Sultan Qaboos University Med J, May 2017, Vol. 17, Iss. 4, pp. e191–195, Epub. 20 Jun 17
Submitted 25 Aug 16
Revisions Req. 18 Oct & 5 Dec 16; Revisions Recd. 7 Nov 16 & 18 Jan 17
Accepted 5 Feb 17
doi: 10.18295/squmj.2016.17.02.009

CLINICAL & BASIC RESEARCH

The Accuracy of the Broselow™ Pediatric Emergency Tape for Weight Estimation in an Omani Paediatric Population

*Azher A. Al-Busaidi,[1] Lakshmanan Jeyaseelan,[2] Hilal M. Al-Barwani[3]

دقة شريط الطوارئ بروسلو للأطفال لتقدير أوزان الأطفال العمانيين

أزهر بن أحمد البوسعيدي، لاكشمنان جاياسلان، هلال بن محمد البرواني

abstract: ***Objectives:*** This study aimed to evaluate the accuracy of the Broselow™ Pediatric Emergency Tape (BT) for estimating weight in an Omani paediatric population at a tertiary care hospital. ***Methods:*** This retrospective cross-sectional study was conducted during July 2015. The electronic medical records of Omani outpatients <14 years old attending the Sultan Qaboos University Hospital, Muscat, Oman, between July 2009 and June 2013 were reviewed for recorded height and weight data. The BT Version 2002A was used to predict weight based on actual height measurements. Predicted weight measurements were then compared with actual weight to determine the accuracy of the estimation. ***Results:*** A total of 3,339 children were included in the study, of which 43.5% were female and 56.5% were male. The mean age was 6.4 ± 3.1 years and the mean height was 93.2 ± 23.5 cm. The mean actual weight was 13.9 ± 6.7 kg while the mean BT-predicted weight was 14.4 ± 6.9 kg. The BT-predicted weight estimations correlated significantly with actual weight measurements (intraclass correlation coefficient: 0.97; *P* <0.001). A Bland-Altman analysis indicated that the BT performed well when estimating weight among Omani children, with an overestimation of only 0.5 kg for the entire cohort. ***Conclusion:*** The BT was found to be an effective tool for estimating weight according to body length in an Omani paediatric population. It should therefore be considered for use in emergency situations when actual weight cannot be determined.

Keywords: Paediatrics; Body Weight; Body Height; Emergency Medicine; Oman.

الملخص: الهدف: هدفت الدراسة لتقييم دقة شريط بروسلو في تقدير أوزان الأطفال العمانيين في مستشفى رعاية ثالثية. الطريقة: تم إجراء هذه الدراسة المستعرضة بأثر رجعي خلال شهر يوليو 2015. تمت مراجعة السجلات الطبية الإلكترونية للمرضى الخارجيين العمانيين الذين تقل أعمارهم عن 14 عاما والذين كانوا يعالجون في مستشفى جامعة السلطان قابوس، مسقط، عمان، بين يوليو 2009 ويونيو 2013 واستخلاص بيانات الطول والوزن المسجلة. تم استخدام شريط بروسلو (النسخة 2002A) للتنبؤ بالوزن على أساس قياسات الطول الفعلي. تمت مقارنة قياسات الوزن المتوقعة بعد ذلك مع الوزن الفعلي لتحديد دقة التقدير. **النتائج:** شملت الدراسة 3,339 طفلا، منهم 43.5% في المائة من الإناث و 56.5% في المائة من الذكور. متوسط العمر في العينة 3.1 ± 6.4 سنة و متوسط الأطوال 23.5 ± 93.2 سم ومتوسط الأوزان 6.7 ± 13.9 كجم ومتوسط الأوزان المقدرة بشريط بروسلو 6.9 ± 14.4 كجم. يرتبط الوزن المقدر لشريط برسلو بشكل ملحوظ بالوزن الحقيقي (P <0.001؛ intraclass correlation coefficient: 0.97). تحليل بلاند-ألتمان أظهر أن أداء شريط بروسلو يقارب قياس الوزن الحقيقي ولا يزيد عن الوزن الحقيقي إلا بقدار 0.5 كجم في كامل عينات الدراسة. **الخلاصة:** أثبتت الدراسة دقة شريط بروسلو كأداة لتقدير أوزان الأطفال العمانيين باستخدام الطول. ولذلك ينبغي النظر في استخدامها في حالات الطوارئ عندما لا يمكن تحديد الوزن الفعلي.

