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The accuracy of three weight estimation tools in children

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THE ACCURACY OF THREE WEIGHT ESTIMATION TOOLS IN CHILDREN



Mncedisi Junior Manyoni

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Medicine in Emergency Medicine

Johannesburg 2018

Declaration

I Mncedisi Junior Manyoni declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Emergency Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



.....

(Signature of candidate)

.....6.....day of .....November.....2018.....in..Johannesburg South Africa.....

Dedication

To my wife and family, thank you for all the support and encouragement.

Presentations arising from research project:

Preliminary results were presented at the Emergency Medicine Society of South Africa (EMMSA) conference in Sun City, on the 3rd of August 2017

Publications arising from research project:

Nil

Abstract

BACKGROUND
One of the most important parameters that must be obtained when resuscitating a critically ill or injured paediatric patient is their weight. The best-known paediatric weight estimation system is arguably the Broselow Tape, but the tape has been shown to be very inaccurate.

OBJECTIVES
The study has two objectives, to determine and compare the accuracy of the Broselow tape, a modified Broselow tape system, the PAWPER XL tape and the hanging leg weight technique for potential utilisation in the paediatric resuscitation setting.

METHODS
A convenience sample of 200 children between the ages of 1 month and 16 years were enrolled. All the children's weights were estimated using the Broselow tape, a habitus-modified Broselow tape system, the PAWPER XL tape and the hanging leg weight technique. Overall accuracy was evaluated using the percentage of weight estimations falling within 10% of actual weight (PW10).

RESULTS
The PAWPER XL tape performed the best, whilst the hanging leg weight technique performed the poorest with PW10s of 74% and 19.5%, respectively. The Broselow tape with and without habitus-modification only showed modest accuracy, with PW10s of 59.1% and 61.7% respectively.

CONCLUSIONS
The PAWPER XL tape performed notably better than the Broselow tape, modified Broselow system and the hanging leg weight technique. And is most appropriate for use in South African paediatric emergencies. The Broselow tape's overall accuracy was only modestly improved upon by the habitus-modified Broselow system.

Acknowledgements

The author would like to thank his supervisors (Prof M. Wells and Dr L. Goldstein) for continued guidance in this project.

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Nomenclature

HS	Habitus Score
MPE	Mean Percentage Error
PAWPER	Paediatric Advanced Weight Prediction in the Emergency Room
PW	Percentage of Weight
RMSPE	Root Mean Square Percentage Error

CHAPTER 1

1 Introduction

1.1 Background

One of the most important parameters that must be obtained when resuscitating a critically ill or injured paediatric patient is their weight. The dose of emergency medications, the volume of intravenous fluids such as in burns fluid replacement or the amount of blood and blood products to be infused in the hypotensive paediatric trauma victim as well as the equipment to be utilised, are all determined by the child's weight.[1] Ideally, a calibrated scale would be used to obtain an accurate weight, but during resuscitation this would be difficult as patients may be immobilised on spine boards or undergoing emergency interventions such as intubation.[2] Therefore, healthcare providers need a way to rapidly and accurately estimate a child's weight without impeding or causing delays in resuscitation.

There are numerous ways that have been devised to estimate a paediatric patient's weight such as guesses, age-based formulae and length-based or dual length- and habitus-based methods. The American Heart Association recommends that, in the absence of measured weight, length-based weight estimations be used.[3] The prototype of length-based weight estimation is the Broselow tape, which, apart from the estimated weight, also provides pre-calculated drug dosages and equipment size recommendations[4]. The major drawback of the Broselow tape is that its drug dosages are based on ideal body weight and not a child's actual weight. Therefore, there are inherent risks of under- and over-dosing medications in patients with higher or lower than average weight-for-length, respectively. Body habitus needs to be considered as weight based on length alone has the potential to result in substantial drug dosing errors.[5] In order to limit these effects in obese children, the manufacturers of the Broselow tape have suggested the use of a visual estimate to allow the examiner to take the body habitus into account and "bump (the child) up" a colour zone for weight estimation and drug dosing purposes.[6] The accuracy of this technique has only been evaluated once before.[7]

