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Are Various Weight Estimation Formulas Used To Calculate Weight-For-Age Applicable To Rural Indian Children?

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Abstract: **Introduction:** Accurate weight estimation in the pediatric population is critical for determining drug dosages, fluid volumes, and equipment sizes, particularly in emergency or rural settings where weighing scales may be unavailable. While various formulas exist, their accuracy in rural Indian populations—who may differ significantly from the urban or Western cohorts used to derive these methods—remains under-researched. **Material and methods**: A prospective cross-sectional observational study was conducted in the Patan district of India from August 2024 to February 2025. Data from **384 children** (aged 12 to 144 months) were analyzed. Actual weights were compared against weights calculated using age-specific APLS and Nelson formulas. Accuracy was defined as an estimated weight within **±10%** of the actual weight. Sub-group analyses were performed based on age (≤6 years and >6 years) and nutritional status. **Results:** The APLS and Nelson formulas correctly estimated weight in only 30.47% and 32.55% of participants, respectively. This difference was not statistically significant (p=0.928). Both methods showed a strong tendency toward **over-estimation**, exceeding +10% of actual weight in 59.64% (APLS) and 55.21% (Nelson) of the total population. Significant differences were noted in under- and over-estimation proportions when comparing younger (≤6 years) and older (>6 years) children (p<0.05). **Conclusion:** Both the APLS and Nelson formulas are relatively inaccurate for weight estimation in rural Indian children, correctly predicting weight in only about one-third of the population. Their performance is particularly poor in undernourished children due to reliance on Western growth standards. There is a critical need for more accurate, population-specific weight estimation methods for rural pediatric care.

Keywords: Weight estimation, Pediatric drug dosage, APLS formula, Nelson formula

I. Introduction:

In the pediatric population drug dosage, various instrument sizes (e. g. blood pressure cuff) and volume of fluid to be administered are dependent on the weight or surface area of the child.

Routinely when child presents in the outpatient department of a hospital, the child's weight is estimated using a weighing machine and the doses of drugs to be administered and the volume of fluid to be provided are calculated as per weight. However, in rural areas, during school health visits or in emergencies, it is not possible to accurately weigh child before treatment is initiated. It needs to be estimated. Various methods have been described to estimate the weight of a child. These include direct estimation made by the physician [(1)], or using weight estimation formulas e.g., Advanced Pediatric Life Support (APLS) formula [(2)], and formula provided by the Nelson's Textbook of Pediatrics[(3)]. These formulas are from standard used by American academy of pediatrics and standard pediatric text book used all over, respectively.

A number of studies have been carried out in Indian children to check if these methods can accurately predict weight, but these cohort involves urban children and those visiting hospitals[(4,5)].

These studies do not specifically include rural Indian children.

II. Material and methods:

The study was carried out in children in rural arears of Patan district of India.

The participants in the study were enrolled from August 2024 till February 2025. The data was analyzed from March 2025 to November 2025. A participant was in the study only for the period when his weight was being determined using various formulas.

It is a prospective cross-sectional observational study.

An informed consent was taken from parents/ guardian for enrolment in the study. If the consent was provided the prospective child participant was approached for assent, as applicable.

A child fulfilling all the inclusion criteria was considered eligible for participation in the study:

Inclusion Criteria:

1. Age: 12 months to 144 months
2. Gender: male or female or other
3. One of the parents/ guardians providing written consent for the enrolment of the child in the study.
4. For a child aged 7-12 years: providing verbal assent after a parent has given written consent for enrolment.

Exclusion Criteria:

1. Critically ill child
2. A child with manifestation(s) requiring immediate conduct of a procedure and/ or immediate institution of therapy
3. Children in whom actual weight measurement is not possible or is deferred for any reason (e.g., Preterm by birth, Small for gestation, syndromic children, joint contracture).
4. Children whose parent aren't giving consent.

The child's actual weight, height and BMI was recorded/ calculated. The children were classified as obese, overweight, appropriate weight as per the BMI charts (WHO and IAP growth charts for age 0-5 years and 5-18 years, respectively)

The participant's weight was calculated using the APLS formula[2]

Children (1-5 years): Weight (kg) = (2 x Age in years) + 8

Children (6-12 years): Weight (kg) = (3 x Age in years) + 7.

