A Rapid and Accurate Method of Estimating Body Weight

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Pediatric cardiopulmonary resuscitation drug therapy is based upon body weight, a statistic that often requires estimation. Using two current techniques of estimating body weight and the devised weight-estimating method (DWEM), the authors estimated the weights of 258 children. The DWEM, which is based on body habitus and height, was more accurate than other methods ($P < 0.01$). Using height, habitus, sex, and age in a multiple regression analysis, habitus and height—two readily available measurements—were the best predictors of body weight. The DWEM, based on these two measurements, is a simple method of estimating children's weights and is more accurate than currently used body-weight estimations. (Am J Emerg Med 1986;4:390–393)

Pediatric cardiopulmonary drug and fluid therapy is based upon body weight.[1] Obtaining an accurate weight during pediatric resuscitation is often difficult, and weight information obtained by history may be inaccurate or unavailable. Medical personnel are required to estimate rapidly and accurately a child's weight so that appropriate drug doses can be administered.

Methods currently used to estimate body weight are based upon either age alone, or height and age plus a correction factor.[2–3] These methods necessitate knowledge of the child's age and rely on fiftieth-percentile standard growth curve statistics. An obese or slender child's actual weight may vary considerably from the fiftieth-percentile weight, requiring markedly different drug dosages.

We have devised a method of estimating weight (DWEM) based upon a child's body habitus and height. We define this method, as well as show that it is more accurate at estimating body weight than methods currently used.

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MATERIALS AND METHODS

All children admitted to the Primary Care Clinic or Emergency Department at Milwaukee Children's Hospital during one of the authors' shifts were entered into the study. Sex and age to the nearest month were recorded. Patients were weighed to the nearest 0.1 kg by a clinic or emergency department nurse; children unable to stand were weighed in a reclining position on a table scale. Three of the authors, one of whom was inexperienced in the field of pediatrics, measured children to the nearest 0.5 cm in the supine position. The author who measured the patient also assessed body habitus without knowledge of the child's age or weight. At least two authors assessed habitus on fifty children. (They agreed on 48 [96%].) The DWEM uses height and habitus (Table 1) to estimate weights. Table 1 is based upon information from standard weight curves.[4] Slim, average, and heavy children are those children whose weights are on the fifth, fiftieth, and ninety-fifth percentile weight curves, respectively. Heights are listed in 5-cm increments. For each increment, three separate weights are listed depending on body habitus. If a patient's height was between listed values, the nearest height was used to obtain the estimated weight.

Children's weights were also estimated using two other methods. Fiftieth-percentile weights for age and sex were recorded from standard weight curves (Estimation 2). For example, if a child were three years and six months old, the fiftieth percentile weight for a child that age and sex was used as the estimated weight. The other weight estimation technique that the DWEM was compared with was based on age alone (Estimation 3).[3] This estimation method is shown in Table 2. These two estimations were recorded and compared for accuracy with the DWEM.

STATISTICAL METHODS

Simple linear regression analysis was used to determine the relationship between each of the three methods of weight estimation and the actual weight. The actual regression line was determined, and the Pearson correlation coefficient was calculated. A statistic based on the t distribution[5] was calculated to determine whether two correlation coefficients were significantly different. To determine what factors were most important in estimating weight, we used stepwise multiple regression. The χ^2 statistic was used to test differences in categorical data.

RESULTS

The age and sex distribution of the 258 children in this study is given in Table 3. Because each weight estimation method was equally accurate for males and females, males and females were grouped together for analysis. The actual weight of the children varied from 3.2 kg to 83.6 kg. The median weight was 17.3 kg. The median height was 104.5 cm with a range from 49.5 cm to 183.5 cm.

Figures 1 through 3 show the regression of the three weight estimates against the actual weight. All three regression lines have slopes close to one and highly significant correlations. However, the DWEM, which is based on habitus and height, was a significantly better predictor of weight than either Estimation 2 ($t = 8.13$, $P < 0.001$) or Estimation 3 ($t = 10.4$, $P < 0.001$).

Although the DWEM correlated better with actual weight than Estimation 2 and Estimation 3, it is possible that this difference does not hold for the entire weight distribution. To determine whether the DWEM was a better predictor regardless of weight, we ran the correlation analysis selecting for various weights. At all weights selected, the DWEM was a better predictor of actual weight than either Estimation 2 or Estimation 3. At the lowest weights (0–10 kg), there was a small but statistically significant difference in correlation ($P < 0.05$). The greatest difference was found in the weight range 10 to 20 kg ($P < 0.01$).

