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APPLICABILITY OF BROSELOW PEDIATRIC EMERGENCY TAPE PAEDIATRIC POPULATION OF SUB-URBAN PUDUCHERRY

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ABSTRACT

Introduction: The accurate measurement of weight is important in clinical practice, more so in paediatric population where the growth trajectories are dynamic and different affecting the body weight. While measurement of weight of paediatric patients could be done easily in a healthy state, however, it is difficult in disease state, especially in emergency and critically ill patients. To overcome this several methods through which weight could be estimated without actually measuring it have been developed. **Methodology:** A total of 873 children aged 1-6 years (mean age 3.51±1.55 years) were recruited in the study, of these 493 (56.5%) were females. All the children were clinically examined and were subjected for measurement of Height and Weight using standard techniques. Thereafter the children enrolled in the study were subjected to weight estimation using Broselow's Tape. **Results:** Estimated weight by Broselow's tape also showed significant association with Age, Height and Actual weight. Strong correlations of Estimated weight with actual weight and Age of children were observed (r=0.860 & 0.871). In majority of the children over estimation of 1-25% of actual weight was observed (55.8%). Underestimation of actual weight was observed in 15.8%. Below 1% error in estimation of weight was observed in 17.9% children. Accuracy in estimation of weight was observed in higher proportion of children weighed ≥21 kg (67.4%) as compared to 11-20 kg (15.8%) and ≤10 kg (36.5%). **Conclusion:** Breslow tape was found to overestimate measured body weight by 1.44 kgs. Therefore when used should be cautioned and alarmed.

INTRODUCTION

Determination of dose is quite essential before initiating a treatment. A dose is defined as "a measured quantity of a medicine, nutrient, or pathogen which is delivered as a unit". In simple words it refers to the amount of medication taken at a specific time.[1] The basis for determination of such needs could be patient's age and body weight. However, in hospital medications are more precisely decided on the basis of a patient's body weight, particularly in case of paediatric patients who show extreme variability in their growth pattern that a universal dosing is considered to be inappropriate.[2]

In the routine paediatric clinical practice, the normalization of medication dose is based on body weight with the assumption that there is a linear relationship between weight and dose. However, children requiring medication, particularly in emergency situations present in a variety of clinical conditions like symptoms of respiratory distress accompanied with or without hypoxemia, shock, altered consciousness and shock or seizures. All these conditions worth an immediate intervention and resuscitation attempts. It is here the heathcare providers face a dilemma as they are not in a position to measure the weight of the child in such unstable and critical conditions using the weighing machine only.[3]

Keeping in view the medication needs and its dependence on body weight of the patients to determine the exact dose, especially for the intravenous administration of drugs during resuscitation and anaesthesia it is essential that alternate methods to estimate the body weight of children should be explored and the most suitable method be adopted.[2]

In a number of instances, physicians tend to make estimations on the basis of their perceptions based on age or physical appearance only. However, these estimations have been reported to be inaccurate in upto 85% cases.[4,5,6] It is hence important to use a reliable and reproducible method that can estimate the body weight of hospitalized children with acceptable accuracy. Unfortunately, flawed dose-calculations have been recognized as one of the most common medical errors in prescribing treatment.[7]

A number of systematic methods have been coined to predict the body weight under these circumstances. There are formula based approaches taking into consideration the child's age,[8] combination of age, sex,

ethnicity and height,[9] mid-arm circumference,[10] dual length- and habitus-based systems, such as the Mercy method and the PAWPER (Paediatric Advanced Weight Prediction in the Emergency Room) tape,[11,12] *etc.* with different claims regarding their accuracy.[13] As such newer methods for weight estimation are also being evolved continuously. In India, Nelson formula or Advanced Paediatric Life Support (APLS) formula are the most commonly used methods for weight estimation in Paediatrics.[14,15] however, doubts regarding their accuracy have also been raised from time to time.[16]

The Broselow™ Paediatric Emergency Tape is an alternative that is being used for more than three decades in the United States for determination of medication doses and equipment size. It is a simple to use tape using a color-coded for easy handling. It has been shown to be adaptable in different environments including Europe,[17] Australia,[18] Asia.[19] and other countries.

