Acta Med. Okayama, 2016
Vol. 70, No. 4, pp. 255–259

Acta Medica Okayama
http://escholarship.lib.okayama-u.ac.jp/amo/

Original Article

Validity of Mothers' Reports of Children's Weight in Japan

Nobuyuki Nosaka[a,b]*, Takeo Fujiwara[c], Emily Knaup[d], Ayumi Okada[a], and Hirokazu Tsukahara[a]

[a]*Department of Pediatrics, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, and* [d]*Advanced Emergency and Critical Care Medical Center, Okayama University Hospital, Okayama 700–8558, Japan,* [b]*Department of Pediatrics, Ochiai Hospital, Maniwa, Okayama 719–3197, Japan, and* [c]*Department of Social Medicine, National Research Institute for Child Health and Development, Tokyo 157–0074, Japan*

Estimation methods for pediatric weight have not been evaluated for Japanese children. This study aimed to assess the accuracy of mothers' reports of their children's weight in Japan. We also evaluated potential alternatives to the estimation of weight, including the Broselow tape (BT), Advanced Pediatric Life Support (APLS), and Park's formulae. We prospectively collected cross-sectional data on a convenience sample of 237 children aged less than 10 years who presented to a general pediatric outpatient clinic with their mothers. Each weight estimation method was evaluated using Bland–Altman plots and by calculating the proportion within 10% and 20% of the measured weight. Mothers' reports of weight were the most accurate method, with 94.9% within 10% of the measured weight, the lowest mean difference (0.27 kg), and the shortest 95% limit of agreement (−1.4 to 1.9 kg). The BT was the most reliable alternative, followed by APLS and Park's formulae. Mothers' reports of their children's weight are more accurate than other weight estimation methods. When no report of a child's weight by the mother is available, BT is the best alternative. When an aged-based formula is the only option, the APLS formula is preferred.

Key words: body weight, child, estimation techniques, mothers, parents

Accurately determining the weight of pediatric patients is essential for prescribing medications and choosing appropriate medical devices. However, there are many situations, especially in emergency settings, in which determining weight using a scale is not possible, and medical staff involuntarily begin treatment based on information from parents. Some reports have evaluated the reliability of parental estimates of a child's weight. Some of these reports showed these estimates to have high accuracy [1–3], and others showed them to be unreliable [4, 5]. All of these studies were performed outside of Japan. Consequently, there has been no prospective study in Japan that has evaluated the accuracy of parental reports of a child's weight in the setting of an outpatient clinic. Unreliable information could result in errors in medical treatment.

Generally, mothers come with children on clinic visits. Therefore, this study primarily aimed to evaluate the accuracy of mothers' reports of their children's weight in Japan. We also evaluated potential alternatives for estimating a child's weight, such as the Broselow tape [6] and two age-based formulae (the Advanced Pediatric Life Support (APLS) formula [7] and Park's formula [8]).

Received December 1, 2015; accepted March 16, 2016.
*Corresponding author. Phone:+81–86–235–7249; Fax:+81–86–221–4745
E-mail:pv702xz5@s.okayama-u.ac.jp (N. Nosaka)

Conflict of Interest Disclosures: No potential conflict of interest relevant to this article was reported.

Methods

Setting. This was a prospective study conducted in Ochiai Hospital, located in a sparsely populated area in western Japan. This hospital has approximately 10,000 children presenting to its pediatric outpatient clinic annually. This study was approved by the ethics committee of Ochiai Hospital.

Population. The study was conducted in an outpatient clinic in Ochiai Hospital from 10 July, 2014 to 8 January, 2015. One of the authors (NN) was in charge of the outpatient clinic once a week. Data were prospectively collected from medically stable children aged less than 10 years who were accompanied by their mothers. The age was rounded down to the child's age at the last birthday. Children with endocrine or growth disorders, genetic or chromosomal abnormalities, and illnesses requiring resuscitation were not recruited into the study.

Data collection. Each patient's age and sex were recorded. Before any measurements, the mother was asked to report the child's weight. The patient was then measured on a scale (HA-011, Tanita, Tokyo, Japan), wearing minimal clothing and without shoes. Children who could not stand were measured in the supine position (BD-715, Tanita). Height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg. Scales were calibrated before commencement of the study and at its conclusion.

After these data were obtained, the patients' age was used to estimate their weight by the weight estimation methods (Table 1) of the APLS formula [7] and Park's formula [8]. Subsequently, true height measurements were cross-referenced to Broselow tape markings (version 2007 edition B; Armstrong Medical Industries, Inc., Lincolnshire, IL, USA) to derive an estimated weight based on the Broselow tape [9].