The participant's weight was also calculated using the appropriate Nelson formula[3]

Children (1-6 years): weight= 2n+ 8 was used wherein, 'n' is age in years.

Children (7-12 years): weight= [7n– 5]/2, where 'n' is age in years.

The difference in the weights estimated by these formulas and the actual weight measured was also calculated.

table 1: description/ definitions of various terms used in the study

Term	Definition/ Description/ How determined
Undernourished	Age, 0-5 years: Weight for length ≤ -2SD on WHO growth charts for 0-5 years[8,9] Age, 5-12 years: BMI ≤ 3th percentile on IAP BMI charts for 5-18 years[10,11]
Over-weight	Age, 0-5 years: Weight for length ≥ 2SD on WHO growth charts for 0-5 years[8,9] Age, 5-12 years: BMI ≥ 23kg/m2 of adult equivalent line on IAP BMI charts for 5-18 years[10,11]
Obese	Age, 0-5 years: Weight for length ≥3SD on WHO growth charts[8,9] Age, 5-12 years: BMI ≥ 27kg/m2 of adult equivalent line on IAP BMI charts for 5-18 years[10,11]
Over-estimation by any method/ formula	Weight estimated by the method > 10% above the actual/observed weigh
Under-estimation by any method/ formula	Weight estimated by the method/ formula > 10% below the actual/ observed weigh

Outcome Measures:

1. The difference between the actual weight and the weight estimated by the APLS method was calculated.

Number and percentage of participants whose weight is under-estimated (more than 10% below the actual weight), over-estimated (more than 10% above the actual weight) and correctly estimated (i.e., estimated weight within -10% to 10% of the actual/ observed weight on either side was considered to be of acceptable accuracy)[5].

2. The difference between the actual weight and weight estimated by the Nelson method:

Number and percentage of participants whose weight is under-estimated (more than 10% below the actual weight), over-estimated (more than 10% above the actual weight) and correctly estimated (i.e., estimated weight within -10% to 10% of the actual /observed weight on either side was considered to be of acceptable accuracy)[5].

The above outcome measures were determined for:

(a) The whole study population

(b) Sub-group analysis 1: For the study population divided on the basis of age: 1-6 years, > 6 years

(c) Sub-group analysis 2: For population divided on the basis of nutritional status

Sample size: As study involve large population, we're using variation of the Cochran Formula ($n=Z^2pq/E^2$). Based on this required sample size is 384.

III. Results:

The study was carried out in rural arears located in Patan district in India, over a period of 7 months from August 2024 till February 2025. Three hundred and forty-seven (boys: 216, 56.19%, M:F=1.28:1) participants aged 1 to 12 years and satisfying the eligibility criteria were enrolled in the study.

The demographic characteristics of the study population in terms of age- and gender distribution and nutritional status are shown in Tables 2a- 2b.

table 2a demographic characteristics according to age

	Age ≤ 6 years	Age >6 years
Study population (n=384)	280 (72.91)	104 (27.09)

table 2b. demographic characteristics according to gender

	Girls	Boys
Study population (n=384)	168 (43.80)	216 (56.19)

As shown in table 2a and, 2b, children below the age of 6 years outnumbered those above in the ratio of 2.7: 1. The boys accounted for over 56.19% of the participants.

Table 3 shows the classification of study participants as per the status of their weight.

table 3. nutritional status of the study participants

Weight / Group Participants (N= 384)	Undernourished	Normal	Over-weight/ Obese
All participants (n= 384)	117(30.47)	242(63.02)	25(6.51)
Age ≤ 5years (n= 258)	83(32.17)	160(62.02)	15(5.81)
Age > 5years (n=126)	34(26.98)	82(65.08)	10(7.94)

Figures in parentheses indicate percentages.

For participants aged ≤5 years WHO weight for length growth charts were used

For participants aged > 5 years IAP adult equivalent BMI growth charts were used

As shown in table 3, the maximum number of the study participants (242, 63.02%) had normal nutritional status. Undernourished (117, 30.47%) and over-weight/ obese children (25, 6.51%) together accounted for less than 37% of the study population (142, 36.97%).

