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The Percentage of Error of Different Weight Estimation Methods toward Actual Weight in Children Admitted to 17 Shahrivar Hospital

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ABSTRACT

Background: In pediatric resuscitation, it is necessary to distinguish the weight in order to provide proper doses of drugs, equipment selection, and ventilator settings, therefore, access to a simple, unbiased, and accurate formula can decrease mistakes. The aim of this study is to determine the percentage of error (PE) of different weight estimation methods toward actual weight in children admitted to17 Shahrivar Hospital.

Methods: This is a descriptive cross-sectional study conducted on 1–10 years children admitted in the pediatric clinic of 17 Shahrivar Hospital in Rasht. Data were collected by a checklist, including age, sex, height and mid-arm circumference (MAC). Investigators compared estimated weight by ten different methods with the actual weight. Finally, clinicians measured the PE and data were analyzed in SPSS software version.18.

Results: About 50.9% of participants were male. The mean age was 4.59 ± 3.35 years and the mean weight was 17.4 ± 5.69 (6.5–45) kg. Results showed no significant difference between the estimated weight and the actual one based on visual expert estimation and advanced pediatric life support (APLS) method. Visual estimation (0.017%) and MAC (25.48%) noted the lowest and highest PE, respectively.

Conclusions: Results indicated a significant difference between the estimated weight and the actual one based on visual expert's estimation and APLS method. As, these methods were easy, rapid and accurate for body weight estimation in emergencies and may be more accurate than parent's estimation, it seems that it could be helpful for prescribing medication dosage and equipment sizes.

Keywords: Body weight, child, emergencies, error, estimation

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INTRODUCTION

Error is an unavoidable incidence in medical observations. Administering medication is the leading cause of errors. In the United States of America, 19% of complications were noted according to the delivery and ordering of drugs[1] because physicians commonly determined them by weight.

Measurement of weight itself is rarely possible in critical situations, and there is often no one available who knows the exact child's weight.[2]

Both underdosing and overdosing may indicate severe complications,[3] Therefore, unbiased and accurate method of weight estimation can decrease mistakes and all emergency room personnel must access to a method capable of estimating a child's weight that is reasonably accurate for the population they treat.[4]

Until now, diverse studies have been done on rapid and accurate methods of weight estimation, worldwide. They evaluated different methods of weight estimation such as Traub–Johnson, Traub–Kichen,[4] mid-arm circumference (MAC),[5] Theron formula, Leffler formula,[6] advanced pediatric life support (APLS), devised weight estimation method (DWEM), Oakley,[4] parental report,[7] expert estimation[1,2,6] and Braslow tape.[2,6]

According to previous investigations, there is no available study, which focused concurrently on all different existing weight estimation methods, and based on few published study in our country that compared the accuracy of weight methods, it seems that distinguishing an accurate method for weight estimation in pediatric patients is mandated.

The objective of this study was to determine the percentage of error (PE) of different weight estimation methods toward actual weight.

METHODS

Study design and participants

This is an analytical cross-sectional study. Participants were patients admitted to general pediatric clinic of 17 Shahrivar Children hospital during May 2013 to January 2014 in Rasht, Iran. Participants enrolled by convenience method of sampling. Inclusion criteria were 1–10 years of age and lack of any medical condition that substantially affect their weight and/or height such as amputation or dwarfism; dehydration, volume overload, or edema; growth hormone deficiency; lack of severe joint contractures or neurological defects (e.g. cerebral palsy) that can influence their growth and nonpediatric Intensive Care Unit patients. Ethical approval was obtained from the Ethics Committee of the Guilan University of Medical Sciences and written parental consent letter attained for all participants before enrollment. Children unwilling to continue were excluded.

Data collection and study's instruments

Data were collected by a checklist which consisted of demographic characteristics including age, sex and height and the estimated weight by ten methods including DWEM, Oakley, Traub–Johnson, Traub–Kichen, MAC, Theron formula, Leffler formula, APLS, visual estimation and parental reports. A general (clinical) pediatrician and a trained medical student-staffed the clinic. General pediatrician assessed the height by Seca Tape Meter (Seca, United Kingdom) in an erectile position. He also indicated body habitus and mean MAC was assessed when the child's right arm relaxed in 90° of flexion at the elbow. The tape wrapped around the arm and laid flat against the arm without pinching the underlying skin. In visual estimation, the same general pediatrician could not touch patients or ask their weight. Actual weight was measured by Seca digital weight scale in children with minimal clothing and no shoes. The Scale was calibrated at the beginning and end of each day. After finishing estimation by ten methods, a trained medical student weighed children and indicated the actual weight and assessed the mean PE of each method by the formula: PE =100 × (estimated weight − actual weight)/actual weight. The detailed elements necessary for calculation and the standard formulas can be seen in Table 1.

