# Estimation Body Height according to Tibia Length in Children with Cerebral Palsy Aged 6-12 Years in Bandung, Indonesia

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**Abstract** **Background and Objective**. Children with Cerebral Palsy (CP) have a risk of contracture or hypotonia causing difficulty in measuring their standardized height hence it requires height estimation based on the tibial length as an alternative measurement. Estimation body height formula is not available yet in Indonesia. We aim to determine the estimation body height according to tibia length in children with cerebral palsy aged 6-12 years in Bandung, Indonesia. **Methods**. The subjects are children 6-12 years old with CP who attended Special School, Growth and Development Clinic, Neuropediatric, and Medical Rehabilitation Outpatient Department at Hasan Sadikin General Hospital in Bandung, Indonesia between March until May 2019. This research performed a cross-sectional study. The height, body length, and tibia length of subjects who met the inclusion criteria were measured concomitantly. Data analysis was performed using linear regression. **Results**. We found 68 CP patients who met the inclusion criterion. Patients could be measured using the standard method are 36 children which then analyzed statistically. There were 36 subjects consisting of 22 boys (61,1%) and 14 girls (38,9%). The new calculation formula for body height estimation based on the tibia length in CP children aged 6-12 years is = 32,01 + 2,90 * tibia length (Standard error of the estimate ±1,85). **Conclusion**. Measurement of tibia length is important in determining the height estimation in children with CP so growth could still be monitored in the patients. There is a new calculation formula that we can use for height estimation based on the tibial length in children with CP aged 6-12 years.

*Keywords:* cerebral palsy, estimation body height, tibia length

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## 1. Introduction

Growth is an important aspect to determine children's health status [1]. Physical growth in children has been measured using anthropometry classic, which includes body height or length [1,2]. Height measurement is very important for growth monitor, identifying nutrition disturbance, an endocrine disorder, metabolic disorder, genetic disorder, psychosocial disorder, chronic disease, caused by other diseases, measure and determine nutritional needs and drug dosage calculation [3]. Impaired growth is an indicator of linear growth failure, which leads to short stature [4]. These numbers had been increased from 2010 data with 35.6%. The possible causes were nutritional intake, chronic disease, iron deficiency anemia, poverty, and low birth weight [5]. World Health Organization (WHO) target is to decrease short stature as much as 40% in 2010 and 2025 [6]. Asia is still considered as a continent with most short stature children [7]. Short stature can be complicated with a higher rate of

morbidity and mortality caused by infection, especially pneumonia and diarrhea [8]. Therefore, body height measurement is very important to be done correctly and accurately [8]. Body length or height is commonly measured using a length board or height board (stadiometer ) [1,9].

Children with Cerebral Palsy (CP) have a higher risk of growth disorder so that they have a better body height monitoring system [10]. These cases in the world are found between 1.5-4 per 1,000 live births [11]. A number of events in countries with middle to lower income are reported a higher case with 10 per 1,000 live birth [12]. The population of premature babies leads to much higher CP events [13,14,15]. Children with contracture or hypotonus condition usually are difficult to be measured with standard body height measurement [2,16,17]. Children with this condition need the alternative measurement method, therefore the growth monitoring still can be done using body height estimation by measuring the segmental height, which is by measuring the upper arm length, tibia length, or knee-length [2,16,17]. Long bones are found as the best indicator for body height

measurement [17]. Basically, Height growth averages approximately 5 to 6 cm per year throughout childhood [18,19]. The adolescent growth spurt is the fast and intense increase in the rate of growth in height and weight that occurs during the adolescent stage of the human life cycle. This growth practically occurs in all of the long bones and most other skeletal elements. Growth spurt begins on average at 9-10 years for girls and 11-12 years for boys [20].

