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Original Research Article

Validation of three age based weight formulae for estimating weight among Indian children

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ABSTRACT

Background: Weight estimation in paediatric emergencies is often required to calculate drug dosages, fluid therapy and defibrillation. The 'gold standard' of actually weighing the patient is not practically possible in emergency conditions. Many formulae have been developed in an attempt to accurately estimate a child's weight using age like advanced paediatric life support (APLS), Luscombe, and Argall's modification. However, these formulae might not be applicable in the Indian context. This study aims is to validate standard age-based formulae (APLS, Luscombe, and Argall's) and their accuracy in estimating the weight of Indian children.
Methods: The study used secondary data from the fourth round of the National Family Health Survey (2015-16). The estimated weights as computed by the APLS guidelines, the Luscombe and the Argall formulae were compared to their respective measured weights during the survey.
Results: All three formulae (APLS, Luscombe, and Argall) overestimated the weights. The APLS formula exhibited the least weight difference among the different age groups (-3.51±2.08 kg). The average percentage difference between the estimated weights using the APLS, Luscombe, and Argall formula and the actual weights was 23%, 38%, and 28%, respectively.
Conclusions: All the three age-based weight formulae, namely APLS, Argyll, and Luscombe, overestimated the weight among the Indian children, clearly showing the need to adjust the formulae for accurate weight estimation of Indian children.

Keywords: Age-based weight estimation, Paediatric emergency, APLS, Argall, Luscombe

INTRODUCTION

Weight estimation in paediatric emergencies is often required to calculate drug dosages, fluid therapy, and optimal resuscitation/defibrillation.[1] Inaccurate weight estimations may lead to suboptimal response or increased adverse events and toxicity to interventions.[2] The 'gold standard' of actually weighing the patient is not practically possible in emergency conditions. Many formulae have been developed in an attempt to accurately estimate a child's weight using age, like Advance Paediatric Life Support guidelines, APLS, Luscombe, and Argall's modification.[3-5] All age-based weight formulae have been derived and validated in the western paediatric population. However, these formulae might not apply to a developing country like India, where the prevalence of malnutrition is still on the higher side. As per the National family health survey 2019-20 (NFHS-5), approximately one-fourth (23.7%) of the children under 5 years in India are underweight.[6] As per the National nutritional monitoring bureau, India (NNMB) rural survey conducted in 2012, the overall prevalence of underweight in rural areas was about 45%, and it was significantly higher among 3-5 years (47.9%), compared to 1-3 year children (42.7%).[7] The prevalence of low birth weight among Indian children is

around 18.6% which further aggravates the problem of malnutrition (RSOC 2013).[8] This study aims is to validate standard age-based formulae (APLS, Luscombe, and Argall's) and their accuracy in estimating the weight of Indian children.

METHODS

The study was based on the utilization of secondary data from the fourth round of the National family health survey (2015-16), the Indian version of the demographic and health survey (DHS).[9] NFHS-4 survey is a countrywide representative survey that provides child weight covering all the districts from 37 States and UTs. For the NFHS-4 survey, Census 2011 served as the sampling frame for selecting primary sample unit (PSUs). PSUs were villages in rural areas and census enumeration blocks (CEBs) in urban areas. PSUs with fewer than 40 households were clubbed with the nearest PSU. The survey adopted a stratified two-stage sample design to select a representative sample of households. Children aged up to 5 years were included in this study and the estimated weight based on APLS, 2 (age in years + 4), Luscombe (3xage in years) +7, and Argall (3(age in years +2) formulae were calculated for each child and documented by rounding up the age at last birthday. Children with conditions that could affect the weight (amputation, dwarfism, severe joint contractures, or neurologic defects known to affect growth, e.g., cerebral palsy, oedema); children with any chronic disease, uncooperative children, and severe acute malnutrition were excluded from this study. The mean percentage weight difference between the measured weight and the estimated weight was also determined. Finally, this study analysis considered 171,738 live births among age 7-59 months in the five years preceding the survey were considered.