Table 4 shows the differences among these methods in terms of percentages of study population whose weight was correctly estimated. correct estimation of weight i.e., weight in acceptable range (-10% to +10% of the actual/observed weight) was used in the assessment, as this is withing acceptable range.

table 4. comparison among APLS formula and nelson formula in correct estimation of the weight

N=384	APLS formula	Nelson formula
Correct estimation	117 (30.47)	125 (32.55)
Incorrect estimation	267 (69.53)	259 (67.45)

Figures in parentheses indicate percentages

Table 4 shows that the number and percentage of study participants in whom the weight was estimated correct was 117 (30.47%) and 125 (32.55%) using APLS formula and the Nelson formula, respectively. These differences were not statistically significant (p= 0.928).

Table 5 shows the comparison between the actual weight and weight estimated by the APLS formula for weight estimation using the percentage for the determination of under estimation, over-estimation or correct-estimation in two age-groups studied.

table 5. comparison of actual/ observed weight with weight predicted by the APLS formula based on acceptable range criteria: Sub-group analysis as per age-group

N=384	Under-estimation (n=38)	Correct estimation (n= 117)	Over-estimation (n= 229)
Age≤ 6 years (n= 280)	27(9.64)	89(31.78)	166(59.29)
Age> 6 years (n= 104)	11(10.58)	28(26.92)	65(62.50)

Figures in parentheses indicate percentages

Table 5 shows APLS method of weight estimation, correctly estimates weight in about 31.78% of population ≤ 6 years age and in 26.92% of population > 6 years of age. Over estimation in ≤ 6 years was 59.29% in contrast to 62.50% in >6 years population. In 9.64% of ≤ 6 years age it underestimated the weight compared to 10.58% in > 6years of age overlap between underestimation and correct estimation of weight. These differences were statistically significant (P value<0.05)

Table 6 shows the comparison between the actual weight and weight estimated by the Nelson formula for weight estimation using the percentage for the determination of under estimation, over-estimation or correct-estimation in two age-groups studied.

table 6. comparison of actual/ observed weight with weight predicted by the nelson formula in accordance with acceptable range criteria: Sub-group analysis as per age-group

N=384	Under-estimation (n= 47)	Correct estimation (n= 125)	Over-estimation (n= 212)
Age≤ 6 years (n= 280)	27(9.64)	96(34.29)	157(56.07)
Age> 6 years (n= 104)	20(19.23)	29(27.88)	55(52.89)

Figures in parentheses indicate percentages

As shown in Table 6, Nelson formula correctly estimates weight in approximately 34.29% of children in ≤ 6 years age and 27.88% children in > 6 years of age. Percentage of underestimation is relatively less accounting to approximately 9.64% of ≤ 6 years population compared to 19.23% in > 6 years of age. Overestimation of weight in either population was comparable with 56.07% in ≤ 6 years and 52.89% in > 6 years.

Table 7 provides comparison among the three methods of weight estimation (APLS method and Nelson method) in determining underestimation, correct estimation and overestimation of weight in comparison to actual/ observed weight according to two age-related sub- groups studied.

table 7. comparison among APLS formula and nelson formula in weight estimation according to age group

(N=384)	Age-group	APLS formula	Nelson formula
Under estimation	Age ≤6 years (n=280)	25(8.93)	27(9.64)
	Age >6 years (n=104)	17(16.35)	20(19.23)
Correct estimation	Age ≤6 years (n=280)	89(31.78)	96(34.29)
	Age >6 years (n=104)	28(26.92)	29(27.88)
Over estimation	Age ≤6 years (n=280)	166(59.29)	157(56.07)
	Age >6 years (n=104)	59(56.73)	55(52.89)

Figures in parentheses indicate percentages

As shown in Table 7, APLS formula accurately estimated the 31.78% of participants aged ≤6 years, whereas in participants aged over 6 years, the corresponding figure was 26.92%. APLS method overestimated weight in 59.29% in younger population as compared to 56.73% participants in the older age-group. It underestimated weight in 8.93% and 16.35% in the two age-related two sub-groups studied (6 years of age). The Nelson formula accurately estimated the 34.29% of participants aged ≤6 years, whereas in participants aged over 6 years, the corresponding figure was 27.88%. Underestimation of weight was noted in 9.64% in younger children, in contrast to 19.23% in older children. The overestimation proportions were comparable in both the age-groups (>50%). The differences were statistically significant.

