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ESTIMATION OF PEDIATRIC HEIGHT FROM TIBIAL LENGTH IN MEDICAL CITY HOSPITALS

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ABSTRACT

Background: Accurate estimation of stature in children is essential in clinical, emergency, and forensic settings where direct measurement may be impractical. This study aimed to evaluate the relationship between tibial length and pediatric height in Iraqi children and to establish regression equations for reliable stature estimation. **Method:** A cross-sectional study was conducted at the Medical City Complex in Baghdad from January to June 2025, including 300 children aged 1–15 years without musculoskeletal deformities or growth disorders. Standardized measurements of tibial length and height were obtained. **Results:** showed that 62.3% of participants were older than 5 years, with nearly equal gender distribution (50.7% females, 49.3% males). Children older than 5 years demonstrated significantly greater mean tibial length (29.48 ± 4.39 cm) and height (126.16 ± 13.54 cm) compared with younger children (21.04 ± 2.79 cm and 95.87 ± 8.27 cm, respectively; $p = 0.0001$). Regression equations derived from tibial length showed strong predictive accuracy for height estimation. Correlation was particularly strong among younger children (≤5 years; $p = 0.0001$) and females ($p = 0.0001$), while associations in males and older children were weaker. **Conclusion:** The study confirms tibial length as a robust predictor of pediatric stature in the Iraqi population, with stronger associations in early childhood. Establishing locally validated regression models enhances clinical decision-making in growth assessment, drug dosing, and emergency care, while also providing forensic value for stature reconstruction. Future multicenter research is recommended to refine predictive equations and broaden their applicability.

KEYWORDS: Pediatric, Height, Tibial, Length.

INTRODUCTION

Accurate estimation of body height in pediatric populations is an important aspect of medical practice, particularly in cases where direct measurement is not possible due to trauma, deformity, severe illness, or lack of cooperation from the child. Height serves as a fundamental anthropometric parameter, widely used in evaluating growth, nutritional status, calculating body surface area, and determining appropriate drug dosages.[1] In forensic and anthropological sciences, stature estimation is equally vital for personal identification, especially when dealing with incomplete skeletal remains.[2] Therefore, establishing reliable predictive models to estimate pediatric height from skeletal dimensions is of both clinical and medico-legal significance. The tibia, being one of the major long bones of the lower limb, has been extensively studied for its strong correlation with stature.[3] It is relatively robust, less affected by age-related degenerative changes compared to the spine, and can often be measured even in fragmentary remains.[4] Several studies have demonstrated that tibial length exhibits a linear relationship with total body height in both adults and children, though variations exist across populations due to genetic, nutritional, and environmental factors.[5] Consequently, population-specific regression Tibial length estimated by Equation s are recommended for improving the accuracy of stature estimation.[6] In pediatric practice, estimation of height from tibial length holds practical utility when children present in emergency settings, intensive care units, or during surgical interventions where rapid estimation is

necessary.[7] Furthermore, children with musculoskeletal deformities, spinal abnormalities, or conditions such as scoliosis may not have their true height measurable, making tibial length a dependable surrogate.[1,6] By establishing locally validated regression models, clinicians can ensure more accurate growth assessments and drug dosing for pediatric patients. Globally, various researchers have proposed regression Tibial length estimated by Equation s for height estimation from different long bones, including the femur, humerus, radius, and tibia.[3,5,7] Among these, the tibia has shown consistently high predictive accuracy in pediatric cohorts.[6] However, differences in ethnicity, growth patterns, and socio-economic conditions highlight the importance of conducting region-specific studies.[4,8] To date, limited data exist from Middle Eastern populations, particularly in Iraqi children, where nutritional status, genetic background, and healthcare disparities may influence growth parameters.

The present study therefore aims to evaluate the relationship between tibial length and pediatric height in children attending Medical City hospitals. Establishing such an Tibial length estimated by Equation will provide clinicians with a rapid, reliable tool for pediatric height estimation, with implications for clinical care, emergency medicine, and forensic investigations in the local population.