As a result of the limitations of length-based weight estimation, Wells at el developed a dual length- and habitus-based weight estimation tool, the PAWPER (Paediatric Advanced Weight Prediction in the Emergency Room) tape, which takes body habitus into account when estimating weight. It allows the examiner to adjust the weight estimation up or down depending on the child's habitus. It has performed better than the Broselow tape in multiple previous studies.[2, 5, 8]

The PAWPER tape did not perform as well in a recent study in a very obese population, with an overall accuracy of 64%, failing to achieve the same accuracy as in studies in the rest of the world[9]. As a result, the PAWPER XL tape was developed, which has 7 habitus scores instead of 5 and the length of the tape was extended from 153cm to 180 cm.[10] Further highlighting the significance of body habitus.

Haftel at el. also recognised the importance of body habitus on weight estimation when they described the hanging leg weight technique in 1990. It was one of the most accurate weight estimations ever reported in its initial study, but no subsequent validation study has been done to assess its accuracy. It is performed on supine children whose fully extended lower limbs are suspended by the heels in a sling hung from a calibrated scale. It uses this weight to predict the actual total body weight from a formula: Estimated weight = 5.176 X Leg Weight (kg) + 3.487.[11]

There are numerous tools and techniques used in weight estimation, and during a paediatric patient resuscitation the only thing more important than getting the weight of the patient, is getting an accurate weight for that patient.

1.2 Study Aim and Objectives

The purpose of this study was to determine and compare the accuracy of four paediatric weight estimation modalities in the South African emergency setting: the Broselow tape, a modified Broselow method, the PAWPER XL tape and the hanging leg weight system.

CHAPTER 2

2 Methodology

2.1 Study setting

Our study was conducted in the Chris Hani Baragwanath Academic Hospital paediatric emergency department in Soweto, Johannesburg, South Africa. It is a tertiary institution, which serves a community of low to middle socioeconomic healthcare users.

2.2 Study participants

A convenience sample of 200 participants between the ages of 1 month and 16 years were enrolled between the period 1 November 2016 and 31 March 2017. This number was predicted to be sufficient and able to detect an absolute difference in weight estimation accuracy of 10% between weight estimation systems, with a power of 80% and 95% confidence. Children that required emergency treatment were excluded. Approval to conduct this study was obtained from the Human Research Ethics Committee of the University of the Witwatersrand (M160631). All parents signed informed consent and assent was obtained from children over the age of seven years.

2.3 Study protocol

All data was obtained and recorded by MM, who had received training on the use of the PAWPER XL tape, the Broselow tape and the hanging leg weight technique. Data collection was only started once competence had been achieved. The data collection procedure was the same for each child. The child, accompanied by the guardian, was ushered into an examination room. The child was undressed to his or her underwear and their habitus was estimated with the aid of reference images (supplementary Figure 1) and recorded. The child was then positioned supine on an examination bed. The Broselow tape was used to estimate weight using its standard methodology.[12] Children who were considered to be obese, based on a simple visual assessment of habitus, were "bumped up" a colour zone and this weight was recorded as their modified Broselow tape estimated weight.[6]
Their weight was next estimated using the standard PAWPER XL tape using the PAWPER methodology.[2] The children's legs were then put in a sling and weighed; this was recorded as the predicted weight for the hanging leg weight technique.[11] Lastly, the children were put on a calibrated scale (SECA 769 COLUMN SCALE) to get their actual weight, which was documented and used as the reference standard.

2.4 Data analysis

Children were categorised for subgroup-analysis based on their weight-status and age. The weight categories were based on the habitus score (HS): HS3 represented children of average weight, greater than HS3 represented overweight and less than HS3 represented underweight children. Age-categories of children ≤5 years, children aged 5 to 10 years and children >10years of age were used for subgroup analysis (supplementary Table 1).
The results from the four weight estimation tools were compared to the actual weight (reference standard) using methods that analysed the bias, precision and overall accuracy of the systems. Bias was measured using the mean percentage error (MPE) of the weight estimates. Precision was measured using the Bland & Altman limits of agreement of the MPE and the root-mean-square percentage error (RMSPE). The overall accuracy was represented by the percentage of weight estimates falling with 10% and 20% of actual weight (PW10 and PW20 respectively). Estimated weights greater than 20% above or below actual weight were deemed to be critical errors. The McNemar test was used to compare the accuracy between each weight estimation tool.
Microsoft Excel version 15.38,2016(Microsoft, USA) and Stata Statistical Software release 14,2015(StataCorp, USA) were used to analyse all the data.