The sample size was determined based on Bland's recommendation that a sample size of 100 subjects is adequate, and a sample size of 200 subjects is better, to accurately estimate the limits of agreement (LOA) between 2 methods of measurements [10]. Multiple studies comparing 2 methods of measurement have used this recommendation [10-12].

Table 1 Weight estimation formulae of children

	Age	Formula
APLS†	1-10 years	(age + 4) × 2
Park	<12 months	[(age in month) + 9]/2
	1-4 years	(2 × age) + 9
	5-14 years	(4 × age) − 1

† Advanced Pediatric Life Support.

Outcomes. The primary outcome of this study was to evaluate the accuracy of mothers' reports of their children's weight in the setting of an outpatient clinic in Japan. The secondary outcome was to identify useful alternatives for measuring the weight of Japanese children among various conventional tools, as described above.

Data analysis. Data analysis was performed using Prism 6.0 software (GraphPad Software, San Diego, CA, USA) and Excel for Mac 2011 (Microsoft Corporation, Redmond, WA, USA).

The accuracy and precision of the estimation methods were evaluated using the Bland-Altman method and the proportions of the estimates within 10% and 20% of the true weight (ρ10 and ρ20, respectively). Bland-Altman plots were used to determine the bias and 95% LOA. The bias indicates the mean weight difference between the true and estimated weights. Positive bias indicates underestimation of the weight on average, while negative bias indicates overestimation of the weight on average. The 95% LOA indicates the range in which 95% of the differences between the true and estimated weights will fall [13].

Bland-Altman plots were generated with Prism 6.0 to visually assess the agreement with the measured weight for each estimation method. Ideally, the bias should be zero and the width of the 95% LOA should be as short as possible, as represented by a narrow band around the mean when plotted. A more accurate and precise weight estimation method will also have a larger ρ10 [9].

Results

A total of 237 patients (105 boys; 44.3%) were enrolled in the study. The mean (SD) age was 3.5 (2.7) years. The mean (SD) weight was 15.7 (6.8) kg and the mean (SD) height was 97.1 (20.0) cm. The mean (SD) body mass index of patients was 16.1 (1.8) kg/m^2.

The performance of the 4 weight estimation methods is visually summarized in Bland-Altman plots (Fig. 1). In each graph, the difference between the