The measurement of the knee, upper arm, and tibia length had been studied before with a significant result in Cheng study in 1998 which created a formula for height estimation according to tibia length. Height estimation = 41.05+ (.64x age) + (0.84x gender) + (2.55x tibia length), girls = 0, boys = 1. This formula is used for children and adolescents aged 3-18 years old in China [2]. Other study by Gauld in 2004 in Australia also resulted in height estimation formula which were divided into for girls = (2.771 x tibia length) + (1.457 x age) + 37.748 and for boys = (2.758 x tibia length) + (1.717x age) + 21.818 for healthy children with 5-19 years old [2]. In 1995, Stevenson mentioned that his formula for height estimation according to the segmental length of CP children below 12 years old can be done using height estimation = (3.26 x tibia length) + 30.8 ± 1.7. According to the previous studies, segmental length measurement is valid and can be relied on for height estimation and recommends to use tibia length measurement as the routine monitoring in CP children if standard height measurement cannot be done and can be plotted in standard growth curve [2,16,17]. Height estimation formula according to tibia length measurement has been developed in several countries, but not in Indonesia. The objective of this research is determining the estimation body height according to tibia length in children with cerebral palsy aged 6-12 years in Bandung Indonesia.

## 2. Method

This study was performed CP children aged 6-12 years old who had been positively diagnosed with CP and studied in a special school (Sekolah Luar Biasa/SLB) in Bandung, neuropediatric and medical rehabilitation outpatient department at Hasan Sadikin Hospital Bandung at March - May 2019. The sample selection was done by consecutive sampling. The sample size was measured using linear regression with a minimum of 28 children. Sample who met the inclusion criteria children 6-12 years old with CP who attended Special School, Growth and Development, Neuropediatric, and Medical Rehabilitation Outpatient Department at Hasan Sadikin General Hospital in Bandung, Indonesia. Before performing the study, researchers had collected informed consent from the parents. The exclusion criterion was children with spinal abnormalities (scoliosis). This research performed a cross sectional study. The procedure for measuring height and body length based on WHO standards use a General Care stadiometer with accuracy 0.1 cm while the body length uses a length board. The Length board is only for measuring the body length in children less than 2 years, therefore for this study, we created a 2 meter-modified length board using Ikoala ruler which had been calibrated

by Management National Standard Measuring Unit, Directorate of Metrology, Indonesia Ministry Of Trade with an accuracy 0.1 cm. Measurement of tibia length based on the CDC (*Centers for Disease Control and Prevention)* standard. The tibial length was measured from the left superomedial edge of the tibia to the inferior edge of the medial malleolus using SECA plastic measuring tape with an accuracy of 0.1 cm. In children with hemiplegia or asymmetry, a healthier side is taken to be measured. The tool has been calibrated by the Management National Standard Measuring, Directorate of Metrology, Indonesia Ministry Of Trade. Tools and procedures of tibia length measurement performed in this study in Figure 1. The measurement procedure is carried out by 3 trained doctors.



**Figure 1.** Tools and procedures of tibia length measurement performed in this study (Source: WHO, CDC [1,10])

Collected data was processed and analyzed descriptively and analytically. For descriptive was performed by providing total statistical measure and percentage for categorical data, while for numeric data was performed by providing the mean, median, and range. The next step for analytic was by performing a linear regression to determine the formula for estimation body height according to tibia length in children with CP aged 6-12 years old. This study has received permission from the

Research Ethics Committee of Dr. Hasan Sadikin Hospital in Bandung, Indonesia.

