

ORIGINAL RESEARCH

Pediatrics

The utility of pediatric age-based weight estimation formulas for emergency drug dose calculations in obese children

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Abstract

Objectives: In obese children, when drug therapy is required during emergency care, an estimation of ideal body weight is required for certain drug dose calculations. Some experts have previously speculated that age-based weight estimation formulas could be used to predict ideal body weight. The objectives of this study were to evaluate how accurately age-based formulas could predict ideal body weight and total body weight in obese children.

Methods: Three age-based weight estimation formulas were evaluated in a secondary analysis, using a pooled sample of children from 3 academic emergency departments in South Africa. The estimates produced by the 3 formulas (and the PAWPER XL tape as a control) were compared against measured total body weight and ideal body weight. The percentages of estimates falling within 10% of the standard weight were used as the primary outcome measure (PW10).

Results: This study included 1026 children. For ideal body weight estimations in obese children, the old Advanced Life Support formula, the new Advanced Life Support formula, and the Best Guess formula achieved PW10s (with 95% confidence intervals [CIs]) of 29% (27.2%, 30.8%), 41.4% (38.9%, 43.9%), and 48.3% (45.3%, 51.3%), respectively. For total body weight estimations, the formulas achieved PW10s of 3.6% (3.4%, 3.8%), 5.2% (4.9%, 5.5%), and 19.0% (17.8%, 20.2%). The PAWPER XL tape achieved an accuracy of ideal body weight estimation of 100% (93.9%, 100%) and total body weight estimation of 49.7% (46.7%, 52.7%) in obese children.

Conclusions: The age-based formulas were substantially less accurate at estimating total body weight and ideal body weight than existing length-based methods such as the PAWPER XL tape, and should not be used for this purpose.

KEYWORDS

age formulas, drug dosing, ideal body weight, PAWPER tape, pediatric obesity, resuscitation, weight estimation

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1 | INTRODUCTION

1.1 | Background

During the management of medical emergencies in children, drugs often need to be administered, and the success and safety of this treatment may depend on the accuracy of the drug dose given.¹ Children can seldom be weighed in these situations and therefore accurate methods of estimating weight must be used. However, although accurate estimations of total body weight are essential for drug dose scaling for underweight and normal weight children, obese children may be overdosed if hydrophilic drug doses are scaled to total body weight.^{2,3} The World Health Organization has recommended that hydrophilic drugs be scaled according to ideal body weight in obese children to avoid this, whereas lipophilic drugs should still be dosed to total body weight.⁴

Some authors have suggested that some age-based formulas can predict ideal body weight accurately and, on that basis, are appropriate for emergency drug dose calculations in an emergency.^{2,5} The relationship between these age-based formulas and ideal body weight has never been formally evaluated. Most of the existing dose scaling methods recommended for determining ideal body weight in obese children are tedious and complex to use.⁶ This is a significant impediment to safe dose calculation and any factor that might simplify this during emergency care would be of enormous potential benefit.

However, length-based methods of weight estimation (such as the PAWPER XL tape and the Broselow tape) have previously been shown to predict total body weight significantly more accurately than age-based formulas.¹ They have also been shown to predict ideal body weight with a high degree of accuracy.^{3,7} It would, therefore, be important for a clinician to know whether age-based formulas could have any role in estimating ideal body weight during the emergency management of obese children, given that other extremely accurate methods are already available.

1.2 | Importance

The increasing prevalence of childhood obesity across the world over the last 2 decades has meant that clinicians have to manage emergencies in obese children increasingly often. Because many drugs used in the resuscitation room are hydrophilic, it is essential that the emergency physician has an approach to manage emergency drug dosing in obese children.⁵ Furthermore, because the use of age-based formulas is still common—despite an increasing body of evidence against them—it was important to clarify whether they could potentially have a secondary role in the prediction of ideal body weight.

1.3 | Goals of this investigation

The objectives of this study were primarily to establish the accuracy with which 3 commonly used age-based weight estimation formulas

The Bottom Line

For children needing resuscitative drugs, length-based body weight estimation has been proven to be better than age-based approaches, but the evidence in obese children is lacking. The current study suggests that length-based approaches are also superior, for both ideal and total body weight estimation in obese children.

are able estimate ideal body weight in obese children. Because total body weight is required for some dose calculations in obese children, primarily for lipophilic drugs, the accuracy of total body weight estimation by the same age-based formulas was also evaluated. This was important to establish whether age-based formulas could be used as stand-alone weight estimation methods during emergency care. Finally, it was important to compare the performance of the age-based formulas with an existing length-based method that is known to be accurate, the PAWPER XL tape.