2.5 Acceptable outcome criteria

A weight estimation system was considered to have performed with acceptable accuracy if it achieved a PW10>70% and PW20>95%. [8]

CHAPTER 3

3 Results

3.1 Demographic information

There were 200 children enrolled in the study – 113 males (56.5%) and 87 females (43.5%). The median age was 3.0 years (IQR 1.5 – 6.0). The median weight was 13.4kg (IQR 8.7 – 19.7). There were 123 children with an average body habitus (HS3) (61.5%), 42 underweight children (21.0%) and 35 overweight children (17.5%).

3.2 Accuracy of the weight estimation tools

The PAWPER XL tape was the only weight estimation tool that achieved acceptable accuracy overall, as shown in Table 1. The Broselow tape and the modified Broselow tape techniques achieved intermediate accuracy. The hanging leg weight technique performed poorly in every analysis. Table 2 shows the comparison of the accuracy of the estimation tools using the McNemar test.

Table 1 Data for each weight estimation tool, indicating overall measures of bias, precision and accuracy.

	PW10	PW20	MPE	ULOA	LLOA
BT	59.1	88.6	3.0	30.3	-24.2
BT_mod	61.7	89.1	3.5	30.1	-23.2
PTXL	74.0	96.5	0.2	19.5	-19.5
HLW	19.5	50.0	-6.7	48.6	-62.1

BT= Broselow Tape; BT_mod= Broselow tape with modified habitus; PTXL= PAWPER XL Tape
HLW= Hanging leg weight technique; PW10= Percentage within 10% of actual weight; PW20= Percentage within 20% of actual weight; MPE= Mean percentage error; ULOA= upper limits of agreement; LLOA=Lower limit of agreement.

Table 2 The overall statistical test outcomes between the weight estimation tools using the McNemar test.

	PW10	PW20
BT vs BT_mod	0.6828	1
BT vs PTXL	0.0021	0.0037
BT vs HLW	<0.0001	<0.0001
BT_mod vs PTXL	0.0101	0.006
BT_mod vs HLW	<0.0001	<0.0001
PTXL vs HLW	<0.0001	<0.0001

BT= Broselow Tape; BT_mod= Broselow tape with modified habitus; PTXL= PAWPER XL Tape; HLW= Hanging leg weight technique.

3.3 Weight Category

In each weight category, the PAWPER XL tape showed the lowest bias, narrowest limits of agreement and the greatest accuracy of the weight estimation tools. Its poorest performance was noted in underweight children, with a PW10 and PW20 of 71.4% and 90.5%, respectively. The performance of the weight estimation tools is illustrated in Figure 1.

