overestimate height and that of the forearm showed a better correlation with the measured height, data consistent with the literature[1,4]. The ulna, on the other hand, presented a lower correlation with height, which differs from some studies[3,6]. For the population studied, the forearm presented a better correlation and fewer errors when compared to height, which is the replacement measure with better applicability to previously healthy children. in the present study. As there is divergence in the literature on which replacement measure (forearm or ulna) would be most appropriate for a given population, a new study in the same location, but addressing patients in primary and non-tertiary care settings, would facilitate the increase in the sample of children previously healthy.

We did not approach children with contractures, neuromuscular or osteoarticular involvement, born preterm, with comorbidities or on current or previous use of medications that could affect growth. Some of the studies that addressed these populations obtained better results with the length of the ulna in relation to that of the forearm, upper arm or span, probably because it reduces the presence of contractures[1,3,4]. Evaluating this population in a future study is also extremely important for continuity of work, especially if multicenter, which would expand the sample to be studied.

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