2 | METHODS

2.1 | Study design and setting

This study was a secondary analysis using raw data from 3 previous weight estimation studies, which was pooled for analysis (Human Research Ethics Committee of the University of the Witwatersrand approval M151107).⁷⁻⁹ The contributing studies were prospective, cross-sectional investigations conducted in 4 academically aligned hospitals in Johannesburg, South Africa.

2.2 | Selection of participants in the contributing studies

The contributing studies enrolled a convenience sample of children from birth to 18 years of age who presented to the emergency department but did not require emergency medical treatment. All children who presented on a day on which one of the investigators was working were enrolled. Informed consent was obtained from parents and assent was obtained from children over the age of 7 years.

2.3 | Measurements

Basic demographic information was captured after which the children were dressed in a hospital gown for the anthropometric measurements. Each child was positioned supine on the bed for total body weight and ideal body weight estimation by the PAWPER XL tape. These were generated according to the directions on the tape, from measurements of length and a visual assessment of body habitus.

TABLE 1 The age formulas evaluated in this study

Name	Formula	Age restrictions
APLS formula (old)	$Wt = 2 \times (Z + 4)$ or $[Wt = (2 \times Z) + 8]$	Age restriction 1–10 years of age
APLS formula (new)	$Wt = \frac{z}{2} + 4$	For infants ≤ 12 months of age
	$Wt = (2 \times Z) + 8$ or $[Wt = 2 \times (Z + 4)]$	For children 1–5 years of age
	$Wt = (3 \times Z) + 7$	For children 6–12 years of age
Best Guess formulas	$Wt = \frac{z + 9}{2}$	For infants ≤ 12 months of age
	$Wt = (2 \times Z) + 10$ or $[Wt = 2 \times (Z + 5)]$	For children 1–5 years of age
	$Wt = 4 \times Z$	For children 6–14 years of age

Wt, weight in kilograms; Z, age in years; z, age in months; APLS, advanced pediatric life support. The same formulas were used to provide estimations of total body weight and ideal body weight.

Additional anthropometric measurements were obtained with the child still supine: length, mid-arm circumference (MAC), and humerus length. The child was then weighed on a calibrated digital scale (Tanita SC-240 Body Composition Analyser).

2.4 | Outcomes

Three different commonly used age-based formulas were evaluated (Table 1). The old and the new APLS formulas were selected because they have previously been postulated to be appropriate for estimating ideal body weight in obese children.^{5,10} This was because these formulas approximated the 50th centile of weight-for-age, or the “ideal” child. However, the authors of these studies also speculated that a formula that produced lower weight estimation (such as the old APLS formula) might be advantageous as it would not overestimate ideal body weight and lead to potential overdoses.^{2,5} These studies did not provide or evaluate any supporting data to support their theories, however. In addition to these 2 formulas, the Best Guess formula was included in the present study as it is one of the most studied formulas of the last decade, and it would be useful to establish its relationship to ideal body weight.

The accuracy of estimation of total body weight and ideal body weight by the age-based formulas (with the PAWPER XL tape data as a reference) were the primary outcomes of interest.

2.5 | Analytic methodology

Each age formula was used to generate weight estimates for each child from the pooled raw data. These formula-generated estimates were then compared against total body weight (actual measured weight) and the calculated standard for ideal body weight. The body mass index (BMI₅₀) method was used to calculate the reference weight for ideal body weight because this is generally regarded as the best method for estimating ideal body weight in children.⁶

The accuracy of the estimates of total body weight and ideal body weight by the age-based formulas was evaluated using parametric and non-parametric statistical methods based on a percentage error analysis. The mean percentage error was calculated to determine the esti-

mation bias; the 95% limits of agreement of the mean percentage error were used to determine the precision of the estimates (by means of a modified Bland & Altman methodology); and the percentage of weight estimations falling within 10% (PW10) and 20% (PW20) of the measured total body weight or calculated ideal body weight were used to determine overall accuracy.