Statistical analysis

Quantitative data were reported by mean (standard deviation) and median (interquartile range). Qualitative data were noted by number and percentage. Normality was assessed by Kolmogorov–Smirnov test and indicated abnormal distribution ($P < 0.05$) and indicated nonparametric tests for analysis. Data were analyzed by nonparametric Wilcoxon test, Intraclass correlation, nonparametric Mann–Whitney U-test and nonparametric Kruskal–Wallis test in SPSS 18. $P < 0.05$ considered to indicate statistical significance.

RESULTS

In this study, 238 children were eligible to participate. Twenty-two children unwilling to participate were excluded, and 216 children aged 1–10 years enrolled. The majority of participants were male (50.9%). The mean age were 4.59 ± 3.35 years old and the mean weight were 17.4 ± 5.69 (6.5–45) kg. Furthermore, the mean height were 106.08 ± 17.01 (61–144) cm [Table 2].

Wilcoxon test revealed no significant difference between estimated weight by visual expert estimation and APLS and actual weight (respectively, $P = 0.105$, $P = 0.618$) [Table 3]. The lowest and highest mean PE were respectively observed by Visual expert Estimation (0.017%) and MAC method (25.48%).

Intraclass correlation showed the highest correlation (0.98) between weights by visual estimation and parental reports. Also, the lowest correlation (0.712) was indicated through MAC [Table 4].

Table 1: Weight-estimation methods in the pediatric population

Methods	Applicability	Method of application
DWEM[8]	Length range: 50-175 cm	Measure length Assign habitus Read weight from table
Oakley[9]	Length range: 50-160 cm	Measure length Read weight from graph
Traub and Johnson[10]	Age: 1-18	Weight in kg=2.05×e0.02×X or, for males >60 inches Weight in kg=39+2.27× (Y−60) or, for females >60 inches Weight in kg=42.2+2.27× (Y−60) X=Height in cm, Y=Height in inches
Traub and Kichen[11]	Length over 74 cm and age range: 1-17 years	Weight in kg=2.396×1.0188X X=Height in cm
MAC[5]		(MAC-10) ×3
Theron formula[12]	Age: 1-10	Weight in kg=Exp ((0.175571×age in years) +2.197099)
Leffler formula[13]	Age: 1-10	<1-year: Weight in kg=(Age in month/2) −4 1-10 year: weigh in kg=(2×age in year) +4
APLS[14]	Age: 1-10	Weight in kg=2× (Z+4) Z=Age in years (to nearest half year)
Visual estimation by an expert	Age: 1-10	Kg
Parental reports	Age: 1-10	Kg

APLS=Advanced pediatric life support, DWEM=Devised weight estimation method, MAC=Mid-arm circumference

Table 2: Mean weight and height for each age

Age (years)	Number	Percentage	Mean weight (kg)	Mean height (cm)
1	29	13.4	10.73±1.57	80.48±4.83
2	35	16.2	12.98±1.71	91.51±7.38
3	16	7.4	14.61±1.60	98.81±6.31
4	36	16.7	16.67±3.36	105.47±7.17
5	31	14.4	18.91±3.58	110.69±4.05
6	20	9.3	19.15±3.02	115.16±5.84
7	14	6.5	23.07±3.04	125.03±6.38
8	26	12	24.82±4.24	127.90±7.78
9	8	3.7	22.06±4.94	130.56±10.89
10	1	0.5	45±00	144±00
Total	216	100	17.40±5.69	106.08±17.01

In addition, Mann–Whitney U-test indicated that there were no significant difference between weights based on gender except by DWEM ($P = 0.01$).

Kruskal–Wallis test showed significant difference between PE based on visual expert estimation ($P = 0.033$), DWEM ($P = 0.031$), Theron formula ($P = 0.0001$), MAC ($P = 0.0001$) and Traub–Johnson ($P = 0.0001$).

DISCUSSION

In this study, there were no significant difference between estimated weight and actual one, based on visual expert estimation and APLS method, which was inconsistent with the results mentioned by Black *et al.* They demonstrated the highest PE by APLS method. They indicated that the APLS method underestimated the weight and had the least precision among the methods. In addition, they obtained that the most accurate methods of estimating weights in the pediatric population were length-based methods such as the DWEM and Braslow tape.[4]

Furthermore, in this study results indicated lowest PE by visual estimation and parental reports (0.17% and 0.63%, respectively) and the highest intraclass correlation was obtained between estimated weight and actual one based on these methods (0.98). Although, Akaberian *et al.* mentioned significant consistency between maternal estimation and actual weight for children except tall ones (>97.5 cm).[15] However, the imposed stress may induce false reports, and this method could not be an indication in emergency situations. In addition, as parents may not be always available, and hence it seems that this method cannot be applicable.