Data analysis

Categorical data are presented as figures, mean with standard deviation. The mean percentage weight difference between the measured and estimated weight was calculated by the formula: measured weight – estimated weight / measured weight x 100. Data were analysed using SPSS software version 20.

RESULTS

Total 1,71,738 children up to the age of 5 years met the eligibility criteria for the study. The mean measured weight up to the age of 5 years was 11.41 kg. All three formulae (APLS, Luscombe, and Argall) overestimated the weights. APLS formulae overestimated the weight by 3.51 kg. The least overestimation was -0.75±1.7 kg by Argall formulae up to 1 year of age. The mean difference in weights by Luscombe and Argall formulae were -4.09 kg and -6.5 kg, respectively. Thus, Luscombe and Argall's formulae overestimated the weights in all the age groups. The formula with the least weight difference among the different age groups was the APLS formula (-3.51±2.08). Accuracy was also compared by calculating the percentage differences between the estimated weights from each formula and the measured (actual) weights of the patients.

Table 1: Comparison of APLS, Luscombe and Argall formulae from NFHS-4 data (2015-2016).

Age in years	Number of subjects	Mean measured weight (kg)	Mean weight difference in kg (%)		
			APLS 2 (n+4)	Luscombe 3 (n+7)	Argall 3 (n+2)
1	34,396	8.25±1.68	-1.75±1.68 (25)	-1.75±1.68 (25)	-0.75±1.7, (13)
2	38,372	10.10±1.93	-1.89±1.94 (22)	-2.89±1.93 (32)	-1.89±1.93 (22)
3	39,998	11.83±1.95	-2.17±1.95 (21)	-4.17±1.94 (39)	-3.17±1.95 (30)
4	39,483	13.47±2.28	-2.53±2.27 (22)	-5.53±2.28 (45)	-4.53±2.28 (37)
5	19,489	14.49±2.23	-3.51±2.29 (27)	-7.51±2.29 (55)	-6.51±2.29 (48)
Total	1,71,738	11.41±2.92	-3.51±2.08 (23)	-4.09±2.29 (38)	-6.50 ±2.29, (28)

Negative sign implies a mean weight overestimation, if no sign, it represents a mean weight underestimation, n=age in years, %=mean percentage difference between measured weight and estimate weight.

Table 2: Comparison of APLS, Luscombe and Argall formula using Bland-Altman method.

Age (years)	Number of subjects	APLS formula		Luscombe Formula		Argall formula	
		Bias (Estimated measured weight-kg)	95% Limits of agreement	Bias (Estimated measured weight-kg)	95% Limits of agreement	Bias (Estimated measured weight-kg)	95% Limits of agreement
1	34,396	-1.70	-4.72 to 1.33	-1.70	-4.73 to 1.33	-0.70	-3.73 to 2.33
2	38,372	-1.85	-5.25 to 1.55	-2.85	-6.25 to 0.55	-1.85	-5.25 to 1.55
3	39,998	-2.12	-5.41 to 1.66	-4.12	-7.19 to -0.34	-3.12	-6.19 to 0.66
4	39,483	-2.55	-6.69 to 1.59	-5.55	-9.69 to 1.41	-4.55	-8.69 to -0.41
5	19,489	-3.48	-7.7 to -0.84	-7.48	-11.78 to -3.16	-6.48	-10.79 to 2.16
Total	1,71,738	-2.23	-6.10 to 1.64	-4.06	-9.25-1.13	-3.06	-8.25 to 2.13

The average percentage difference between the estimated weights using the APLS formula and the actual weights was 23%, least marked in the one-year age group and most marked in the five-year age group.