The body mass index-for-age Z-score was used to identify subgroups of obese children ($Z \geq 2.0$) within the study sample. The performance of the formulas was assessed within these subgroups as described above. The predictive accuracy of the formulas for ideal body weight was not calculated for underweight and normal weight children, however, as this would not be considered to be an appropriate usage of this dosing scalar.

The accuracy data of estimations of total body weight and ideal body weight by the PAWPER XL tape in this pooled study sample was used as a control against which to compare the performance of the age-formulas.³

3 | RESULTS

A summary of the demographic and anthropometric data for the pooled dataset is shown in Table 2.

The performance of the age-formulas, in terms of their ability to predict total body weight and ideal body weight, is shown in Table 3. A key to the interpretation of the accuracy data (PW10) and critical error data (PW20) has been included, as has been described elsewhere.³ All of the age-formulas were substantially less accurate than the PAWPER XL tape, the control standard for this study, for both the total body weight and ideal body weight predictions. The old APLS formula was more accurate than the other formulas in underweight children and the Best Guess the most accurate of the formulas in obese children. The new APLS formula and the Best Guess formula were moderately accurate in predicting ideal body weight in obese children.

The mean percentage errors and 95% limits of agreement exhibiting the formulas' bias and precision for the estimations of total body weight and ideal body weight are shown in Figure 1. The age-based formulas exhibited a large bias to underestimate total body weight in obese children. The formulas had a smaller bias but similar precision when used to predict ideal body weight in obese children when

TABLE 2 Demographic composition of the study sample

No.	1026
Age [median (LQ, UQ)]	4.5 (2.1, 7.2)
Sex = male [n (%)]	530 (51.6)
Length (cm) [median (LQ, UQ)]	108.0 (89.3, 123.0)
Weight (kg) [median (LQ, UQ)]	17.5 (12.7, 24.1)
Body mass index [median (LQ, UQ)]	16.0 (14.7, 17.4)
Z-score [median (LQ, UQ)]	-0.1 (-1.0, 0.8)
Slightly underweight [n (%)] -2.0 < Z-score ≤ 1.3	82 (8.0)
Severely underweight [n (%)] Z-score ≤ -2.0	107 (10.4)
Overweight [n (%)] 2.0 > Z-score ≥ 1.4	78 (7.6)
Obese [n (%)] 2.5 > Z-score ≥ 2.0	31 (3.0)
Severely obese [n (%)] Z-score ≥ 2.5	27 (2.6)

LQ, lower quartile; UQ, upper quartile.

compared to predictions of total body weight. The PAWPER XL tape was substantially better in every analysis.

The critical error rates (estimation errors of > 20%) are shown for each of the formulas in Figure 2. As can be seen, the critical error rate varies widely between the formulas in the subgroups of obese children. Despite relatively large differences in PW10 for ideal body weight between the formulas (from Table 3), the critical error rate is similar for each formula. The critical error rates for the PAWPER XL tape were very low.

TABLE 3 The performance of the age-based formulas in predicting total body weight and ideal body weight

		APLS formula (old)	APLS formula (new)	Best Guess formula	PAWPER XL tape (control)
TBW all children	n	934	1025	1026	1026
	PW10 (95% CI)	41.9 (39.3, 44.5)	34.0 (31.9, 36.1)	35.5 (33.3, 37.7)	84.1 (79.0, 89.2)
	PW20 (95% CI)	74.1 (69.6, 78.6)	63.8 (59.9, 67.7)	60.8 (57.1, 64.5)	98.2 (92.2, 100)
TBW obese children	n	55	58	58	58
	PW10 (95% CI)	3.6 (3.4, 3.8)	5.2 (4.9, 5.5)	19.0 (17.8, 20.2)	49.7 (46.7, 52.7)
	PW20 (95% CI)	18.2 (17.1, 19.3)	25.9 (24.3, 27.5)	43.1 (40.5, 45.7)	89.7 (84.2, 97.2)
IBW obese children	n	55	58	58	58
	PW10 (95% CI)	29.1 (27.2, 30.8)	41.4 (38.9, 43.9)	48.3 (45.3, 51.3)	100 (93.9, 100)
	PW20 (95% CI)	81.8 (76.8, 86.8)	82.8 (77.7, 87.9)	79.3 (74.4, 84.2)	100 (93.9, 100)
PW10	Interpretation	PW20		Interpretation	
<50%	Low accuracy	<80%		High critical error rate	
50%–70%	Moderate accuracy	80%–95%		Moderate critical error rate	
>70%	High accuracy	>95%		Low critical error rate	
Overall acceptable performance criteria: PW10 > 70% (high accuracy) and PW20 > 95% (< 5% critical error rate)					