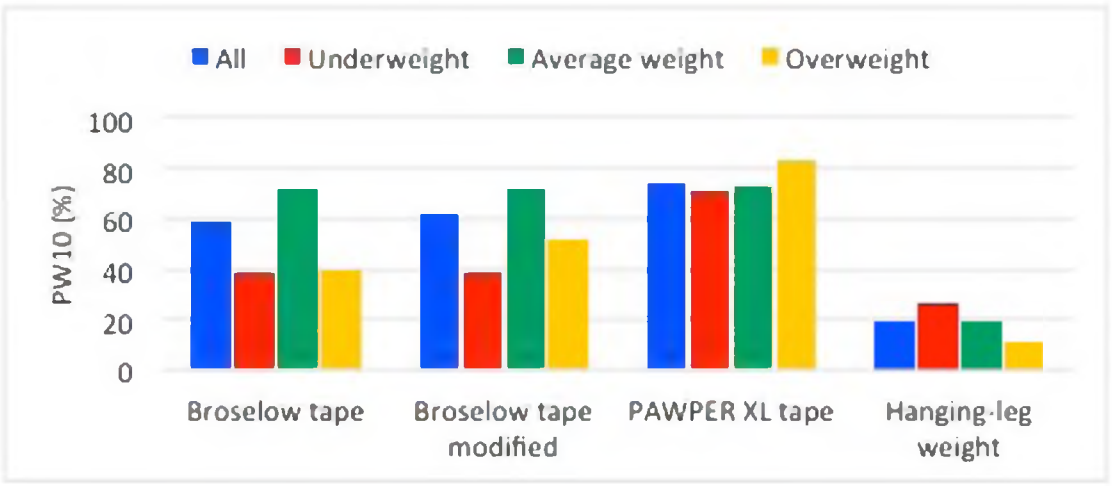

Figure 1

The accuracy of weight estimation tools to estimate weight within 10% of actual weight in the weight subgroups.

3.4 Age Category

The PAWPER XL tape performed the best in all three age categories as illustrated in Figure 2. In children older than 10 years of age, the Habitus Modified Broselow Tape had the lowest bias (-1.8) and predicted weight accurately with 73.7% and 89.5% of estimations within 10% and 20% of actual weight, respectively. However, the PAWPER XL tape was able to predict all of the participants' weights within 20% of actual weight and 84.6% within 10% of their actual weight.

Figure 3 illustrates the percentage of critical errors (weight estimation error >20%) produced by each estimation tool.

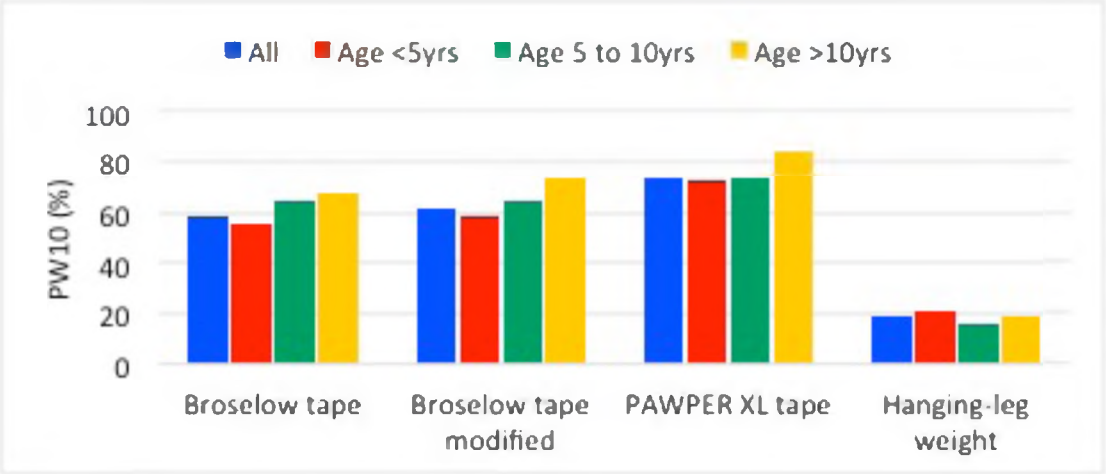

Figure 2.The accuracy of weight estimation tools to predict weight within 10% of actual weight in each age category.