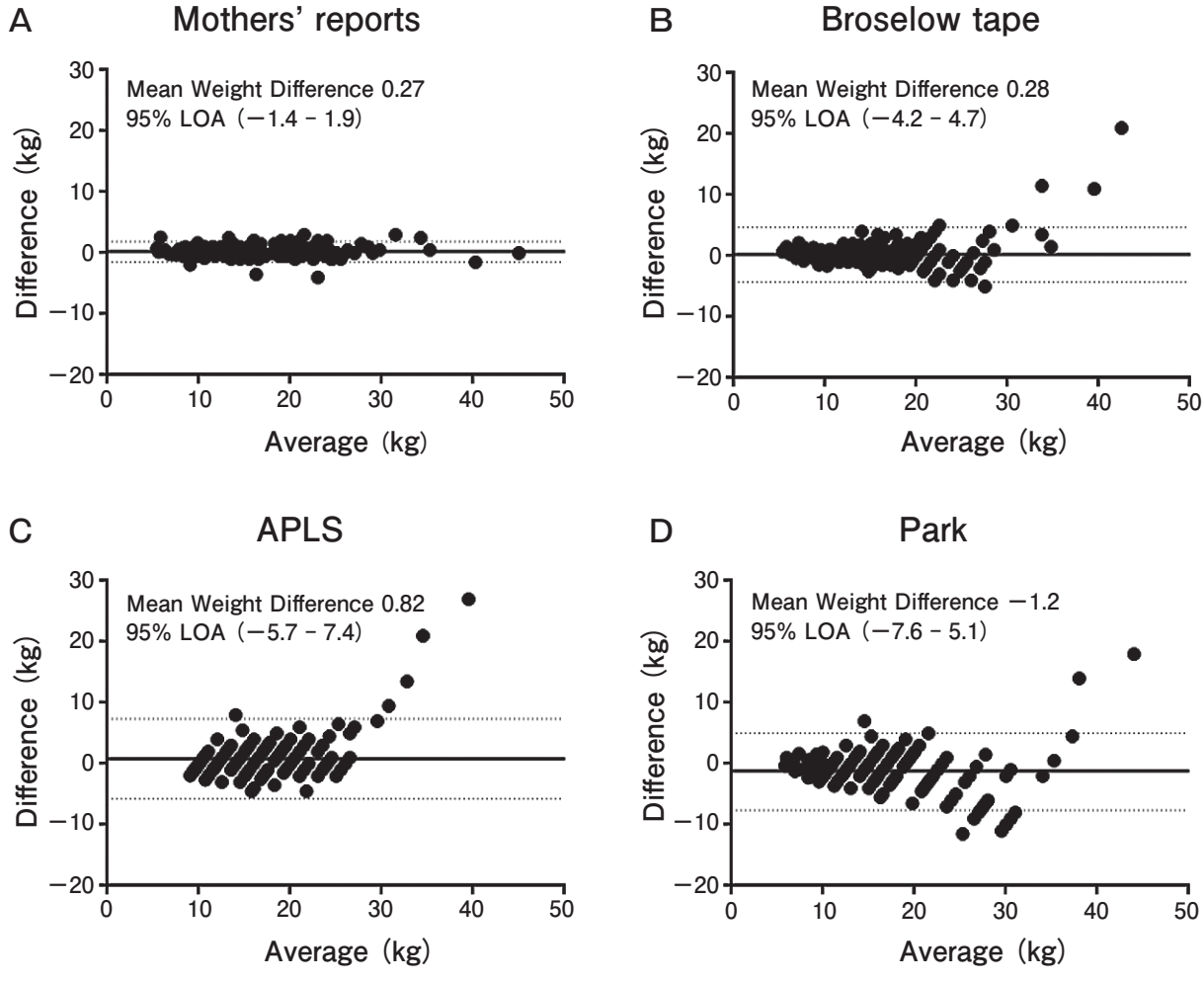

Fig 1 Bland–Altman plots for estimated weight and measured weight. Mothers' reports (**A**), Broselow tape (**B**), APLS formula (**C**), and Park's formula (**D**). For the Bland–Altman plots, the solid line indicates the bias, and the area between the dashed lines denotes the 95% limits of agreement.

measured and estimated weight is plotted against the average weight. The Bland–Altman plot for the mothers' reports was visually the best of all of the graphs. This plot showed that for the mothers' reports the bias was closest to zero and had the shortest 95% LOA. The Bland–Altman plot for the Broselow tape was visually the second-most reliable, with a bias that was the second-closest to zero and the second-shortest 95% LOA. The other plots, which were based on age-based formulae, had larger biases with a wider range of 95% LOA.

Table 2 shows the proportion of estimated weights within 10% (ρ10) and 20% (ρ20) of the measured weight for each method. The mothers' reports were the most optimal, followed by the Broselow tape, the APLS formula, and Park's formula.

Table 2 Proportion of estimated weights within 10% and 20% of the measured weight for each method

	n	ρ10* (95%CI‡)	ρ20* (95%CI‡)
Mothers' report	237	94.9 (91.3 − 97.2)	98.7 (96.2 − 99.7)
Broselow tape	237	75.9 (70.1 − 81.0)	97.5 (94.5 − 99.0)
APLS†	207	63.8 (57.0 − 70.0)	89.9 (84.9 − 93.3)
Park	237	45.1 (38.9−51.5)	75.5 (69.7 − 80.6)

†Advanced Pediatric Life Support, ‡confidential interval, *proportion of estimates within 10% or 20% of the measured weight.