CI, confidence interval; TBW, total body weight; IBW, ideal body weight; PW10, percentage of estimates within 10% of reference weight; PW20, percentage of estimates within 20% of reference weight; APLS, advanced pediatric life support.

The PAWPER XL data are provided as a control for comparison. The accuracy of ideal body weight predictions is only shown for the subgroup of obese children. The differences in the number (n) of weight estimations for the different formulas are a result of the differing age restrictions of the individual formulas.

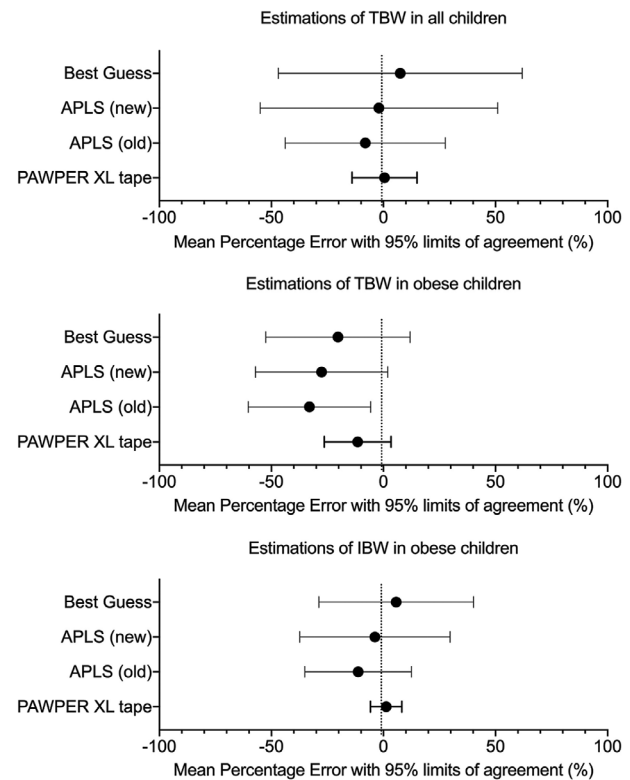


FIGURE 1 Bias and precision of the age-based formulas with respect to their ability to predict total body weight and ideal body weight. A negative mean percentage error is indicative of a bias to underestimation of weight. The top 3 panels show the data for total body weight estimation in all children, underweight children, and obese children. The bottom panel shows the data for ideal body weight estimation for obese children (data are not shown for normal weight and underweight children)