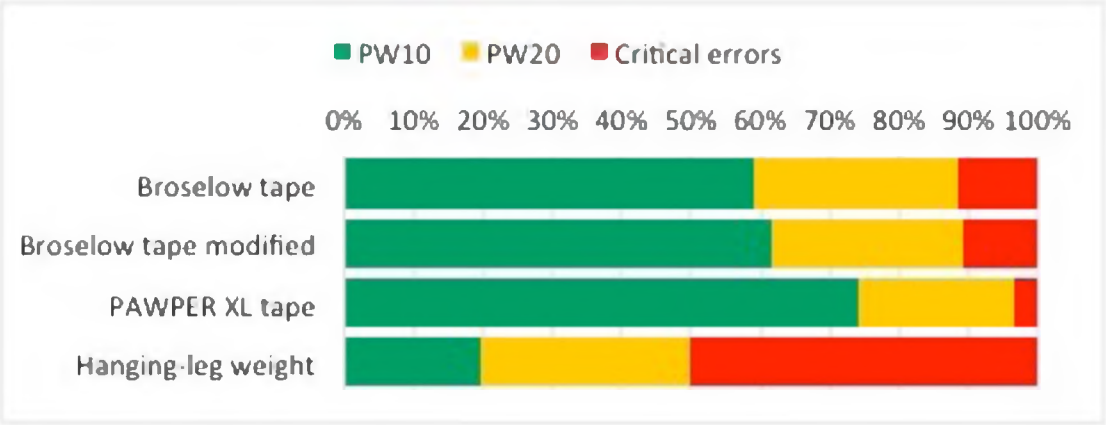

Figure 3. The overall percentage of critical errors made by each weight estimation tool.

CHAPTER 4

4 Discussion

4.1 Study sample demographics

In this study, which was performed in a low to middle socioeconomic population, there was a high prevalence of average weight children followed by underweight children. This is a similar distribution noted by Georgoulas et al. whose study was also based in a public hospital serving a low to middle socioeconomic class in South Africa[13]. Moreover Shisana et al. found that 13.5% of South African children are overweight, which is in keeping with our 17.5%, making our sample suitable and probably generalisable to the area and similar populations in South Africa.[14]

4.2 Performance of the PAWPER XL tape

The PAWPER tape and PAWPER XL tape were originally developed and validated in South Africa, the latter being the most accurate weight estimation tool in this study. The PAWPER XL tape met the acceptable outcome criteria overall, having PW10 and PW20 greater than 70% and 95%, respectively. Furthermore it had good accuracy in the whole group and in every subcategory (see supplementary data). It was the most consistent and reproducible tool, with virtually neutral bias (MPE 0.2) and minimal differences between age groups and habitus types. Its poorest performance was in the underweight habitus subcategory, producing a PW20 of 90.5% that did not meet our acceptable accuracy of 95%. This was the only subcategory that the PAWPER XL tape failed to meet the acceptable accuracy. With the inclusion of the above mentioned failure, the PAWPER XL tape still performed significantly better than the other weight estimation tools, confirming that length-based estimation tools with body habitus modifications are the most accurate.[5, 8]

4.3 Performance of the Broselow tape and a modified Broselow tape system

The Broselow tape is probably the best-known and most widely utilised paediatric weight estimation tool. It has been in clinical use for more than 30 years. However, it has shown to have poor accuracy in estimating weight, especially in children with extremes of habitus.[15,16] In an attempt to improve the accuracy of the Broselow tape, the manufacturers have suggested that a visual estimate of body habitus can be used to modify the estimate of body weight in overweight or obese children.[6] Overall, in this study, the unmodified Broselow tape did not meet the acceptable accuracy of 95% and the habitus modification thereof only improved its PW10 and PW20 by only 2.6% and 0.5% respectively. In overweight children specifically, it improved the PW10 and PW20 by 11.4% and 2.8%, respectively. Furthermore, with the incorporation of the body habitus, the tendency to underestimate obese children decreased from a MPE of -10.4 to -8.3. This is in keeping with numerous studies done in South Africa and internationally showing the tape's inaccuracy in children at extremes of weights.[7, 15,16] Despite these improvements the habitus modified Broselow Tape only performed with acceptable accuracy in the average weight subgroup but failed to reproduce this in all the other categories. Its worst performance was seen in the underweight subgroup, with a significantly large bias to overestimate their weight. Clark et al. found the same in a study that took place in a low socio-economic population in Sudan.[15] In this study, in a South African population, the Broselow tape and habitus modified Broselow tape system only met acceptable weight estimation criteria in the average weight subgroup and failed in all the other categories.