الكلمات المفتاحية: أطفال؛ وزن الجسم؛ طول الجسم؛ طب الطوارئ؛ عمان.

Advances in Knowledge

- *To the best of the authors' knowledge, this is the first study from Oman to investigate the accuracy of the Broselow™ Pediatric Emergency Tape (BT) in a paediatric population.*

Application to Patient Care:

- *The results of this study indicate that the BT can be used to accurately predict the weight of Omani paediatric patients; this may be useful in emergency situations or during resuscitation.*

In paediatric emergencies, an accurate and rapid estimation of a child's weight is critical as it allows physicians to determine appropriate drug doses, use proportionately sized equipment and establish the level of defibrillation energy necessary.[1–3] Inaccurate weight estimations may have adverse effects, such as causing the patient to become unresponsive or experience toxicity during certain interventions.[4] However, it is often extremely difficult to use traditional methods to determine a paediatric patient's weight during a critical or emergency situation. A variety of methods have therefore been developed over the years to rapidly estimate a child's weight.[5–7]

[1]*Department of Emergency Medicine, Rustaq Hospital, Rustaq, Oman; Departments of* [2]*Statistics & Health Information and* [3]*Emergency Medicine, Sultan Qaboos University Hospital, Muscat, Oman*

**Corresponding Author e-mail: u038664@gmail.com*

The Broselow™ Pediatric Emergency Tape (BT) was developed in the late 1970s as a tool to determine a child's weight based on height calculated by measuring the head-to-heel body length while the patient is in a supine position.[8,9] Subsequently, the tool sorts children into weight categories based on their length, with each category assigned a colour that corresponds to a list of proportionally-sized equipment, appropriate doses of emergency drugs and safe levels of defibrillation energy.[8,9] The BT is now the standard method for estimating paediatric weight in many emergency departments, as it reduces the need for recalling complicated weight estimation equations or calculations in an emergency situation.[10–12] It has been recommended by both the American College of Surgeons and the American Heart Association for use in their Advanced Trauma Life Support® and Pediatric Advanced Life Support® courses.[13,14]

Although originally developed using data from a Western population, recent studies from the USA and Canada now indicate that the BT may significantly underestimate weight due to the rising prevalence of childhood obesity.[15,16] In addition, to the best of the authors' knowledge, no studies have yet been performed to assess the accuracy of the BT in estimating weight in an Omani paediatric population. Nevertheless, the BT is still used in Oman to gauge weight during paediatric emergencies. As such, this study therefore aimed to determine the accuracy of the BT Version 2002A in estimating weight among an Omani paediatric population.

Methods

This retrospective cross-sectional study took place in July 2015 at the Sultan Qaboos University Hospital (SQUH), a tertiary care institution in Muscat which receives referrals from all over Oman. All paediatric Omani patients <14 years old who visited the general outpatient clinic at SQUH between July 2009 and June 2013 were included in the study. Children were excluded if their weight was >35 kg or their height was outside the recommended range (50–150 cm).[8,9] Patients were also excluded if they had any medical conditions that would substantially affect their weight and/or height, such as an amputation, dwarfism, a growth hormone deficiency, metabolic disease, severe joint contractures or neurological defects like cerebral palsy. In order to obtain an intraclass correlation (ICC) of 0.8 to compare BT weight estimations with actual weight, the required sample size was calculated to be 300 subjects, assuming an ICC of 0.7, with α and β errors at 5% and 10%, respectively, and an expected dropout rate of 10%. However, as many subgroup analyses were planned, a minimum of 3,000 subjects was deemed necessary.