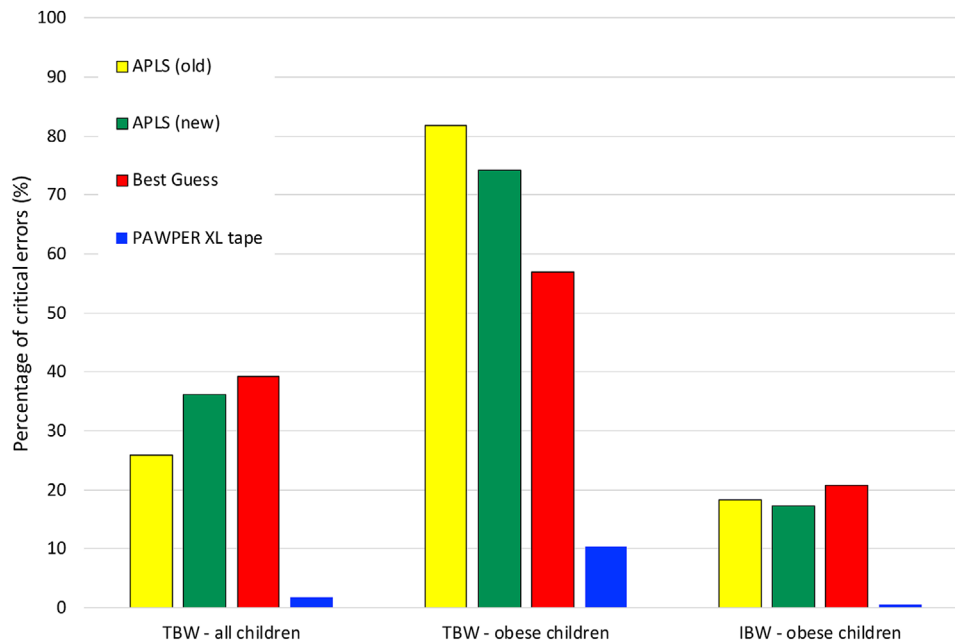


FIGURE 2 Critical error rates of the age-based formulas with respect to their ability to predict total body weight and ideal body weight. A critical error was defined as a weight estimation error of > 20% of the reference weight. The first 3 clusters show the data for total body weight estimation in all children, underweight children, and obese children. The last cluster shows the data for ideal body weight estimation for obese children (data is not shown for normal weight and underweight children). APLS, advanced pediatric life support; TBW, total body weight; IBW, ideal body weight

4 | LIMITATIONS

There were some limitations to the sampling for this study. First, children requiring emergency treatment were excluded, which potentially may limit the generalizability of the study findings. Second, there were also relatively few overweight and obese children in the sample. This was in keeping with the obesity rate of our population, but many other populations both in high-income and low- and middle-income countries have a higher rate of obesity, for example, the obesity rate in children under 5 years of age in the United States is 13.9%, compared with the 6% in this study.¹¹ It is unlikely that this would have influenced the core underlying findings, however.

There is evidence that the various methods of determining ideal body weight differ significantly in older children and children with a high body mass index. We did analyze the performance of the age-based formulas and PAWPER XL tape against the Moore, McLaren, Traub-Johnson, and Australian Prescriber methods and found no significantly different results than with the BMI₅₀ method. Given that some experts have favored this method, and given that we found no major differences, we elected not to include the specific data in this paper for simplicity's sake.

5 | DISCUSSION

The mechanism for the dose calculations required in obese children are currently complex and onerous, especially if ideal body weight must be calculated, which may constitute a significant impediment to

safe dose administration.² Nonetheless, correct dosing is important as there is evidence that erroneous dosing in obese children during emergency care may be associated with poor outcomes.¹² Arbitrary dose reductions to prevent toxic effects of drugs in obese children are not desirable over best-evidence methods.² It is essential then, that dosing guidelines be developed as well as the resources made available to simplify the necessary dose calculations (computerized point-of-care decision support systems or mobile phone apps).¹³ Obesity in children is common enough that this is a problem that cannot be ignored.

This is the first study to have evaluated the ability of age formulas to predict ideal body weight. We found that none of the age formulas predicted ideal body weight with reasonable accuracy (a PW10 of > 70% or a PW20 of > 95% have previously been suggested as acceptable benchmarks for accuracy).^{1,14} Despite the large differences in accuracy represented by the PW10 data, all the formulas had a similar proportion of critical errors of around 20% (< 5% has been suggested to be an acceptable threshold).¹⁴ There has been only 1 previous study that has evaluated the ability of any weight estimation system to predict ideal body weight. This study assessed the accuracy of the PAWPER XL tape and the Broselow tape in predicting ideal body weight.³ Similar to the findings in the present study, these tape-based systems achieved an accuracy substantially better than that of the age formulas in the present study, exceeding 90% of estimations within 10% of actual ideal body weight.

None of the formulas were able to predict total body weight with even a reasonable degree of accuracy, especially in obese children. These findings were similar to those reported in recent

TABLE 4 Pharmacokinetic and dosing characteristics of selected commonly used resuscitation room drugs