In the recent years, some Indian workers have also made an attempt to use Broselow Tape for estimation of body weight in Paediatric population[16,20,21] and have found it to be useful. Encouraged by these studies, in the present study we make an attempt to assess the applicability of Broselow Pediatric Emergency Tape in paediatric population of sub-urban Puducherry.

METHODOLOGY

This cross sectional hospital-based study was planned in Department of Pediatrics, Aarupadai Veedu Medical College and Hospital, Puducherry. The paediatric population, aged 1 year to 6 years of both genders entering into outpatient department from 1st December 2019 to 30th November, 2021 of respective hospital were chosen as sample population.

Inclusion criteria include the Paediatric population, aged 1year to 6 years of both sexes who are of length > 70 cm or < 130cm. Exclusion criteria include those who have Skeletal dysplasia, joint contractures, Acute severe malnutrition, Storage disorders, Syndromic children with abnormal facies and Child with height for age <3rd percentile &>97th percentile.

Children fulfilling the inclusion criteria will be subsequently divided into three groups on the basis of their actual weight measurement, *viz.*,
Group 1 = Actual weight ≤10 kg
Group 2 = Actual weight 11-20 kg
Group 3 = Actual weight ≥21 kg

After getting consent from parents, data was collected which included demographic information such as gender and age in years. The Brose low tape weights were determined in accordance with the instructions provided in the manual.Child was made to lie in supine position with head kept at neutral position with no pillow in place.

One end of the tape mentioning "MEASURE FROM THIS END" was kept at the vertex and then the tape was stretched to child's heel. The heel markings were made on the tape and child's weight was noted from the tape.

Then the child was weighed using a child weighing scale or baby weighing scale which was calibrated every day. Performance of broselow tape was compared with the actual measured weight. The constant variable was the height by which the estimated weight of the Broselow tape was compared with the actual weight of the patients.

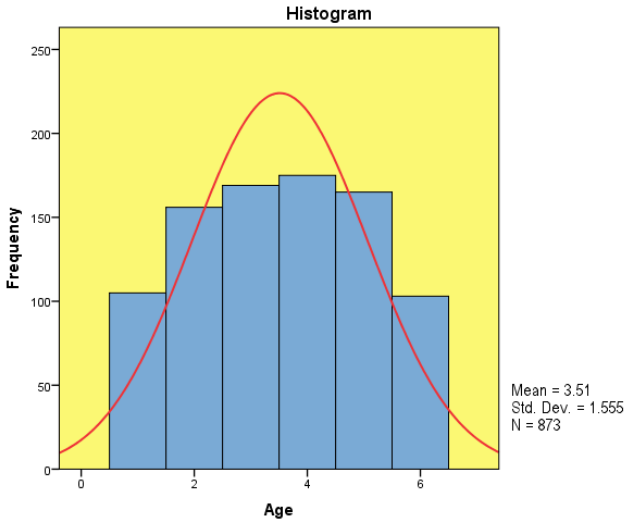
Statistical analysis

The data was analysed using IBM Statistical Package for Social Sciences (SPSS) version 21.0. Reporting of the data has been done in terms of numbers (frequency) and percentages (proportions) or mean with standard deviation. Analysis of variance and Chi-square tests were done to find out associations. Agreement between actual weight category and Broselow tap estimated weight category was made using Kappa-coefficient. Linear correlation between actual weight and Broselow tape estimated weight was done using Pearson correlation coefficient. Bland-Altman analysis was done to assess the correlation of estimation error with the actual weight. Overall estimated bias was also calculated. The confidence level of the study was kept at 95% and hence a 'p' value less than 0.05 was considered to depict a statistically significant association/ relationship.

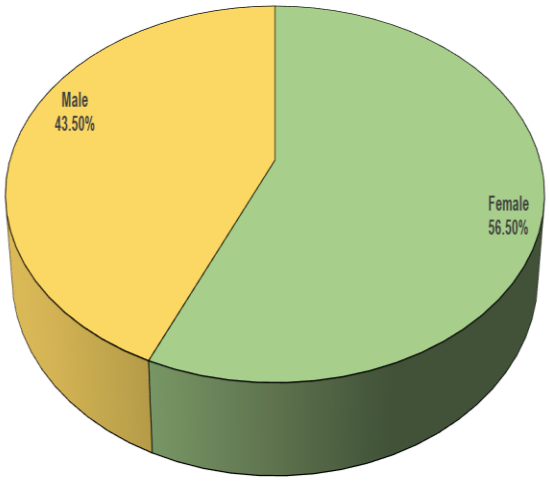
RESULTS

The total number of paediatric patients included in definitive time period were 873 fulfilling the inclusion criteria. The demographic data of the participated paediatric patients was 493 females and 380 males. Majority of children were Female (56.5%). Gender ratio (M:F) was 0.77:1. The mean age of the patients was 3.51with standard deviation of 1.55.