Another method of comparing the accuracy of the three estimates is to determine the percentage error of the estimates. Of the estimates using the DWEM, 61% were within ± 10% of the actual weight. This compares with only 51% for Estimation 2 and 34% for Estimation 3. These differences are statistically significant ($\chi^2 = 37.6$, DF 2, $P < 0.001$). The differences for the more severe errors were even greater. Only 5% of the DWEM estimates differed from the actual value by 25% or more, whereas 13% of Estimation 2 values and 24% of Estimation 3 values differed by at least 25% from the actual weight ($\chi^2 = 40.7$, DF 2, $P < 0.001$).

In the lowest weight group (0–20 kg), where weights are often more difficult to estimate, the differences in percentage error were even greater. Of the DWEM estimates, 66% were within ±10% of the actual weight, as compared with only 52% for Estimation 2 and 35% for Estimation 3. This difference represents a 27% improvement in precision of measurement using the DWEM as compared with the second best method.

TABLE 1. Estimated Weights Using the Devised Weight Estimate Method (DWEM)

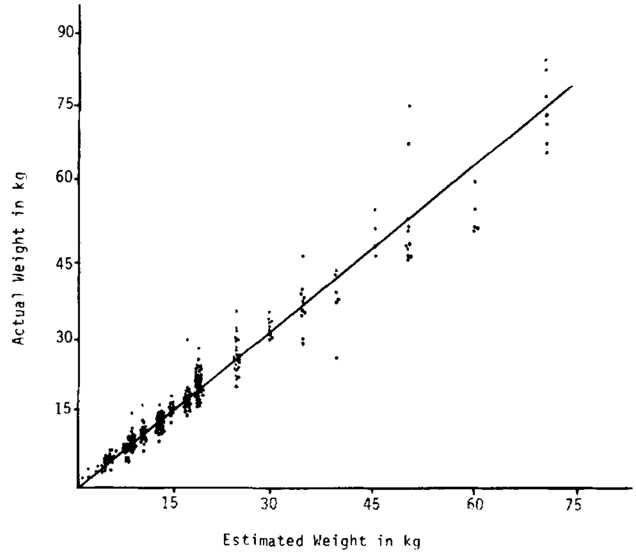
	Weight (kg)		
	Habitus		
Length (cm)	Slim	Average	Heavy
50	2	3	4
55	4	5	6
60	4	6	7
65	6	7	9
70	7	9	10
75	8	10	12
80	9	12	14
85	10	12	14
90	10	14	16
95	12	14	16
100	14	16	20
105	14	18	20
110	16	20	25
115	18	20	25
120	18	20	30
125	20	25	35
130	20	25	40
135	25	30	45
140	25	35	50
145	25	35	50
150	30	40	60
155	35	45	70
160	35	50	70
165	40	50	70
170	45	60	—
175	50	70	—

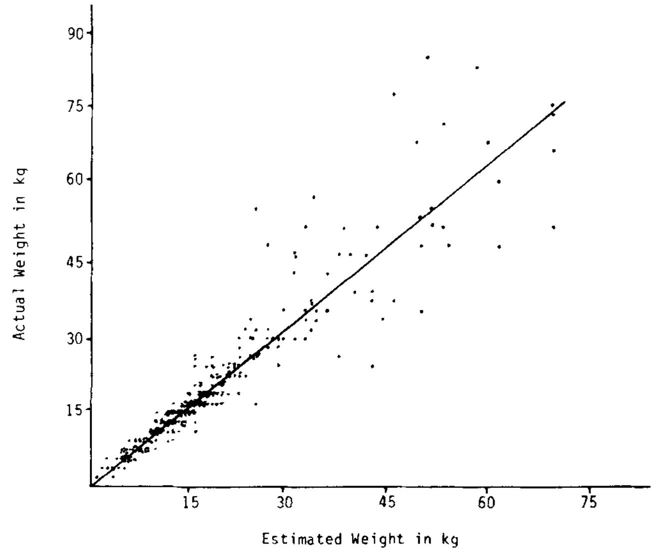
TABLE 2. Estimated Actual Weight Using Estimation Method 3

Age	Weight (kg)
Term	3.5
6 months	7.0
1 year	10.0
4 years	16.0
8 years	25.0
10 years	35.0
15 years	55.0
18 years	70.0 (Male)
18 years	60.0 (Female)