Indication	Drug	Dosing scalar	Titratable	Comments	
Airway management	Ketamine	IBW ²¹ TBW ⁵	Yes	Ketamine (lipophilic) has a wide therapeutic window and can easily be titrated to effect, depending on the indication. Initiating doses based on IBW and supplementing with additional boluses is a reasonable strategy to avoid overdose.	
	Propofol	TBW ²¹ AdjBW ²²	Yes	Propofol (lipophilic) can also be titrated to effect. Although pharmacologically it should be dosed to TBW, side effects might be amplified in obese critically ill children. Starting doses at the low end of the dosing range are recommended.	
	Suxamethonium	AdjBW ²¹ TBW ^{2,23} IBW ⁵	No	Suxamethonium (hydrophilic) should be dosed at a higher rather than a lower dose to endure optimum effect. It cannot be titrated. The use of TBW or AdjBW (0.8 cofactor) would be appropriate.	
	Rocuronium	TBW AdjBW ²¹	No	Rocuronium is one of the most lipophilic muscle relaxants. The anesthetic indications for rocuronium depend on a predictable reversibility. The emergency medicine indications require rapid onset with less concern over a prolonged duration of action. TBW should be used rather than AdjBW.	
Ventilation	Atropine	TBW ²¹	Yes	Atropine (lipophilic) is widely distributed into fatty tissue and adequate doses are required to ensure effectiveness.	
	Tidal volume	IBW	Yes	Tidal volume for mechanical ventilation must be based on IBW. Excessively large volumes are associated with lung injury.	
	Dexamethasone	TBW ^{5,21}	No	Corticosteroids are highly lipophilic. These drugs have a wide therapeutic window and should be dosed to ensure effectiveness.	
	Hydrocortisone	TBW ^{5,21}	No		
	Magnesium sulfate	IBW ^{5,21}	Yes	All electrolytes are highly hydrophilic and must be dosed to IBW. Additional doses can be given if required.	
	Naloxone	TBW ²¹	Yes	Naloxone is highly lipophilic. Adequate doses are required for this very lipid soluble drug therefore dosing to TBW is preferred.	
	Cardiac arrest	Epinephrine	IBW ^{5,21}	No	Epinephrine is hydrophilic and must be dosed to IBW. Excessive doses might be harmful during cardiac arrest in obese children.
		Amiodarone	TBW ^{5,21}	No	Amiodarone is correctly regarded as amphiphilic (part of the molecule is hydrophilic and part lipophilic), but it should be dosed to TBW. In cardiac arrest, it is not titratable and an adequate dose for therapeutic effectiveness is required.
		Lidocaine	TBW ²¹ TBW ^{5,23}	Yes	Lidocaine (lipophilic) should be dosed to TBW for all indications. Additional boluses can be used if required.
	Other cardiac	Adenosine	IBW ⁵	No	Adenosine (hydrophilic) is not titratable and is best dosed to IBW as its effects are not related to distribution into peripheral tissues.
Verapamil		TBW ⁵	Yes	Verapamil (lipophilic) is generally best administered as an infusion for most current ED indications. Dosing to TBW is therefore most appropriate based on its pharmacokinetics.	
Furosemide		IBW ²¹ TBW ⁵	Yes	Furosemide (lipophilic) can be effectively titrated and should therefore be dosed to IBW to avoid harmful side effects related to overdosing.	
Calcium gluconate		ideal body weight ^{5,21}	Yes	All electrolytes are highly hydrophilic and must be dosed to IBW. Additional doses can be given if required.	
Sodium bicarbonate		IBW ^{5,21}	Yes		
Hypovolemia	Balanced crystalloid fluid bolus	IBW	Yes	Intravenous fluids should be dosed to IBW and sparingly administered, with additional small boluses used as required.	
Status epilepticus	Lorazepam	TBW ²¹ TBW ^{5,23}	No	Benzodiazepines of different types may require different dosing strategies. Lorazepam (lipophilic) should generally be dosed to TBW when prompt efficacy is required, but side effects might be higher in obese children.	

(Continues)

TABLE 4 (Continued)