Table 3 shows the performance of the weight esti-

Table 3 Performance of weight estimation methods by age

Age	n	Parental report			Broselow tape			APLS			Park		
		Bias (SD‡)	95% LOA†	ρ10*	Bias (SD‡)	95% LOA†	ρ10*	Bias (SD‡)	95% LOA†	ρ10*	Bias (SD‡)	95% LOA†	ρ10*
0	30	0.22 (0.57)	(−0.89, 1.3)	93.3	0.46 (0.68)	(−0.87, 1.8)	73.3				−0.10 (1.0)	(−2.1, 1.9)	56.7
1	42	0.16 (0.61)	(−1.0, 1.4)	92.9	−0.12 (0.79)	(−1.7, 1.4)	83.3	0.19 (1.7)	(−3.1, 3.5)	64.3	−0.81 (1.7)	(−4.1, 2.5)	40.5
2	33	0.35 (0.54)	(−0.71, 1.4)	97.0	0.24 (1.1)	(−2.0, 2.5)	81.8	0.33 (1.7)	(−3.0, 3.6)	66.7	−0.67 (1.7)	(−4.0, 2.6)	48.5
3	27	0.14 (1.0)	(−1.9, 2.1)	92.6	0.63 (0.99)	(−1.3, 2.6)	77.8	0.59 (1.6)	(−2.5, 3.7)	70.4	−0.41 (1.6)	(−3.5, 2.7)	59.3
4	23	0.45 (0.81)	(−1.1, 2.0)	91.3	0.20 (1.1)	(−2.0, 2.4)	87.0	0.59 (2.0)	(−3.4, 4.6)	47.8	−0.41 (2.0)	(−4.4, 3.6)	47.8
5	28	0.089 (0.97)	(−1.8, 2.0)	96.4	0.27 (1.9)	(−3.4, 3.9)	71.4	0.41 (2.5)	(−4.5, 5.3)	60.7	−0.59 (2.5)	(−5.5, 4.3)	42.9
6	16	0.31 (1.0)	(−1.6, 2.3)	100	0.19 (1.8)	(−3.3, 3.7)	75.0	0.75 (2.0)	(−3.1, 4.6)	68.8	−2.3 (2.0)	(−6.1, 1.6)	56.3
7	13	0.42 (0.74)	(−1.0, 1.9)	100	−0.31 (2.3)	(−4.8, 4.2)	76.9	0.46 (2.7)	(−4.9, 5.8)	78.6	−4.5 (2.7)	(−9.9, 0.79)	23.1
8	14	0.21 (1.1)	(−1.9, 2.3)	92.9	−0.75 (4.2)	(−8.9, 7.4)	42.9	2.0 (6.2)	(−10, 14)	64.3	−5.0 (6.2)	(−17, 7.2)	21.4
9	11	0.77 (1.4)	(−1.9, 3.5)	100	2.8 (7.5)	(−12, 17)	63.6	5.9 (8.8)	(−11, 23)	54.5	−3.1 (8.8)	(−20, 14)	27.3

†Limits of agreement, *proportion of estimates within 10% of the true weight, ‡standard deviation.

mation methods by age. While the mothers' reports maintained their accuracy across the age range, the performance of the other methods, especially the performance of the age-based formulae, decreased with increasing age, particularly with children older than 7 years of age.

Discussion

We found that the mothers' reports were the most accurate for estimating the weight of pediatric patients. This study showed the validity of mothers' reports of children's weight in Japan for the first time. Further, in the present study, the accuracy of the mothers' reports was higher, with a 94.9% accuracy to within 10% of the measured weight, compared with previous studies outside of Japan [1-3]. Easier access to medical facilities, close, regular, medical check systems for children, and a high prevalence of weight scales in homes, accompanied by the current widespread interest in physical fitness might be the reasons for this excellent accuracy.

Our study showed that the Broselow tape should be the second choice when the measured weight is unavailable. Many studies in the setting of the emergency department have shown that the Broselow tape performs better than age-based formulae [9]. The advantage of the Broselow tape over age-based formulae is also accepted in Japan. Based on this result, we recommend that the Broselow tape should be ready for use in pediatric clinics or ambulances, although further studies in multiple facilities are warranted to evaluate the usability of the Broselow tape for Japanese children.

The current study included the evaluation of age-based formulae. We used the APLS formula because many previous studies, most of which were performed in Western countries, have used this formula. Some studies have shown that the accuracy of the APLS formula is poor [2, 14, 15]. Therefore, new formulae have been created [8, 16]. The current study, however, showed a relatively good performance of the APLS formula in the Japanese population. Moreover, the estimation of weight with the APLS formula is better than those of other age-based formulae, such as the Leffler formula (data not shown). The ethnicity of the subjects might be the reason for this difference between studies. The performance of each weight

estimation formula that was created based on a Western population must be evaluated when it is adapted for Japanese children. Therefore, we used Park's formula in our study. This formula was created based on the Korean pediatric population [8], which should be ethnically close to the Japanese population. However, the accuracy of Park's formula was lower than that of the APLS formula, in contrast with our expectations. Park's formula tends to overestimate the weights of Japanese children. The reasons for this finding were not explored in our study.

For the APLS formula, Park's formula, and the Broselow tape, there was a general decreasing trend in the proportion of estimates that were accurate to within 10% as the age of the child increased in our study. This same tendency was found and discussed in other previous studies of weight estimation [9, 17]. This tendency may be due to body habitus. Further elucidation of these trends is required in order to adapt these methods to school-age children in Japan.