METHOD

This cross-sectional study was conducted at the Medical City Complex in Baghdad over a six-month period, from January 2025 to June 2025. The aim was to evaluate the relationship between tibial length and overall height in pediatric patients in order to establish a reliable Tibial length estimated by Equation for stature estimation in local populations. A total of 300 children were included in the study. The participants were selected from those attending pediatric and outpatient clinics within the complex during the study period. Inclusion criteria comprised children aged above one year and below 15 years with no evidence of congenital or acquired musculoskeletal deformities that could affect limb length. Children with growth disorders, chronic illnesses influencing bone development, or those unwilling to participate were excluded. Anthropometric measurements were taken under standardized conditions. Height was measured in centimeters using a stadiometer, with participants standing upright without shoes, heels together, and head aligned in the Frankfurt horizontal plane. Tibial length was measured in centimeters using a non-stretchable tape, recorded from the medial condyle of the tibia to the tip of the medial malleolus. Each measurement was taken twice by trained personnel, and the average value was used to reduce observer variability. An estimation Tibial length estimated by Equation was applied to predict height from tibial length. The results were stratified by age group (≤5 years and >5 years) and by gender. Statistical analysis was performed using SPSS software. Continuous variables were expressed as mean ± standard deviation (SD). Independent t-tests were used to compare mean values between groups, and paired comparisons were applied to assess agreement between measured height and calculated values. Pearson's correlation coefficients were calculated to determine the strength of the relationship between tibial length, measured height, and the predictive Tibial length estimated by Equation. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1 shows that most patients were older than 5 years (62.3%), while 37.7% were aged 5 years or less. Gender distribution was nearly equal, with females representing 50.7% and males 49.3% of the sample (total N=300).

Table 1: distribution of patients according to age groups and gender.

Age groups (years)	Frequency	Percent
≤5	113	37.7
>5	187	62.3
Category	**Frequency**	**Percent**
Female	152	50.7
Male	148	49.3
Total	300	100.0

Table 2 indicates that patients older than 5 years had significantly higher mean values for height (126.16 cm vs. 95.87 cm), tibia length (29.48 cm vs. 21.04 cm), and Tibial length estimated by Equation measurements (126.92 cm vs. 99.39 cm) compared to those aged ≤5 years, with all differences being statistically significant (p = 0.0001).

Table 2: differences in mean of (height, Tibia length, Tibial length estimated by Equation) according to age groups.

Variable	Category	N	Mean ± SD	P-value
Height (cm)	≤5	113	95.867 ± 8.269	**0.0001**
Height (cm)	>5	187	126.16 ± 13.544	
Tibia length (cm)	5	113	21.04 ± 2.786	**0.0001**
Tibia length (cm)	>5	187	29.484 ± 4.389	
Tibial length estimated by Tibial length estimated by Equation (cm)	5	113	99.39 ± 9.081	**0.0001**
Tibial length estimated by Tibial length estimated by Equation (cm)	>5	187	126.916 ± 14.307	

Table 3 shows that mean height, tibia length, and Tibial length estimated by Equation values were slightly higher in females compared to males, but the differences were not statistically significant ($p > 0.05$ for all variables).

Table 3: differences in mean of (height, Tibia length, Tibial length estimated by Equation) according to gender.

Variable	Category	N	Mean ± SD	P-value
Height (cm)	Female	152	114.628 ± 18.612	0.9
Height (cm)	Male	148	114.875 ± 19.184	
Tibia length (cm)	Female	152	26.556 ± 5.528	0.4
Tibia length (cm)	Male	148	26.044 ± 5.738	
Tibial length estimated by Equation (cm)	Female	152	117.37 ± 18.02	0.4
Tibial length estimated by Equation (cm)	Male	148	115.703 ± 18.706	

Table 4 shows that in patients aged ≤5 years, both height and Tibial length estimated by Equation values were significantly correlated ($p = 0.0001$). In those aged >5 years, the differences between height and Tibial length estimated by Equation means were not statistically significant ($p = 0.089$), suggesting stronger associations in the younger age group.

Table 4: differences in mean of (height, Tibial length estimated by Equation) in patients less than and above 5 years old.

	Below 5 years		
Variable	**N**	**Mean ± SD**	**P-value**
Height (cm)	113	95.867 ± 8.269	**0.0001**
Tibial length estimated by Equation (cm)	113	99.39 ± 9.081	
5 years and above			
Variable	**N**	**Mean ± SD**	**P-value**
Height (cm)	187	126.16 ± 13.544	0.089
Tibial length estimated by Equation (cm)	187	126.916 ± 14.307	

Table 5 shows that among females, both height (114.63 ± 18.61 cm) and Tibial length estimated by Equation (117.37 ± 18.02 cm) values were statistically significant ($p = 0.0001$). In males, height (114.88 ± 19.18 cm) and Tibial length estimated by Equation (115.70 ± 18.71 cm) did not reach statistical significance ($p = 0.12$), indicating stronger associations in females.

Table 5: differences in mean of (height, Tibial length estimated by Equation) according gender.