Hospital electronic medical records were reviewed to collect data for all eligible subjects during their initial outpatient visit. All children were weighed on a standard calibrated paediatric scale and their height was measured using a stadiometer. For children <2 years old, recumbent length was measured using a standard medical measuring tape and weight was calculated using an electronic infant scale while the child was wearing diapers. Weight and body length/height were measured to the nearest 0.1 kg and 1 cm, respectively. During the retrospective chart review, patient information was collected using a data sheet, including their name, medical record number, age in years, gender, body length/height and weight. The 2002A version of the BT was then used to estimate the weight of each patient based on actual body length/height measurements collected from medical records. A regression analysis was used to predict weight using the BT.

Subsequently, actual weight measurements were compared with BT-predicted weight estimates using ICC calculations and a scatter plot. A Bland-Altman plot was also used to determine whether differences were randomly distributed over the range of average weight, with averages of the actual weight and BT-predicted weight plotted on the x-axis and differences between the actual weight and BT-predicted weight plotted on the y-axis.[17–19] To ensure accurate results, other indices such as bias, precision and percentage errors were also calculated.[20] Statistical software including R software, Version 3.2.2 (R Foundation for Statistical

Table 1: Mean age, height and weight according to gender of Omani paediatric outpatients at the Sultan Qaboos University Hospital, Muscat, Oman (N = 3,339)

Characteristic	Mean ± SD		
	Female (n = 1,451)	Male (n = 1,888)	Total
Age in years	6.4 ± 3.2	6.3 ± 3.2	6.4 ± 3.1
Height in cm	92.7 ± 24.2	93.6 ± 23.0	93.2 ± 23.5
Actual weight in kg	13.7 ± 7.0	14.1 ± 6.6	13.9 ± 6.7
BT-predicted weight in kg	14.3 ± 6.9	14.5 ± 6.9	14.4 ± 6.9
Weight difference in kg*	-0.5 ± 2.2	-0.4 ± 1.8	-0.5 ± 1.9
Average weight in kg†	14.0 ± 6.9	14.3 ± 6.7	14.1 ± 6.7

*SD = standard deviation; BT = Broselow™ Pediatric Emergency Tape. *Difference between actual weight and BT-predicted weight. †Average of actual weight and BT-predicted weight.*

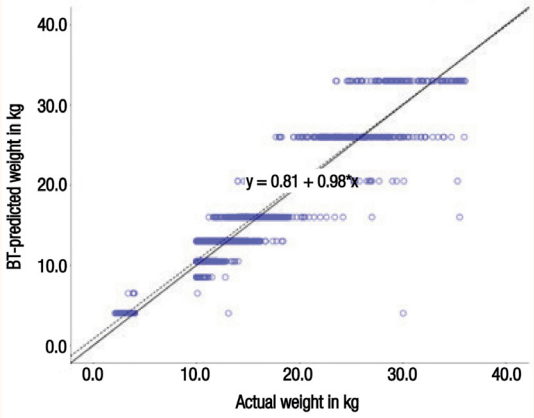

Figure 1: Scatterplot comparing actual weight measurements with predicted weight estimates using the Broselow™ Pediatric Emergency Tape among Omani paediatric outpatients at the Sultan Qaboos University Hospital, Muscat, Oman (N = 3,339).

BT = Broselow™ Pediatric Emergency Tape.

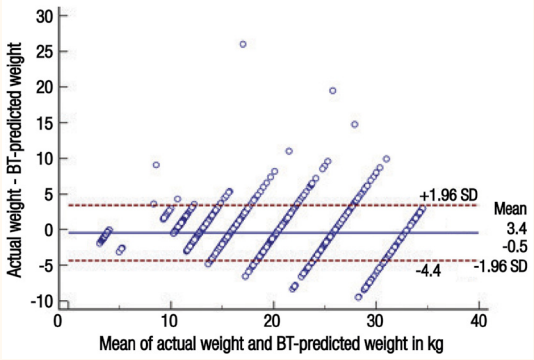

Figure 2: Bland-Altman plot comparing the mean weights of actual weight measurements and predicted weight estimates using the Broselow™ Pediatric Emergency Tape (BT) with the differences between actual weight and BT-predicted weight among Omani paediatric outpatients at the Sultan Qaboos University Hospital, Muscat, Oman (N = 3,339).