# 3. Results

We found 68 CP patients who met the inclusion criterion. Patients could be measured using the standard method are 36 children which then analyzed statistically. The remainder was not included in the analysis because of the spastic condition which made measuring using the standard method was not possible. The procedure of sample size collection in Figure 2.
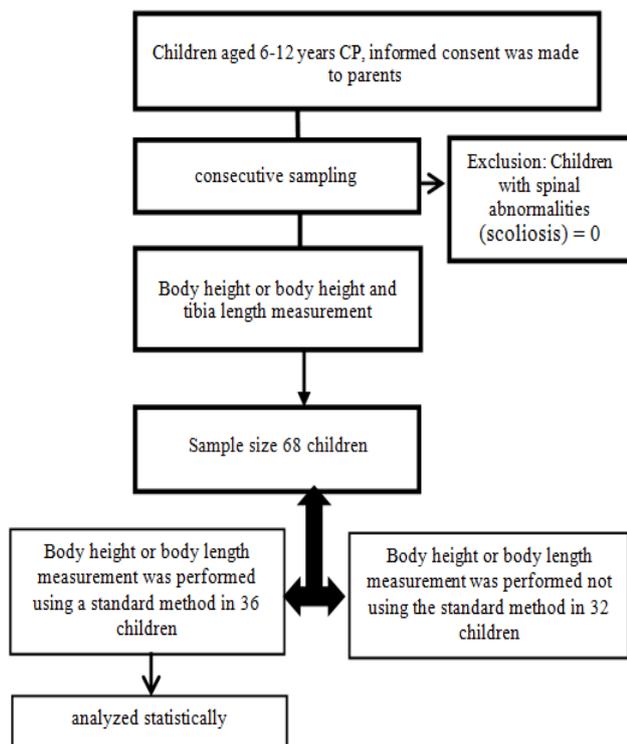


**Figure 2.** Sample size collection

Table 1 showed a total of 36 children, with 22 males (61,1%) and 14 females (38,9%). The age range was 6-12 years old with the mean age was 10 years old.

**Table 1. Characteristics of research subjects**

| Characteristics | n=36 |
|---|---|
| Age (years) | |
| Mean (SD) | 10 (2) |
| Median | 10 |
| Rentang | 6 – 12 |
| Gender, n (%) | |
| male | 22 (61,1) |
| Female | 14 (38,9) |
| CP classification , n (%) | |
| GMFCS level I | 23 (63,9) |
| GMFCS level II | 6 (16,7) |
| **GMFCS level III** | **7 (19,4)** |

SD: Standard Deviation.

In Table 2 showed the regression analysis of the correlation between the tibia length and the actual height.

**Table 2. Linear regression analysis of the correlation between tibia length and actual height**

| Variable | Regression coefficient | SE | P value | $R^2$ |
|---|---|---|---|---|
| Constanta | 32,01 | 7,87 | <0,001 | 0,806 |
| **Tibia length (cm)** | **2,90** | **0,24** | **<0,001** | |

Estimated height = Constanta+ b. Tibia length.

From the regression analysis, we found that:
- The determination coefficient ($R^2$) was 0.806 means we found Body Height variability which could be explained by tibia length with 80.6%.
- Constanta coefficient was found as 32.01 which mean the average tibia length in CP patients aged 6-12 years old was 32.01 cm.
- The regression coefficient of tibia length was 2.90 which mean every 1 cm increment will result in 2.90 cm additional height.

The formula of body height estimation based on tibia length in CP children aged 6-12 years old was body height estimation (cm) = 32.01 + 2.90 * tibia length (Error standard of the estimation ±1.85).
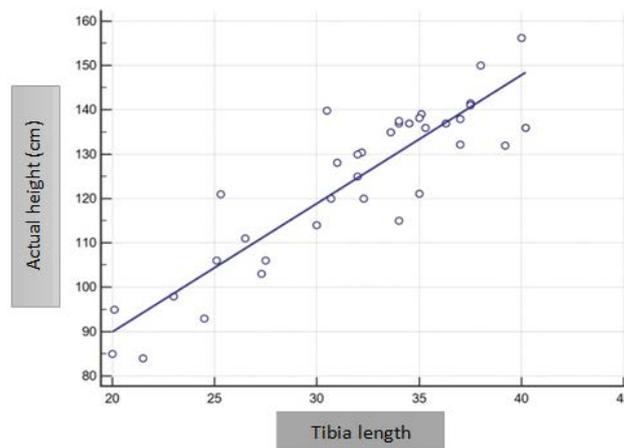


**Figure 3.** The correlation between tibia length and the actual height of cerebral palsy children aged 6-12 years

**Table 3. Distribution of mean actual height and estimation height based on tibia length according to regression analysis results**

| | Actual height (cm) | Estimation height based on tibia length according to regression analysis results (cm) |
|---|---|---|
| Mean (SD) | 124,1 (18,2) | 124,1 (16,3) |
| Range | 84,0 – 156,2 | 90,0 – 148,5 |

SD: Standard Deviation.