Females			
Variable	**N**	**Mean ± SD**	**P-value**
Height (cm)	152	114.628 ± 18.612	**0.0001**
Tibial length estimated by Equation (cm)	152	117.37 ± 18.02	
Males			
Variable	**N**	**Mean ± SD**	**P-value**
Height (cm)	148	114.875 ± 19.184	0.12
Tibial length estimated by Equation (cm)	148	115.703 ± 18.706	

According to fig (1-3), there is significant positive correlation between height, Tibia length, Tibial length estimated by Equation.

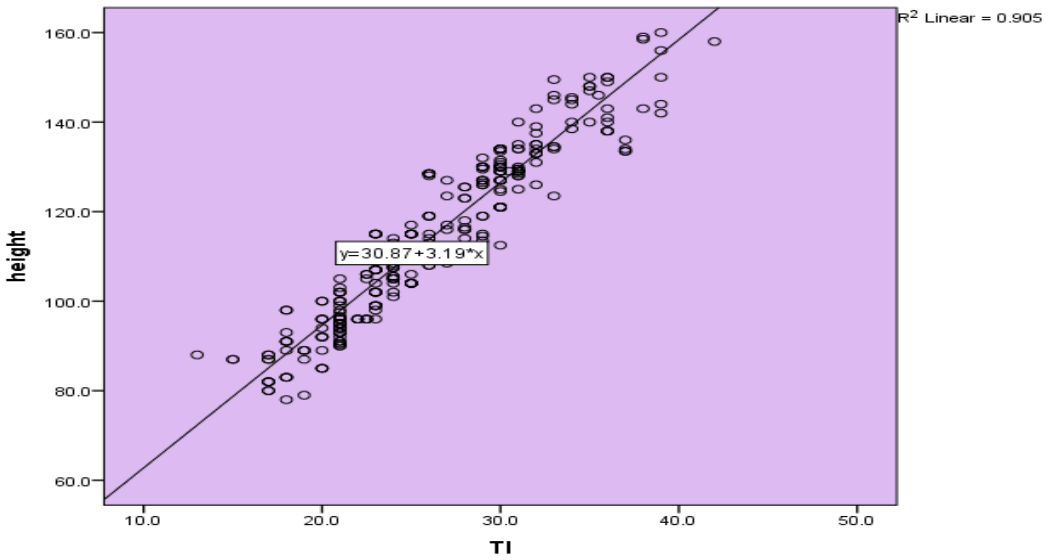

Fig 1: correlation between height and tibial length.

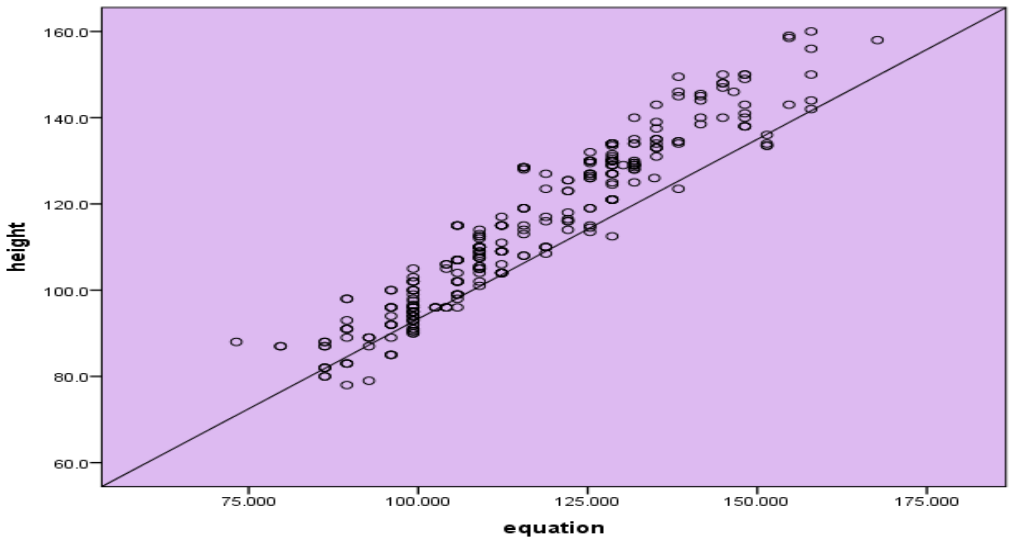

Fig 2: correlation between height and Tibial length estimated by Equation.