BT = Broselow™ Pediatric Emergency Tape; SD = standard deviation.

Computing, Vienna, Austria) and the Statistical Package of the Social Sciences (SPSS), Version 22 (IBM Corp., Armonk, New York, USA) was used for the analysis.

This study received ethical approval from the Research & Ethics Committee of the College of Medicine & Health Sciences, Sultan Qaboos University (MREC #1024).

Results

A total of 3,339 children were included in the study. Of these, 1,451 (43.5%) were female and 1,888 (56.5%) were male. The majority of the participants were 5–9 years old (53.9%), while 28.8% were ≤5 years old and 17.0% were ≥10 years old. The mean age was 6.4 ± 3.1 years and the mean height was 93.2 ± 23.5 cm. The mean actual weight was 13.9 ± 6.7 kg, while the mean BT-predicted weight was 14.4 ± 6.9 kg. The mean difference between actual weight and BT-predicted weight was -0.5 ± 1.9 kg. The combined average of both actual and BT-predicted weight was 14.1 ± 6.7 kg [Table 1].

The ICC of the actual weight and BT-predicted weight measurements was 0.97 (ICC coefficient: 0.97–0.98; P <0.001). A scatter plot of actual weight measurements and BT-predicted weight estimates is shown in Figure 1. The linear regression equation was as follows:

$$\text{predicted weight} = 0.81 + 0.98 \times W$$

where W is the actual weight. This equation implies that a 1 kg increase in actual weight results in a 0.9 kg increase in BT-predicted weight, with a near-perfect correlation between the two measurements. The Bland Altman plot is shown in Figure 2.

The mean bias was -0.49 ± 1.98 (95% confidence interval: -2.46–1.50) with the limits of agreement at -4.37 and 3.40. A total of 53.7% and 85.4% of the BT-predicted weight estimates fell within 10% and 20% of the actual weights, respectively. The precision of the BT-predicted weight estimates was 3.9% and the percentage of error was 27.9%. For children weighing <15 kg, the overestimation was negligible; however, when the actual weight was 15–25 kg, a small difference between actual and BT-predicted weight was observed. Nevertheless, as the percentage of error was within 30%, BT-predicted weight estimation was deemed very reliable and comparable to actual weight measurements.[18,19]

Discussion

In emergency situations, the accurate measurement or estimation of weight is a difficult yet crucial task to select proportionately sized equipment and administer the correct drug doses for paediatric patients.[1–3] The BT is an accessible and unbiased tool to estimate a child's weight based on their body length/height and is useful during paediatric resuscitation.[8,9] However, as the BT was not specifically developed for Omani children, it is important to determine its accuracy among this specific population. Using the BT Version 2002A, the results of this study confirmed that BT-predicted weight estimates correlate with actual weight in an Omani paediatric population. These findings are in agreement with those reported by other studies conducted in various parts of the world, including Saudi Arabia, Korea, the USA, India and Kenya.[2,8,21–24] Furthermore, other indices also suggested that the

BT sufficiently predicts actual weight. Although the BT slightly overestimated the actual weight of the population in the current study by 0.5 kg, the percentage of error still fell within acceptable limits at <30%.[18,19] Nevertheless, while overestimation was negligible in smaller children weighing <15 kg, it was more pronounced in children weighing between 15–25 kg. This implies that the BT performs better in lighter children, a finding which has also been reported in other studies.[2,7,8,21,23–27]

The BT has been shown to perform differently in various populations. Two studies from India and a study from south Sudan have reported that the BT overestimates weight.[28–30] As a result, some researchers have advised that certain adjustments be made to the BT to improve its accuracy for these particular populations.[28,29] Conversely, studies from more economically developed countries have found that the BT tends to underestimate weight among paediatric populations.[5,15,25,31,32] These contradictory data may reflect the increasing prevalence of obesity in more developed countries.[15,16]

The strengths of the current study include its large sample size and the collection of data from a tertiary care centre which receives referrals from all over the country. Therefore, the subjects included in this study may be considered representative of the general Omani paediatric population. However, a potential limitation of this study was the assumption that the sample population were of the same weight as children who require resuscitation. Furthermore, the most recent version of the BT, the BT Version 2011, was not used to estimate weight. This is because the BT Version 2002A is currently used at SQUH in emergency settings. Moreover, intra-rater reliability was also not estimated and the study was conducted in only one hospital.