Indication	Drug	Dosing scalar	Titratable	Comments
	Midazolam	IBW ²¹ TBW ^{5,23}	No	Midazolam (lipophilic) should be dosed to TBW for urgent indications, and to IBW for indications in which it can be titrated.
	Phenytoin	TBW ^{5,21} AdjBW ²³	No	Phenytoin is lipophilic and most experts agree that the loading dose should be scaled to TBW. It is essential that an adequate dose be administered during status epilepticus as this drug cannot be titrated.
	Valproate	TBW ²¹	No	Valproate is also lipophilic, and it is essential that an adequate dose be administered during status epilepticus as this drug cannot be titrated.
	Levetiracetam	AdjBW ²¹	No	Little is known about the dosing of this drug as no studies have been done in children. The use of AdjBW with a 0.25 cofactor has been suggested.
	Phenobarbitone	total body weight ²¹	No	All barbiturates are lipophilic. It is essential that an adequate dose be administered during status epilepticus as this drug cannot be titrated.
Analgesia	Morphine	ideal body weight ^{2,5,21}	Yes	Opioids are hydrophilic. However, the side effects of opioids can be amplified in obese children, so dosing to ideal body weight is recommended. This drug is most effective when titrated in the acute phase.
	Fentanyl	AdjBW ²¹ LBW ² ideal body weight ²³	Yes	This drug is highly titratable, and the dosing strategy should be based on the clinical scenario and the resultant need to avoid respiratory depression (0.25 cofactor).
	Acetaminophen	AdjBW ²¹ LBW ²	No	Acetaminophen is hydrophilic. It is a problematic drug in obese children. It should probably be dosed to TBW to achieve appropriate therapeutic effect, but the risk of hepatic side effects is high at this dose. It should therefore be dosed to an AdjBW (0.4 cofactor) to ensure safety.

IBW, ideal body weight; TBW, total body weight; AdjBW, adjusted body weight (calculated as follows: AdjBW, $IBW + \text{cofactor} \times (TBW - IBW)$); LBW, lean body weight.

This is not an exhaustive list of drugs but illustrates the variety of dose-scaling strategies required. The dosing recommendations in the table represents the best evidence for loading doses of drugs—maintenance doses are usually calculated differently. The difference in scaling from different expert sources is indicative of the uncertainty of dosing strategies for many of the drugs. In obese children, some drugs cannot be administered at doses high enough to achieve adequate efficacy without risk of significant adverse side effects. For some drugs, this would be unacceptable (eg, acetaminophen) but for other drugs it might require a change in management (eg, higher doses of benzodiazepines might be justified in status epilepticus even though it could increase the risk of respiratory depression and mechanical ventilation). A complete strategy for the management of emergencies in obese children needs to be developed to ensure that these factors are taken into account.

systematic reviews which have shown that age-based weight estimation has never been able to achieve the accuracy of the newer length- and habitus-based methods (such as the PAWPER XL tape and the Mercy method).^{1,15,16} The accuracy of total body weight estimations by the age-formulas in this study was simply not good enough to allow for accurate drug dose calculations for lipophilic drugs and the use of age formulas is inappropriate for this purpose.¹⁷⁻²⁰

Although age formulas have remained popular with many clinicians because of perceived simplicity and independence from equipment, many previous studies have shown that they cannot accurately predict total body weight.^{1,15} In addition, despite previous studies having suggested that age formulas might have a role in predicting ideal body weight, it was clear from this study that they could not accurately predict ideal body weight in obese children either. Because length-based systems such as the PAWPER XL tape are able to predict both total body weight and ideal body weight significantly more accurately than age formulas, the evidence strongly supports the use of such systems, rather than age-based systems.

It is only in obese children that ideal body weight estimations are required for hydrophilic drug dosing calculations (Table 4), because of

the large relative increase in fat mass in these children when compared to normal weight children. However, because total body weight and ideal body weight are very similar in normal weight children, either can be used for dose calculations for all drug classes in these children. As a cautionary note, in underweight children ideal body weight can be far higher than total body weight and may result in substantial overdoses of potentially harmful drugs if it is used inappropriately. Total body weight must be used for all dose calculations in this group of children.³

In conclusion, the age-based weight estimation formulas evaluated were not able to predict ideal body weight accurately in obese children. None of the formulas were accurate in estimating total body weight in obese children, either. The PAWPER XL tape was significantly more accurate at predicting both total body weight and ideal body weight than the age-formulas.

The use of age formulas to estimate total body weight or ideal body weight for the purposes drug dose calculations in emergencies in obese children cannot be recommended. Rather, it is recommended that length-based tapes or length- and habitus-based methods such as the PAWPER XL tape should be available in the ED and preferentially used.

CONFLICT OF INTEREST

Professor Wells is the developer of the PAWPER tape systems but receives no financial benefit.

AUTHOR CONTRIBUTIONS

MW and LG contributed equally to the data collection, analysis, and writing of the paper. MW takes final responsibility for the paper.

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