Table 3 shows the mean actual height and Estimation height based on regression analysis Results were 124.1 (18.2) cm and 124.1 (16.3) cm.

**Table 4. Comparison between estimation height based on of tibia length according to regression analysis results and actual height**

| | Mean different with actual height (95% CI) | p-value |
|---|---|---|
| Estimation height based on of formula regression analysis results (cm) | 0,0 (-2,7 – 2,7) | 1,000 |

Use paired t-test.

From the results of paired t-test in Table 4 showed no significant difference between the mean estimation height based on formula regression analysis results and actual body height.

**Table 5. Accuracy of estimation body height according to tibia length based on a regression analysis result**

| Variable | Concordance Correlation Coefficient (95% CI) | Pearson ρ (precision) | Bias correction factor $C_b$ (accuracy) |
|---|---|---|---|
| Estimation body height according to tibia length based on regression analysis result (cm) | 0,893 (0,803 – 0,943) | 0,898 | 0,994 |

Conformity analysis according to concordance correlation showed that the concordance correlation coefficient in estimation body height according to tibia length based on the regression analysis result was 0.893 with 0.898 precision and 0.994 accuracy.

# 4. Discussion

Cerebral palsy is motoric development disorders that are not progressive and cause limited activities, resulting from brain damage that occurs when the brain has not reached maturation. This population is considered to have contracture joints, weak muscle, scoliosis, or uncontrollable movement in CP children which leads to difficulties in keeping the standing position or straighten the joints, therefore the standard measurement method is usually hard to be done [2,17,22,23]. Linear growth disorder can lead to short stature [24]. The equation or formula to determine the estimation of body height using segmental length has been developed and found an accurate body height especially in CP children. In Stevenson study in 1995 from Virginia, America found a formula from segmental length including tibia length from CP children population aged below 12 years old [2,17]. The formula for estimating body height according to tibia length measurement in CP children aged 2-12 years old is body height estimation (cm) = (3.26 x tibia length) + 30.8. SEE: ± 1.7. This body height estimation could be plotted in a standard growth curve [17].

In this study, we found more males than the female with an average age of 10 years old. According to linear regression analysis measurement, we found a new formula that could be used to estimate CP children body height based on the tibia length in 6-12 years old, which was: Body height estimation (cm) = 32.01 + 2.90* tibia length (standard error of the estimation ±1.85). The mean between actual body height and body height estimation result according to tibia length based on the regression analysis formula showed a closer number to the actual body height. Different tests using a paired t-test on the mean of body height estimation result according to tibia length based on the regression analysis formula showed no significant difference with actual body height, with an average difference was 0.0 cm (p=1.000). Conformity analysis result using Concordance Correlation showed that the estimation of body height according to tibia length on the regression analysis formula had good accuracy and precision.

This study was the first to estimating body height based on tibia length on cerebral palsy children age 6-12 years in Indonesia. The limitation of this study is not to distinguish the estimated body height based on the tibia length between boy and girl. Further study with the same method is needed in the CP population with a bigger sample size in other cities in Indonesia to improve the precision result and differentiate the gender. Further study also should be performed to determine the comparison between body height estimation formula according to tibia length in CP children which already available with body height estimation according to this regression analysis result.

# 5. Conclusion

Tibia length measurement is crucial to estimating body height in CP children. This study was found a new formula to estimating body height according to tibia length in CP children aged 6-12 years old with Body height estimation (cm) = 32.01 + 2.90 * tibia length (Standard error of the estimation ±1.85). This body height estimation showed no difference with actual body height.

# Conflicts of Interest

The authors have no conflicts of interest relevant to this article to disclose.

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