Conclusion

The BT was found to accurately predict weight in an Omani paediatric population. As such, it can be considered an effective tool to estimate paediatric weight in emergency situations where the actual weight of the child cannot be easily determined. Accurate weight estimation allows physicians to administer the correct drug doses, use proportionately sized instruments and determine safe shock levels for defibrillation when treating critically ill children.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

FUNDING

No funding was received for this study.

References

1. ECC Committee, Subcommittees and Task Forces of the American Heart Association. 2005 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2005; 112: IV1–203. doi: 10.1161/CIRCULATIONAHA.105.166550.
2. Hofer CK, Ganter M, Tucci M, Klaghfer R, Zollinger A. How reliable is length-based determination of body weight and tracheal tube size in the paediatric age group? The Broselow tape reconsidered. Br J Anaesth 2002; 88:283–5. doi: 10.1093/bja/88.2.283.
3. Davis D, Barbee L, Ririe D. Pediatric endotracheal tube selection: A comparison of age-based and height-based criteria. AANA J 1998; 66:299–303.
4. 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; 157:229–36. doi: 10.1001/archpedi.157.3.229.
5. Black K, Barnett P, Wolfe R, Young S. Are methods used to estimate weight in children accurate? Emerg Med (Fremantle) 2002; 14:160–5. doi: 10.1046/j.1442-2026.2002.00311.x.
6. DuBois D, Baldwin S, King WD. Accuracy of weight estimation methods for children. Pediatr Emerg Care 2007; 23:227–30. doi: 10.1097/PEC.0b013e31803f5aca.
7. Argall JA, Wright N, Mackway-Jones K, Jackson R. A comparison of two commonly used methods of weight estimation. Arch Dis Child 2003; 88:789–90. doi: 10.1136/adc.88.9.789.
8. Lubitz DS, Seidel JS, Chameides L, Luten RC, Zaritsky AL, Campbell FW. A rapid method for estimating weight and resuscitation drug dosages from length in the pediatric age group. Ann Emerg Med 1988; 17:576–81. doi: 10.1016/S0196-0644(88)80396-2.
9. Luten RC, Wears RL, Broselow J, Zaritsky A, Barnett TM, Lee T, et al. Length-based endotracheal tube and emergency equipment in pediatrics. Ann Emerg Med 1992; 21:900–4. doi: 10.1016/S0196-0644(05)82924-5.
10. Agarwal S, Swanson S, Murphy A, Yaeger K, Sharek P, Halamek LP. Comparing the utility of a standard pediatric resuscitation cart with a pediatric resuscitation cart based on the Broselow tape: A randomized, controlled, crossover trial involving simulated resuscitation scenarios. Pediatrics 2005; 116:e326–33. doi: 10.1542/peds.2005-0320.
11. Chavez H, Peterson RE, Lo K, Arel M. Weight estimation in an inner-city pediatric ED: The effect of obesity. Am J Emerg Med 2015; 33:1364–7. doi: 10.1016/j.ajem.2015.07.040.
12. Khouli M, Ortiz MI, Romo-Hernández G, Martínez-Licona D, Stelzner SM. Use of the Broselow tape in a Mexican emergency department. J Emerg Med 2015; 48:660–6. doi: 10.1016/j.jemermed.2014.12.082.
13. American College of Surgeons. Advanced Trauma Life Support: ATLS® student course manual, 9th ed. Chicago, Illinois, USA: American College of Surgeons, 2012. P. 250.
14. Leon C, Samson RA, Schexnayder SM, Hazinski MF. Pediatric Advanced Life Support: Provider manual. Dallas, Texas, USA: American Heart Association, 2012. P. 91.
15. Milne WK, Yasin A, Knight J, Noel D, Lubell R, Filler G. Ontario children have outgrown the Broselow tape. CJEM 2012; 14:25–30. doi: 10.2310/8000.2011.110523.