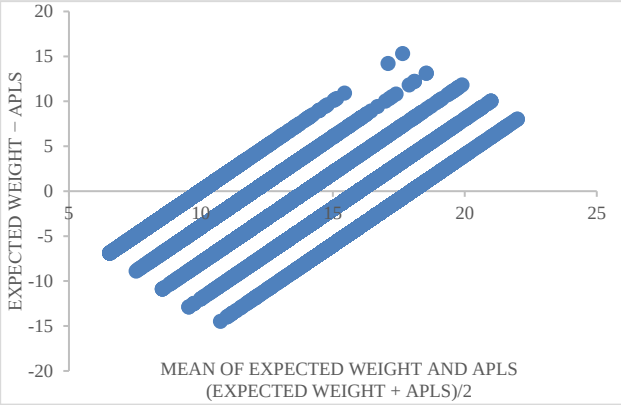

Figure 1 : Bland-Altman plot of measured weight versus APLS estimated weight.

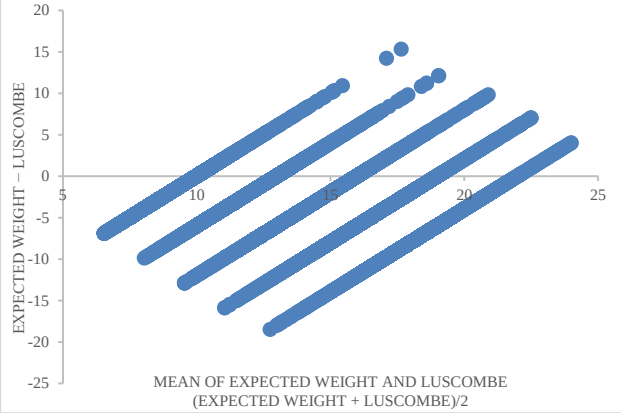

Figure 2: Bland-Altman plot of measured weight versus Luscombe estimated weight.

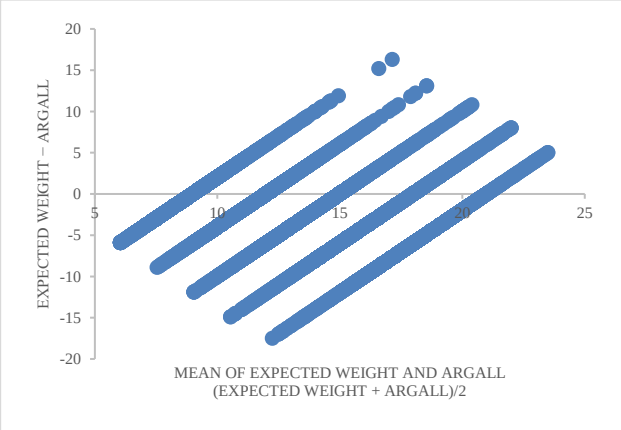

Figure 3: Bland-Altman plot of measured weight versus Argall estimated weight.

The average percentage difference between the estimated weights using the Luscombe and Argall formula and the actual weights was 38% and 28%, respectively. Again, the difference was more marked with the older age groups of children, clearly showing the declining state of nutrition as the age increases.

DISCUSSION

The results indicate that all the three formulae overestimate weights in the Indian children, which can be attributed to multiple reasons. The mean difference between measured weights and the estimated weight in the sample population increases with age. This observation is indicative of a trend that the prevalence of underweight among children in India increases with increasing age. NNMB rural survey also clearly indicates a very high prevalence of moderate acute malnutrition in India, which shows an increasing trend with an increase in age.[7] The above findings can be attributed to the very high prevalence of moderate acute malnutrition in India, up to the tune of 35%.[6] Another challenge to the growth of children is the high rate of very low birth weight (VLBW) in India (20 %) that causes significant mortality and morbidities and most probably affects the normal growth.[8] Varghese et al in their study on estimation of weight based on Argyll, APLS, and Nelson formulae, showed that the formulae overestimate the weight of Indian children, which is similar to our study findings.[9,10] It has been shown by several studies that the APLS formula underestimates weight.[11-14] However, few studies have been conducted in India, and in our study the APLS formulae overestimate the weights by 23%. Among Indian children, Luscombe formulae had the maximum weight overestimation of around 38% (-4.09kg ± 2.29 kg), similar to the study's findings conducted in the ethnic South African population.[13] Contrasting results have been seen in weight estimation by Luscombe formulae among the western population, which have shown that it provided the most accurate weight estimate across the age group of one to ten years.[11,15,16]