Histogram representing age of the study population



Graph 1: Distribution of study population according to gender.



Range of height of children included in the study was 71 to 129 cm. Mean height was 95.00±12.50 cm. Actual weight of children included in the study ranged between 7 & 27 kg. Mean weight was 13.62±3.39 kg.Weight of children measured by Broselow's tape ranged between 8 & 28 kg. Mean Broselow's tape weight was 14.75±3.53 kg. 202 patients were categorised into Group 1,639 into Group 2, 32 into Group 3 which was categorised based on their weight.

Table 1: Anthropometric profile of study population (n=873).

S. N.	Parameter	Mean ± SD (Range)
1	Height (cm)	95.00±12.50 (71-129)
2	Actual Weight (kg)	13.62±3.39 (7-27)
3	Estimated Broselow's Tape Weight (Kg)	14.75±3.53 (8-28)

On measuring weight of children using Broselow's Tape, majority of children (84.1%) weighed 11-20 kgs, followed by ≤10 kgs (11.0%). The remaining weighed ≥21 kgs (4.9%).

Age was maximum in Group 3 i.e. ≥21 kg weight according to Broselow tape (5.70±0.56 years) followed by Broselow tape weight category 11-20 kg (3.68±1.37), while age of patients in Broselow tape weight category ≤10 kg (1.32±0.61 years) was minimum. Statistically, a significant association was found for age with Broselow's Tape measured weight

Table 2: Association of Age and Anthropometric parameters with weight measured by Broselow's Tape.

SN	Parameter	≤10 kgs		11-20 kgs		≥21 kgs		ANOVA	
		Mean	SD	Mean	SD	Mean	SD	F	P
1	Age	1.32	0.61	3.68	1.37	5.70	0.56	210.193	<0.001
2	Height	74.31	2.73	96.34	9.72	118.33	3.51	405.998	<0.001
3	Actual Weight	9.44	0.52	14.99	2.70	22.60	1.48	432.039	<0.001

Agreement of Broselow tape weight category and actual weight category was observed in 716 out of 873 children (82.02%). Level of agreement was Moderate and significant (κ=0.497; p<0.001). Agreement of Broselow's tape weight and actual weight categories was observed in 169 out of 260 cases (65.0%). Level of agreement was Fair (κ=0.349; p<0.001) and statistically significant. Agreement in Broselow's tape weight category and actual weight category was observed in 305 (88.7%) but level of agreement was found to be Poor (κ=0.038). Agreement in Broselow's tape weight and actual weight was observed for 242 out of 269 (90%), level of agreement was found to be Moderate (κ=0.575).

Table 3: Agreement of Actual Weight and Broselow's Tape Weight in different age groups.

Age Group	Broselow's weight groups	Total	Group I		Group II		Group III	
			No.	%	No.	%	No.	%
1-2 years (n=260)	≤10 kgs	165	84	50.9	81	49.1		
	11-20 kgs	95	10	10.5	85	89.5		
	≥21 kgs	0						
			Agreement - 65.0% (κ=0.349; p<0.001)					
3-4 years (n=344)	≤10 kgs	36	0	0.0	36	100.0	0	0.0
	11-20 kgs	306	1	0.3	304	99.3	1	0.3
	≥21 kgs	2	0	0.0	1	50.0	1	50.0
			Agreement 88.4% (κ=0.038; p=0.045)					
5-6 years (n=269)	≤10 kgs	1	1	100.0	0	0.0	0	0.0
	11-20 kgs	238	0	0.0	219	92.0	19	8.0
	≥21 kgs	30	0	0.0	8	26.7	22	73.3
			Agreement 90.0% (κ=0.575; p<0.001)					

Out of 493 females enrolled in the study, agreement of Broselow's Tape weight and actual weight was observed for 400 (81.1%). Level of agreement was Moderate (κ=0.474).