Table 8 provides comparison between measured weight and correct estimation of weight using APLS method and Nelson formula according to nutrition status of children (undernourished, normal and over-weight/ obese).

table 8. comparison among APLS formula and nelson formula in correct weight estimation according to nutrition status

	No. of children with appropriate weight estimation	
Nutrition status	APLS formula	Nelson formula
Undernourished(n=117)	7(5.98)	9(7.69)
Normal (n= 242)	103 (42.56)	108(44.63)
Over-weight/ Obese (n= 25)	7 (28)	8 (32)

Figures in parentheses indicate percentages

As shown in Table 8, Correct estimation by APLS method was 5.98%, 42.56% and 28% in undernourished, in children with normal nutrition and those in overweight/obese, respectively. Nelson formula correctly estimated weight in 44.63% of children with normal nutrition compared to 7.69% and 32% in undernourished and over-weight/obese children. According to chi square analysis as P value is >0.05 the difference is statistically not significant between the three compared formulas across three nutritional status.

IV. Discussion:

This study carried out in a private sector hospital in rural arears of Patan district in India, enrolled 384 (boys: 216, 56.19%) children aged up to 12 years. The study population included 242 (63.02%) children with normal nutritional status. 117 (30.47%) children were undernourished and 25(6.51%) children were over-weight or obese.

The two methods, viz. the APLS formula and the Nelson formula were compared on the basis of the criterion of estimated weight being within 10% around the observed/ actual weight and provided correct estimation in 30.47% and 32.55% of children, respectively and that the differences in these proportions were not significant. Sub-group analysis based on age showed that there was no significant difference in the percentage of children with correct estimation using these two methods. However, this study showed that there

were no significant differences in the accuracy of two methods studied. This may be due to the specific population enrolled in this study.

Sub-group analysis based on nutritional status was a unique exploration carried out in this study. It showed that all both methods were associated with very low proportion of correct estimation in under-nourished children: 5.98% and 7.69% with APLS formula and Nelson formula, respectively. This could be considered as per the expected lines, and the formulae are based on western standards of growth in children. These standards are based usually on Caucasian children, who generally have higher weights for age than their Indian counterparts. Figures for the proportion of children with normal nutritional status having correct estimation were similar and above 40% with all both (42.56% and 44.63% with APLS and nelson formulas respectively). APLS formula and Nelson formula provided correct estimation in 28% and 32%, respectively in overweight/ obese children. Both these methods showed a greater tendency to over-estimate the weight (beyond +10%): with the percentage of participants with over estimation being 58.59%, and 55.21% APLS formula and Nelson formula, respectively.

However, there was a significant difference in the proportion of children with under, correct- or over-estimation using APLS and Nelson formula based on age. Sub-group analysis based on age, showed that there were significant differences in the proportions of children with under-, correct- and over-estimation with these methods. Several studies have been carried out to determine the most accurate method for quick estimation of weight. The salient observations of studies from India are summarized in Table 15a and those from other countries are provided in Table 15b.

table 15a: comparison with studies carried out in India

Author, Place & Yr. of publication	Salient features of studies
Varghese A, et al, Bangalore, 2005[4]	Compared Broselow, APLS, Argall method and Nelson formula It concluded that Argall, Nelson and APLS formula overestimated weight.
Shah V, et al, Mumbai, 2017[5]	Compared Broselow estimated weight, APLS formula and updated APLS formula for weight estimation. In conclusion APLS formula overestimates weight of children.

table 15b: comparison with studies carried outside India

Author, Place & Yr. of publication	Salient features of studies
Garcia AKL, et al, Philippines, 2017[6]	To compare among mid upper arm circumference (MUAC), APLS and Broselow tape for weight estimation. All three had positive correlation with measured weight.
Boedelu, et al, Nigeria, 2020[7]	Compared between APLS formula, the Best Guess formula, the Nelson formula, and the Luscombe and Owen formula. Percentage error was used to compare real and estimated weight. The APLS, Nelson and Luscombe and Owen formula underestimated weight in younger children. The Best guess formula over-estimated across all ages. The Nelson formula has best agreement among all methods for weight estimation falling between 10-20% of observed weight.

V. Conclusion:

In Children weight measurement is essential part of clinical assessment. In certain settings it is not possible to weigh the child. We compared two different internationally used methods of weight estimation in children. Both of these correctly estimate weight in slightly above 40% of rural Indian children. We need better method to estimate weight of rural pediatric population. This study was conducted only in limited geographical location; further studies may be needed to determine accuracy of these methods.

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