4.4 Performance of the hanging leg weight technique

In its original study, the hanging leg weight technique was performed on unmoving, anaesthetised children and was able to achieve a PW10 of 73.7%.[11] In our study, this could not be reproduced. This system was very inaccurate across the whole group as well as in each subgroup. It had a large

bias to underestimate weight (MPE -6.5) overall, but overestimated weight in underweight children. The hanging leg weight technique performed significantly worse than all the other tools and is not suitable for a South African population. The technique's shortcomings are predictable when compared to the original study, in that our participants were not inert. It was virtually impossible to weigh a fully conscious child's legs without them moving and affecting the measurement. Moreover it assumes that leg weight and body weight are related independent of body habitus, length and age.[11] However, studies since the originally published hanging leg weight technique have shown that body weight is intimately related to length and more importantly body habitus. [3,5-8] The hanging leg weight technique is not suitable for clinical use. This technique was not user-friendly and is impractical.

4.5 Critical weight estimation errors

The corollary to a tape performing with acceptable accuracy (PW10% >70, PW20 >95%) is its generation of critical errors.[8] Critical errors are weight estimates greater than 20% of the actual weight, deemed critical as medication dosing at that estimated weight has a high risk of adverse events. It was not surprising that the hanging leg weight technique had the highest critical error rate of 50%. The Broselow Tape, modified Broselow tape method and PAWPER XL tape critical error rates were 11.4%, 10.9% and 3.5%, respectively (Figure 3). These findings were in keeping with a study done in an ethnically diverse Australian population. In that study the Broselow tape and PAWPER tape had critical error rates of 12.5% and 3.5%, respectively [4]. Similar critical error rates have been found in studies done in the South African setting as well. [17]

4.6 Difficulties experienced with the tools

The Broselow tape was too short for seven of the participants, resulting in weights that could not be estimated. This is a well-documented limitation and disadvantage of the tape, not only in South Africa, but other countries too [18]. The tape is limited between the lengths of 46 to 143 cm whilst the PAWPER XL tape has an upper limit of 180 cm. The PAWPER XL and hanging leg weight technique could be used on all the children, although the latter with difficulty as it is dependent on the child remaining still.

4.7 Utility of weight estimation tools in resuscitation

Accurate weight prediction of paediatric patients is crucial to their safe and effective management in the emergency setting. The weight estimation system utilised for this purpose needs to be readily available, easy-to-use and accurate. The PAWPER XL tape was the most accurate and is substantially cheaper than the other methods analysed. [2, 10, 17]

4.8 LIMITATIONS

In this study from a low to middle socioeconomic population in South Africa. This is a marked difference to the North American population, which has a higher socioeconomic status. The Broselow tape is based on North American paediatric growth charts.

One of the major limitations to the study is that it was done in one hospital and may not be generalisable to other populations. The number of participants was also relatively small. Further research on a larger scale is required especially with a greater representation of obese and underweight children.
A single researcher (MM) took measurements and therefore interobserver variability of the methods could not be assessed.

CHAPTER 5

5 Conclusion

In this study population the PAWPER XL tape was the most accurate weight estimation tool. It performed better than the other weight estimation tools in all categories and met acceptable accuracy in all categories but underweight children. The Broselow tape and a habitus modified Broselow tape system had similar performance but the modified system was understandably slightly more accurate in overweight children. Acceptable accuracy was obtained in the average weight population only. The hanging leg weight technique was grossly inaccurate and is not recommended for clinical use. In South African paediatric emergencies, the PAWPER XL tape is the most accurate tool for weight estimation.