16. Nieman CT, Manacci CF, Super DM, Mancuso C, Fallon WF Jr. Use of the Broselow tape may result in the underresuscitation of children. Acad Emerg Med 2006; 13:1011–19. doi: 10.1197/j.aem.2006.06.042.

17. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986; 1:307–10. doi: 10.1016/s0140-6736(86)90837-8.

18. Bland JM, Altman DG. Comparing methods of measurement: Why plotting difference against standard method is misleading. Lancet 1995; 346:1085–7. doi: 10.1016/s0140-6736(95)91748-9.

19. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res 1999; 8:135–60. doi: 10.1177/096228029900800204.

20. Cecconi M, Rhodes A, Poloniecki J, Della Rocca G, Grounds RM. Bench-to-bedside review: The importance of the precision of the reference technique in method comparison studies – With specific reference to the measurement of cardiac output. Crit Care 2009; 13:201. doi: 10.1186/cc7129.

21. Varghese A, Vasudevan VK, Lewin S, Indumathi CK, Dinakar C, Rao SD. Do the length-based (Broselow) tape, APLS, Argall and Nelson's formulae accurately estimate weight of Indian children? Indian Pediatr 2006; 43:889–94.

22. Jang HY, Shin SD, Kwak YH. Can the Broselow tape be used to estimate weight and endotracheal tube size in Korean children? Acad Emerg Med 2007; 14:489–91. doi: 10.1111/j.1553-2712.2007.tb01814.x.

23. 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; 61:1–8. doi: 10.1016/j.annemergmed.2012.07.110.

24. AlHarbi TM, AlGarni A, AlGamdi F, Jawish M, Wani TA, Abu-Shaheen AK. The accuracy of Broselow tape weight estimate among paediatric population. Biomed Res Int 2016; 2016:7042947. doi: 10.1155/2016/7042947.

25. Theron L, Adams A, Jansen K, Robinson E. Emergency weight estimation in Pacific Island and Maori children who are large-for-age. Emerg Med Australas 2005; 17:238–43. doi: 10.1111/j.1742-6723.2005.00729.x.

26. So TY, Farrington E, Absher RK. Evaluation of the accuracy of different methods used to estimate weights in the pediatric population. Pediatrics 2009; 123:e1045–51. doi: 10.1542/peds.2008-1968.

27. Mishra DG, Kole T, Nagpal R, Smith JP. A correlation analysis of Broselow™ Pediatric Emergency Tape-determined pediatric weight with actual pediatric weight in India. World J Emerg Med 2016; 7:40–3. doi: 10.5847/wjem.j.1920-8642.2016.01.007.

28. Ramarajan N, Krishnamoorthi R, Strehlow M, Quinn J, Mahadevan SV. Internationalizing the Broselow tape: How reliable is weight estimation in Indian children. Acad Emerg Med 2008; 15:431–6. doi: 10.1111/j.1553-2712.2008.00081.x.

29. Asskaryar F, Shankar R. An Indian pediatric emergency weight estimation tool: Prospective adjustment of the Broselow tape. Int J Emerg Med 2015; 8:78. doi: 10.1186/s12245-015-0078-z.

30. Clark MC, Lewis RJ, Fleischman RJ, Ogunniyi AA, Patel DS, Donaldson RI. Accuracy of the Broselow tape in south Sudan, "The hungriest place on Earth". Acad Emerg Med 2016; 23:21–8. doi: 10.1111/acem.12854.

31. Anstett D, Bawden J, Moylette E, Milne WK. Abstract 126: Does the Broselow tape accurately estimate the weight of healthy Irish children? In: 2009 CAEP/ACMU Scientific Abstracts, June 6–10, 2009, Calgary, Alta. CJEM 2009; 11:289. doi: 10.1017/S1481803500011301.

32. Bourdeau S, Copeland J, Milne WK. Accuracy of the Broselow tape in estimating the weight of First Nations children. Can J Rural Med 2011; 16:121–5.