Out of 380 males, agreement of Brose low's tape weight and actual weight was observed in 316 (83.2%). Level of agreement was Moderate (κ=0.527).

Table 4: Correlation of Broselow's Tape Weight with Actual Weight and Age.

		Broselow's Tape Weight	Actual Weight	Age
Broselow's TapeWeight	Correlation Coff. 'p'	-	0.860 <0.001	0.871 <0.001
Actual Weight	Correlation Coff. 'p'			0.777 <0.001
Age	Correlation Coff.'p'			

A strong correlation of Age was found with Actual weight (r=0.777) and weight estimated by Broselow's Tape (r=0.871). A strong correlation was also found for weight estimated by Broselow's Tape and actual weight (r=0.860).

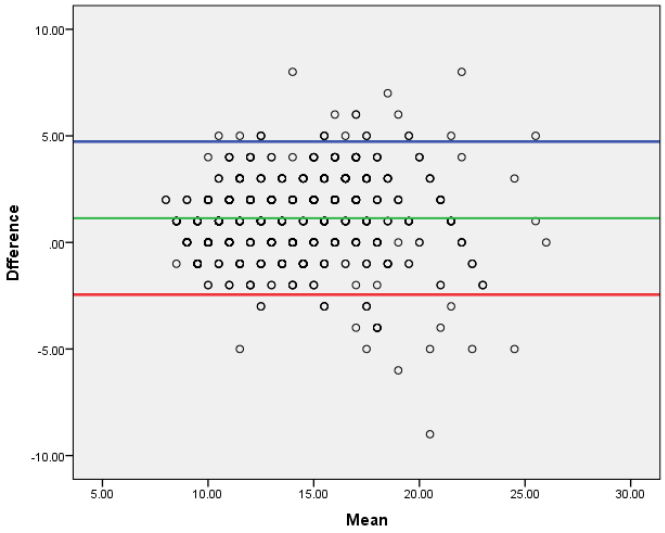
Table 5: Correlation of Broselow's Tape Weight with Actual Weight.

	Group 1	Group 2	Group 3
Correlation Coefficient	0.258	0.786	0.283
p	0.011	<0.001	0.066

A weak correlation was found for Actual weight (Group 1: r=0.258 & Group 3: r=0.283) and estimated weight by Broselow's tape, while a strong correlation was found for Group 2 of actual weight and estimated weight by Broselow's Tape (r=0.786).

Majority of cases were within Bland Altman construct ranging from -2.45 kg to 4.73 kg. The overall bias demonstrated by the Bland-Altman construct was an inaccurate estimation of 1.14 kg.Bland Altman analysis.

Bland altman analysis



DISCUSSION

This study was designed to estimate the accuracy of Weight of breslow pediatric tape to measure weight.Estimation of weight is quite essential to determine the accurate dosing of drugs to be administered. This is more specific for a pediatric population where the calculation and manipulation of drug dosages is highly weight dependent and sometimes very challenging.

In the present study, we enrolled children aged 1 to 6 years. Mean age of children was 3.51±1.55 years. Majority of children were girls (56.5%). Correspondingly sex ratio (M:F) was 0.77. The mean age of children in different studies ranged from 13.02 months[21] to 6.4 years[22] and sex-ratio ranged from 0.92[23] to 1.59.[24] Age close to the present study was also reported by KC Pukar *et al.*[24] who reported it to be 3.83 years while sex ratio of children in the present study also matched with the study by Shah and Bavdekar as 0.92.[23]

Actual weight of children ranged from 7 to 27 kg with a mean of 13.62±3.39 kg. Broselow Tape estimated weight ranged from 8 to 28 with a mean of 14.75±3.53 kg. Thus mean estimated weight was nearly 1.13 kg more than the actual weight. In the comparable mean age, Khouli *et al.*[25] reported the mean estimated weight to be only 0.26 kg less than the actual weight. KC Pukar[24] who also reported the mean age of children close to ours (3.83 years) had a much higher upper age limit of 15 years and reported the mean estimated weight to be higher by nearly 1.44 kg as compared to the actual weight.