CONCLUSION

All three age-based weight formulae, APLS, Argyll, and Luscombe, overestimated the weight among the Indian children, indicating the need to adjust the formulae for accurate weight estimation among Indian children.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Luscombe MD, Owens BD, Burke D. Weight estimation in paediatrics: a comparison of the APLS formula and the formula "Weight=3(age)+7." Emerg Med J. 2011;28(7):590-3.
2. Shah AN, Frush K, Luo X, Wears RL. Effect of an intervention standardization system on pediatric dosing and equipment size determination: A crossover trial

involving simulated resuscitation events. Arch Pediatr Adolesc Med. 2003;23:32-8.
3. Blackwell JO. Structured approach to emergency paediatrics. In: Advanced paediatric life support the practical approach. 5th edn. Netherlands: Elsevier; 2011:14-8.
4. Luscombe M, Owens B. Weight estimation in resuscitation: Is the current formula still valid? Arch Dis Child. 2007.
5. Argall JAW, Wright N, Mackway-Jones K, Jackson R. A comparison of two commonly used methods of weight estimation. Arch Dis Child. 2003;88(9):789-90.
6. National Family Health Survey (NFHS-5). Available at: http://rchiips.org/nfhs/factsheet_NFHS-5.shtml. Accessed on 20 November 2020.
7. National nutrition monitoring bureau (NNMB) Technical Report No. 25. Available at: https://ghdx.healthdata.org/organizations/national-nutrition-monitoring-bureau-india. Accessed on 20 November 2022.
8. Rapid survey on children (RSOC) 2013-14 National Report. Available at: http://wcd.nic.in/issnip/ National_Fact sheet_RSOC _02-07-2015.pdf. Accessed on 20 November 2022.
9. NFHS -4 Research Collaborators. National Family Health Survey-4 (2015-16). Available at: https://ruralindiaonline.org/en/library/resource/national-family-health-survey-nfhs-4-2015-16-India. Accessd on 20 November 2022.
10. Varghese A, Vasudevan VK, Lewin S, Indumathi CK, Dinakar C, Subba Rao SD. Do the Length-based (Broselow) Tape, APLS, Argall and Nelson's Formulae Accurately Estimate Weight of Indian Children? Indian Pediatr. 2006.
11. Luscombe MD, Owens BD, Burke D. Weight estimation in paediatrics: A comparison of the APLS formula and the formula "Weight=3(age)+7." Emerg Med J. 2011;23:32-9.
12. Park J, Kwak YH, Kim DK, Jung JY, Lee JH, Jang HY, et al. A new age-based formula for estimating weight of Korean children. Resuscitation. 2012;32:210-2.
13. House DR, Ngetich E, Vreeman RC, Rusyniak DE. Estimating the weight of children in Kenya: Do the broselow tape and age-based formulas measure up? Ann Emerg Med. 2013;32:23-9.
14. Geduld H, Hodkinson PW, Wallis L a. Validation of weight estimation by age and length based methods in the Western Cape, South Africa population. Emerg Med J. 2011;15:32-8.
15. Kelly AM, Nguyen K, Krieser D. Validation of the Luscombe weight formula for estimating children's weight. Emerg Med Australas. 2011;5:32-9.
16. Argall JAW, Wright N, Mackway-Jones K, Jackson R. A comparison of two commonly used methods of weight estimation. Arch Dis Child. 2003;21:105-9.

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