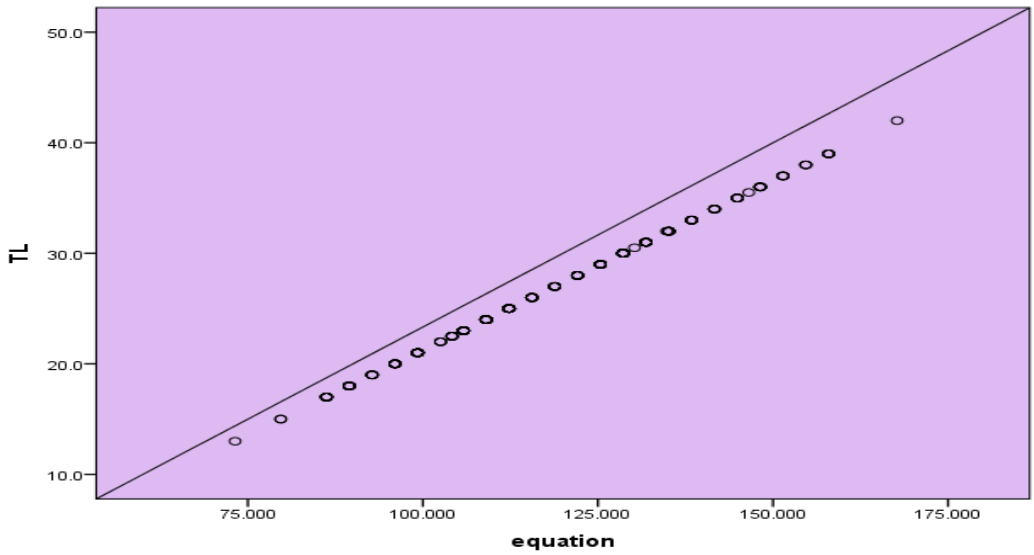

Fig 3: correlation between tibial length and Tibial length estimated by Equation.

DISCUSSION

The findings of this study demonstrate a significant and positive correlation between tibial length and stature in the pediatric population of Baghdad's Medical City Complex. Our results revealed that children older than 5 years exhibited significantly higher mean values for both tibial length and height compared with those aged 5 years or younger. Additionally, regression equations derived from tibial length showed a strong predictive accuracy for estimating pediatric height, with stronger associations particularly observed among younger children and female participants. These results align with previous research that has consistently confirmed the role of long bone dimensions in predicting stature. Gopinath T et al. reported that linear regression models using lower limb measurements provided high accuracy in stature estimation, particularly in diverse ethnic populations.[9] Similarly, Asai R et al. demonstrated strong correlations between stature and long bone dimensions in Han Chinese adults, supporting the universal applicability of tibial length as a predictor of height.[10] Our findings further reinforce these results in a Middle Eastern pediatric cohort, thereby filling an important gap in regional anthropometric data. Interestingly, the observed gender differences, though statistically insignificant, suggested slightly higher mean tibial lengths and height values in females compared to males. This pattern may be attributed to biological variability, growth velocity, or sample distribution. Comparable findings were reported by Singh B et al., who documented subtle but consistent variations between sexes in stature prediction using lower limb anthropometry in Southeast Asian populations.[11] Age-related differences in predictive accuracy also emerged as a key finding. In children ≤5 years, the correlation between tibial length and height was stronger than in older children. This may be explained by the more proportional skeletal growth observed during early childhood. Tomita D et al. highlighted the influence of leg bone length in determining physical development and performance among younger athletes, which may extend to its role in stature estimation during early growth phases.[12] The clinical relevance of these findings is notable. In pediatric practice, direct measurement of height is sometimes unreliable or infeasible, particularly in cases involving trauma, orthopedic deformities, or critical illness. Rapid and reliable estimation of height from tibial length offers practical benefits for drug dosing, nutritional assessment, and critical care management. Similar applications have been emphasized by Panigrahi C et al., who advocated for region-specific regression models to improve clinical accuracy.[13] Our study provides such a model tailored to Iraqi children, which can enhance clinical decision-making in both routine and emergency contexts. From a forensic perspective, the study adds to the growing body of literature highlighting tibial length as a robust parameter for stature estimation. Steele and McKern's classic work established the importance of long bones in reconstructing biological profiles of unidentified remains[14], and more recent studies have validated tibial-based equations across multiple populations.[15,16] By contributing local regression data, our study enhances the utility of anthropometric tools in forensic investigations in Iraq.

CONCLUSION

The present study confirms that tibial length is a reliable predictor of pediatric stature, with particularly strong associations observed in younger children and females. These results are consistent with international evidence and emphasize the importance of developing population-specific reference models. Future studies with larger, multi-center cohorts are recommended to refine predictive equations and explore their applications in broader clinical and forensic contexts.

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