TABLE 3. Age Distribution of Study Population

Age (years)	Number (%)
<1	83 (32.2)
1–4	78 (30.2)
5–9	62 (24.0)
10–14	27 (10.5)
15+	8 (3.1)
Total	258 (100.0)





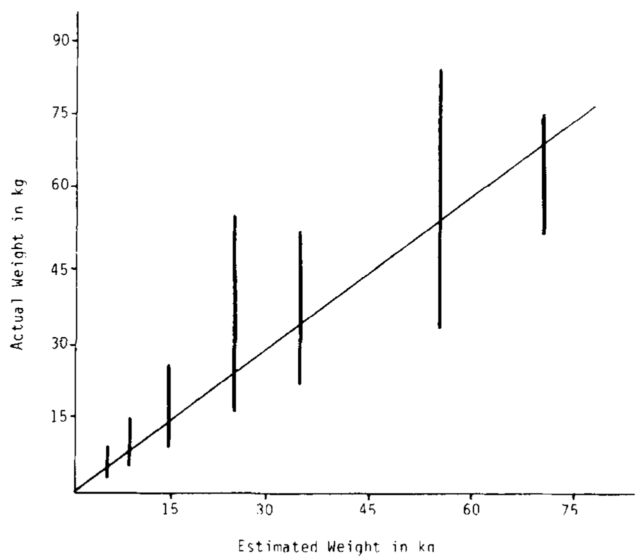


FIGURE 1 (*above, left*). Regression analysis of devised weight estimation method (DWEM) on the actual weight (slope = 1.04, r = 0.97, r^2 = 0.95).

FIGURE 2 (*above, right*). Regression analysis of weight estimation method 2 on the actual weight (slope = 1.06, r = 0.93, r^2 = 0.86).

FIGURE 3 (*left*). Regression analysis of weight estimation method 3 on the actual weight (slope = 0.98, r = 0.91, r^2 = 0.83).

To determine which variables (age, sex, habitus, or height) were most important in estimating weight, we performed a stepwise multiple regression. Using this analysis, height followed by body habitus were the two most important variables in estimating weight. Together, height and body habitus explained 87% of the total variance. Age, the third most important variable, added a small but statistically significant amount to the regression model. The addition of sex was not significant.

DISCUSSION

An accurate body weight is a vital statistic required during any pediatric cardiopulmonary resuscitation so that appropriate drug and fluid dosages can be administered. Weech[2] was the first to develop methods for estimating body weight based upon age and height. These methods involve cumbersome equations. In addition, they require committing several age-specific weights to memory. Because of this, they are not routinely used in stressful situations in which mathematical errors could occur and memorized formulas or weights would be difficult to recall.

Others have modified Weech's formulas so that medical personnel are required to memorize fewer age specific weights (Table 2)[3]; however, wide age intervals can result in very inaccurate weight estimates. Using this weight-estimate technique, an 8-year-old child would weigh 25.0 kg (Table 2). However, actual weights of a child this age varied in our population from 15.0 to 55.0 kg (Figure 3). This method, therefore, underestimated weight in some instances by over 100% and overestimated by 67% in other instances. For similar reasons, fiftieth-percentile growth curve estimations, which are also based upon age as well as sex, result in estimates that were much less accurate than the DWEM.

Body habitus and height are readily available during cardiopulmonary resuscitation and correlate well with a patient's body weight. A centimeter-markd back board can be used to obtain a height in fewer than 10 seconds. As height is obtained, habitus can be assessed. Weight is then rapidly obtained from a table similar to the one shown in Table 1. An enlargement of this table could be conveniently located in the emergency department's critical care room. In fifteen seconds or less, an accurate weight estimate could be obtained. The DWEM eliminates mathematical calculations, memorization, and use of growth curves resulting in a weight estimation technique that is easy to use in stressful situations.

The DWEM was also a more accurate predictor of weight than other methods. Improved accuracy is expected, since the measurements used by the DWEM, height and habitus, are the two best predictors of actual weight. The other methods tested employ the less important predictors of age alone or age and sex as parameters to estimate weight.

Our method of estimation of body weight in children is more accurate than currently used methods. Computation, memorization, and major sources of human error are eliminated, resulting in a rapid, accurate means of estimating a child's weight during cardiopulmonary resuscitation.

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