Furthermore, Harris *et al.* examined estimations of pediatric weights made by doctors, nurses and parents and found they were all unreliable and only 42% of parents, 30% of doctors and 25% of nurses estimated within 5% of the child's weight. Ranges varied from underestimating by 55.6% to overestimating by 29.2%.[16] Furthermore, a recent meta-analysis revealed that 50.7% (95% confidence interval 31.1–70.2%) of parents underestimated their overweight/obese children's weight.[17]

Table 3: The comparison between estimated weight and actual one based on methods

Method	Groups	Numbers	Mean percentage of error	Mean	SD	Median	IQR	Z score	P*
Visual estimation	Actual weight	216	−0.17	17.4	5.69	16	8	1.62	<0.105
	Estimated weight	216		17.3	5.51	16	6.75		
Parental reports	Actual weight	216	−0.63	17.4	5.69	16	8	2.55	<0.011
	Estimated weight	216		17.22	5.5	16	7		
Leffler formula	Actual weight	216	13.94	17.4	5.69	16	8	8.01	<0.0001
	Estimated weight	216		19.18	4.7	19	7		
Theron formula	Actual weight	216	24.96	17.4	5.69	16	8	10.48	<0.0001
	Estimated weight	216		21.97	9.46	19.82	11.84		
MAC	Actual weight	216	25.48	17.4	5.69	16	8	9.88	<0.0001
	Estimated weight	216		20.85	5.32	21	4.5		
APLS	Actual weight	216	11.91	17.4	5.69	16	8	0.499	<0.618
	Estimated weight	216		17.18	4.7	17	12		
Traub-Kichen	Actual weight	216	5.51	17.4	5.69	16	8	5.06	<0.0001
	Estimated weight	216		18.15	5.75	17.57	8.11		
Traub-Johnson	Actual weight	216	4.56	17.4	5.69	16	8	3.94	<0.0001
	Estimated weight	216		18.11	6.16	17.42	8.11		
DWEM	Actual weight	216	8.74	17.4	5.69	16	8	7.62	<0.0001
	Estimated weight	216		18.87	6.77	18	9		
Oakley method	Actual weight	216	13.74	17.4	5.69	16	8	9.14	<0.0001
	Estimated weight	216		19.42	5.87	19	6		

*Wilcoxon test, $P<0.05$ significant difference. DWEM=Devised weight estimation method, CI=Confidence interval, SD=Standard deviation, IQR=Interquartile range, APLS=Advanced pediatric life support, MAC=Mid-arm circumference

Table 4: Intraclass correlation between estimated weight and actual one based on methods

Weight estimation methods	Intraclass correlation	95% CI	P*
Visual estimation	0.98	0.984-0.974	<0.0001
Parental reports	0.98	0.987-0.978	<0.0001
Leffler formula	0.805	0.848-0.753	<0.0001
Theron formula	0.715	0.774-0.643	<0.0001
MAC	0.712	0.772-0.64	<0.0001
APLS	0.805	0.848-0.753	<0.0001
Traub-Kichen	0.883	0.909-0.849	<0.0001
Traub-Johnson	0.88	0.907-0.846	<0.0001
DWEM	0.891	0.915-0.859	<0.0001
Oakley method	0.838	0.873-0.793	<0.0001

*$P<0.05$ significant difference. APLS=Advanced pediatric life support, DWEM=Devised weight estimation method, CI=Confidence interval, MAC=Mid-arm circumference

In addition, Akaberian *et al*. and black mentioned Braslow tape as the most accurate methods of estimating weights in the pediatric population. They mentioned its' application not only for estimating weight, but also for appropriate dosage of medications and equipment sizes in pediatric resuscitation.[4,15] Therefore, according to results, length-based methods were the most common method of weight estimation in a critical condition. In the 1990s, Braslow tape became applicable in many countries, however, unfortunately, had not been widely used in Iran.

In this study, the lowest correlation (0.712) had been observed through MAC, which was inconsistent with the results mentioned by Cattermole *et al*. They revealed that MAC had the strongest relationship with weight.[5]

In our study, Theron formula indicated the highest PE (24.94%) and the lowest correlation between estimated and actual weight had been observed (71.5%). However, So *et al*. mentioned Theron formula as a significantly better weight-estimation method compared with Broselow tape and other alternatives for pediatric patients weighing >40 kg.[6]

CONCLUSIONS

Results indicated a significant difference between the estimated weight and the actual one based on visual expert's estimation and APLS method. As, these methods were easy, rapid and accurate for body weight estimation in emergencies and may be more accurate than parent's estimation, it seems that it could be helpful for prescribing medication dosage and equipment sizes.

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