In effect, it seemed that the Broselow Tape estimations in the present study showed existence of high level of estimation inaccuracies.In the present study, we moderate agreement between estimated weight and actual weight category in younger children (1-2 years; 65% agreement - κ=0.349) and a strong agreement for older children (5-6 years; 90% agreement - κ=0.575). Though % agreement was 88.4% for age group 3-4 years yet the level of agreement was poor (κ=0.038). A similar trend was also reported by Khouli *et al.*[25] who in their study reported a random trend of weight difference between actual and estimated weight for <10 kg (overestimation by 0.24 kg), 10-18 kg (underestimation by -0.12 kg) and >18 kg (overestimation by 0.83 kg) and also found that weight category 10-18 kg which experienced minimal inaccuracy had a mean age amidst the two extremes. These findings imply that age does have an effect on level of inaccuracy between estimated and actual weights.

In the present study we found a strong positive correlation of Broselow Tape estimated weight with both actual weight as well as age. This observation is in agreement with the findings of Sankaranarayan *et a.l*[26] Presence of a weak correlation in higher weight group (>20 kg) can be attributable to fewer number of cases owing to which the linear assessment of this relationship was not feasible.

In the present study, on Blandt Almann analysis we found the 95% confidence construct for weight discrepancy in a very wide range (-2.45 to 4.73 kg) and an overall bias of inaccurate estimation of 1.14 kg. It is close to the mean bias of 1.28 kg and limits of agreement between -4.88 and 1.92 kg as reported by Sankaranarayan *et al.*[26] in another South Indian population. However, Al-Busaidi *et al.*[22] in their study reported the mean overestimation by 0.5 kg as indicated by Bland-Altman analysis.

In the present study, we found absolute agreement between estimated and actual weights in only 17.9% of study population. In majority, the inaccuracy in weight estimation was within ±25% range (71.1%). Overall underestimation was seen in 138 (15.8%) while overestimation was seen in 579 (66.3%) cases. It is interesting to see that while overestimation rate was more than four times that of underestimation and the overall mean discrepancy between actual and estimated weights showed a trend indicative of over-estimation.

Broselow tape measurements are considered to have high level of inaccuracies. Even in the validation cohort >15% error in weight measurement was reported in 79% of the children and the underestimation was found to be weight dependent.[39] Compared to the present study, House *et al.*[27] reported the mean overall percentage difference between actual and predicted weight to be only -2.2%. In the study of Graves *et al.*[28] too estimation to correct weight category could be made in only 48.9% children. In our study the high reported inaccuracy could be owing to the fact that we focused on precise estimation with 0% difference between actual and estimated weights.

Moreover, we also reported the inconsistencies on a much larger scale ranging from 0-25% errors. Had we given an error allowance of ±5% to place the estimated and actual weight at parity then this difference could have lowered. Kholi *et al.*[25] in their study assessed the percentage error in terms of ±10% error and found it to be 46.2%, 64.1% and 51.5% respectively for the three actual weight groups.

The findings of the present study are thus in agreement with most of the previous literature citing a high correlation between actual weight and BT estimated weight while at the same time showing high rates of over or under estimations. One of the limitations of the present study was a short age range of paediatric population, owing to which the higher weight groups had relatively lesser representation that resulted in an inability to assess the group-wise correlations in a better way. Further studies with inclusion of children in higher age groups too are recommended to get a more representative data. Within this limitation the present study differs from much of the previous studies and that could be the reason for some of the inconsistencies in our study when compared to previous studies.

The other limitations were the sample was restricted to a small age group within 1 to 5 years range. There were very few cases in the higher weight groups (>20 kg).The study was carried out in apparently healthy children without malnutrition, however, in critical care scenario where weight cannot be measured and estimation is the only option, these estimates might not translate as they may have malnutrition too.Domination of weight group 10-20kg and the estimation of body weight in OPD children could not translate into good estimates in critical illness would be pitfalls of the present study.

CONCLUSION

The Breslow tape was showing overestimation of weight than the original by 1.14kgs, which might me negligible for using some of the medication, though becomes crucial in some certain conditions when the paediatric patient was in emergency department. Thus the use of Broselow tape for weight measurement in our set of population should be done with caution and proper adjustment.

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