This study has several limitations that must be considered when interpreting the results. First, our data were collected from mothers in a general outpatient clinic, under conditions that were not very stressful. Under stressful conditions (*e.g.*, if the children are critically unwell), the mothers may not be as capable. Second, the Broselow tape itself was not directly used on children in this study. Third, the number of patients was too small to draw a strong conclusion about the differences in the performance of the weight estimation methods by age. Fourth, the validity of reports by fathers or grandparents needs to be assessed in future studies. Finally, this study was performed in a single outpatient clinic in a sparsely populated area in Japan. We are currently preparing for our next study on weight estimation methods that will involve a larger number of patients and multiple pediatric emergency departments in different areas in Japan.

In conclusion, the use of the mother's report of a child's weight appears to be appropriate in the setting of an outpatient clinic when the child cannot be weighed. When the child's weight cannot be estimated, the Broselow tape is the second choice. When an aged-based formula is the only option, the APLS formula is preferred, although its adaptation to school-age children may have a risk of low accuracy.

Acknowledgments. The authors declare no financial support for our research. The authors would like to thank Ms. Sawayo Maeda, Ms. Midori Nakagami, and Ms. Yoshiko Hirayama in the Pediatric Department of Ochiai Hospital for their efforts in collecting data.

References

1. Goldman RD, Buskin S and Augarten A: Parental estimates of their child's weight: accurate for resuscitation drug doses. Pediatr Emerg Care (1999) 15: 19–21.
2. Krieser D, Nguyen K, Kerr D, Jolley D, Clooney M and Kelly AM: Parental weight estimation of their child's weight is more accurate than other weight estimation methods for determining children's weight in an emergency department? Emerg Med J (2007) 24: 756–759.
3. Leffler S and Hayes M: Analysis of parental estimates of children's weights in the ED. Ann Emerg Med (1997) 30: 167–170.
4. Harris M, Patterson J and Morse J: Doctors, nurses, and parents are equally poor at estimating pediatric weights. Pediatr Emerg Care (1999) 15: 17–18.
5. Partridge RL, Abramo TJ, Haggarty KA, Hearn R, Sutton KL, An AQ and Givens TG: Analysis of parental and nurse weight estimates of children in the pediatric emergency department. Pediatr Emerg Care (2009) 25: 816–818.
6. Deboer S, Seaver M and Broselow J: Color coding to reduce errors. Am J Nurs (2005) 105: 68–71.
7. Mackway-Jones K and Advanced Life Support Group: Advanced Paediatric Life Support: The Practical Approach. 4th Ed. Blackwell, Malden (2005) pp7–13.
8. Park J, Kwak YH, Kim do K, Jung JY, Lee JH, Jang HY, Kim HB and Hong KJ: A new age-based formula for estimating weight of Korean children. Resuscitation (2012) 83: 1129–1134.
9. Loo PY, Chong SL, Lek N, Bautista D and Ng KC: Evaluation of three paediatric weight estimation methods in Singapore. J Paediatr Child Health (2013) 49: E311–316.
10. Young TP, Chen BG, Kim TY, Thorp AW and Brown L: Finger counting: an alternative method for estimating pediatric weights. Am J Emerg Med (2014) 32: 243–247.
11. Silveiro SP, Araujo GN, Ferreira MN, Souza FD, Yamaguchi HM and Camargo EG: Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation pronouncedly underestimates glomerular filtration rate in type 2 diabetes. Diabetes Care (2011) 34: 2353–2355.
12. Touger M, Birnbaum A, Wang J, Chou K, Pearson D and Bijur P: Performance of the RAD-57 pulse CO-oximeter compared with standard laboratory carboxyhemoglobin measurement. Ann Emerg Med (2010) 56: 382–388.
13. Bland JM and Altman DG: Statistical methods for assessing agreement between two methods of clinical measurement. Lancet (1986) 1: 307–310.
14. Dearlove CB and Dearlove O: Visual estimation of children's weights. Anaesthesia (1999) 54: 1228–1229.
15. Black K, Barnett P, Wolfe R and Young S: Are methods used to estimate weight in children accurate? Emerg Med (Fremantle) (2002) 14: 160–165.
16. Argall JA, Wright N, Mackway-Jones K and Jackson R: A comparison of two commonly used methods of weight estimation. Arch Dis Child (2003) 88: 789–790.
17. Theron L, Adams A, Jansen K and Robinson E: Emergency weight estimation in Pacific Island and Maori children who are large-for-age. Emerg Med Australas (2005) 17: 238–243.