6 References

1. 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 Jun;48(6):660-6. doi: 10.1016/j.jemermed.2014.12.082.
2. Wells M, Coovadia A, Kramer E, Goldstein L. The PAWPER tape: A new concept tape-based device that increases the accuracy of weight estimation in children through the inclusion of a modifier based on body habitus. Resuscitation.2013 Feb;84(2):227-32. doi: 10.1016/j.resuscitation.2012.05.028.
3. Kleinman ME, Chameides L, Schexnayder SM, Samson RA, Hazinski MF, Atkins DL et al. Part 14: pediatric advanced life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010 Nov 2;122(18 Suppl 3):S876-908. doi: 10.1161/CIRCULATIONAHA.110.971101.
4. Luten RC Luten RC[1], Wears RL, Broselow J, Zaritsky A, Barnett TM, Lee T, Bailey A et al.Length-based endotracheal tube and emergency equiptment in pediatrics. Ann Emerg Med.1992 Aug;21(18):900-4.doi: 10.1016/ S0196- 0644 (05) 82924-5
5. O'Leary F, John-Denny B, McGarvey K, Hann A, Pegiazoglou I, Peat J. Estimating the weight of ethnically diverse children attending an Australian emergency department: a prospective, blinded, comparison of age-based and length-based tools including Mercy, PAWPER and Broselow. Arch Dis Child. 2017 Jan;102(1):46-52. doi: 10.1136/archdischild-2016-310917.
6. Deboer S, Seaver M, Broselow J. Color coding to reduce errors. Am J Nurs. 2005 Aug;105(8):68-71. PMID: 16062063.
7. Wells M, Goldstein L, Bentley A. The accuracy of weight estimation by the Broselow tape can be substantially improved by including a modifier based on a visual assessment of body habitus. Pediatric Research. 2017 Oct 18. doi: 10.1038/pr.2017.222
8. Wells M, Goldstein L, Bentley A. The accuracy of emergency weight estimation systems in children - a systematic review and meta-analysis. International Journal of Emergency Medicine. 2017; 10:29 doi: 10.1186/s12245-017-0156-5
9. Garcia CM, Meltzer JA, Chan KN, Cunningham SJ. A Validation Study of the PAWPER (Pediatric Advanced Weight Prediction in the Emergency Room) Tape–A New Weight Estimation Tool. J Pediatrics. 2015 Jul;167(1):173-7.e1.doi: 10.1016/j.jpeds.2015.04.006.
10. Wells M, Goldstein L, Bentley A. A validation study of the PAWPER XL tape: accurate estimation of both total and ideal body weight in children up to 16 years of age. Trauma and Emergency Care. 2017; 2(4):1-8. doi: 10.15761/TEC.1000141
11. Haftel AJ, Khan N, Lev R, Schonfeld N. Hanging leg weight – a rapid technique for estimating total body weight in pediatric resuscitation. Ann Emerg Med. 1990 May;19(5):523-6. PMID: 2331096.
12. Frush K. Study packet for the correct use of the Broselow™ Pediatric Emergency Tape. Durham, NC: Duke University Medical Center. http://www.progress.com.sg/wp-content/uploads/2015/06/DEPS_Broselow_Study.pdf Accessed 5 May 2018.
13. Georgoulas VG, Wells M. The PAWPER tape and the Mercy method outperform other methods of weight estimation in children at a public hospital. S Afr Med J. 2016 Aug 7;106(9):933-9. doi: 10.7196/SAMJ.2016.v106i9.10572
14. Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, et al & SANHANES-1 Team (2013) South African National Health and Nutrition Examination Survey (SANHANES-1). Cape Town: HSRC Press
15. 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 Jan;23(1):21-8. doi: 10.1111/acem.12854.
16. Geduld H, Hodkinson PW, Wallis LA. Validation of weight estimation by age and length based methods in the Western Cape, South Africa population. Emerg Med J. 2011 Oct;28(10):856-60. doi: 10.1136/emj.2010.098640.

17. Wells M, Goldstein LN, Bentley A. Development and validation of a method to estimate body weight in critically ill children using length and mid-arm circumference measurements: The PAWPER XL-MAC system. S Afr Med J. 2017 Oct 31;107(11):1015-1021. doi: 10.7196/SAMJ.2017.v107i11.
18. Cattermole GN, Leung PY, Graham CA, Rainer TH. Too tall for the tape: the weight of schoolchildren who do not fit the Broselow tape. Emerg Med J. 2014 Jul;31(7):541-544. doi: 10.1136/emermed-2012-202325.

7 Appendices

Supplementary Data



Figure 1. Visual aids used to estimate body habitus.
Image courtesy of Prof. Mike Wells.

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