ORIGINAL ARTICLE

ACCURACY OF PEDIATRIC WEIGHING SCALES BEING USED BY HEALTH INSTITUTIONS IN ADDIS ABABA: CROSS-SECTIONAL STUDY

Yemisrach Mekonnen [1], Atnafu Mekonnen [2], Abate Yeshidinber [3]

[1] Department of Pediatrics and Child Health St. Paul's Hospial Millennium Medical College (SPHMMC)
[2] Department of Pediatrics & Child Health, St. Paul's Hospial Millennium Medical College (SPHMMC)
[3] Department of Pediatrics and Child Health St. Paul's Hospial Millennium Medical College (SPHMMC)
Corresponding author: Atnafu Mekonnen, atnemekonnen@yahoo.com

ABSTRACT

Background : *Weight measurement is part of the care in a pediatric clinic for many reasons. It is important in drug dosing, and nutritional assessment. Error in measuring weight can lead to erroneous clinical care. This study aimed to assess the accuracy of pediatric weighing scales which were in use by the health institutions in Addis Ababa.*

Methods : *One hundred sixty-seven weighing scales from 70 health institutions were included in the study. Data were collected in May and June 2016. The data collector was a certified person by the National Metrology Institute of Ethiopia on scale assessment and weight calibration. Nationally certified International Organization of Legal Metrology CLASS M1 1 kg, 5 kg, 10 kg and 15 kg standard weights were used to assess the precision and accuracy of the weighing scales. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 21.0 for windows. Wilcoxon Signed Rank test was used to compare the mean differences between initial and final measurements of the weighing scales and to assess the mean difference between the displayed weight and actual weights of the calibration weights. Chi-square test was used to assess factors which could lead to inaccuracy or imprecision of the weighing scales. Statistical significance was considered when the p-value was less than* 0.05.

Result : *A total of 167 weighing scales were evaluated during the study period. Of the total weighing scales 87 (52.1%), 55(32.9%), 43(25.7%), and 25(15.0%) of the scales weighed the 1kg, 5kg, 10 and 15kg standard loads, respectively, accurately. The median of the difference of each scale compared to the weight of the respected standard load of 1kg, 5kg, 10kg and 15kg was 0.0kg (IQR=0.0,0.1), 0.1kg (IQR=0.0,0.2), 1.0kg (IQR=0.0,1.0) and 0.4kg(IQR=0.1,0.6) respectively. Wilcoxon Signed Rank test showed no statistically significant difference between the mean weights of the 10kg standard load which was weighed twice using each weighing scale (p=o.971) indicating the weighing scales were precise.*

Conclusion*: Our finding showed that the weight scales were precise but not accurate**. It emphasizes the need for regular recalibration to obtain accurate measurements.*

Keyword: *Accuracy, Calibration, weighing scale, pediatrics*

INTRODUCTION

Anthropometry is a relatively quick, simple, and cheap means of nutritional screening, surveillance, and monitoring (1). Weight measurement is one of most commonly performed anthropometry on children worldwide. In addition to nutritional evaluation, in pediatrics, weight is used for drug dosing and for following specific disease progressions (2).

Studies conducted in United States (US) and United Kingdom (UK) on the accuracy of height and weight measurements of children aged 4-43 months indicated the presence of variations in accuracy between younger infants' and older children's anthropometric measurements (3, 4). Similarly, in Kenya weight-for-length measurement done by health workers on infants aged less than six months was one of the least reliable anthropometric measurements (5). Different factors are known to affect the accuracy and precision of weighing scales. Parent-reported weight, height and Body Mass Index (BMI) were shown to be poor in accuracy for classifying children into BMI categories of underweight, overweight and obesity status indicating that place of anthropometry measurement affects accuracy of weighing scales (6-8). Also, the Norwegian study showed a beam balance weight scale to give better value than digital scales indicating the impact of instrument error for incorrect weight measurement (9). In general, sources of error associated with child's weight measurement could be the observer, the child being measured (hydration and bladder contents, clothing, etc.), and the instrument used (10) including overuse without maintenance or recalibration, incorrect usage and general wear and tear because of frequent transportation (11).

Error in measuring the weight of the child could lead to erroneous clinical care and incorrect clinical judgments particularly in drug dosing and growth and nutritional assessments (12). Population based study showed the prevalence of obesity and overweight were over estimated merely because of failure to calibrate weighing scales (9). So, weight measuring instruments should be calibrated according to a standard and should be adjusted in case of deviation to avoid clinical errors (13). Through literature search the authors have found out that there is paucity of evidence which tried to investigate the reason behind why health care providers fail to do regular calibration of pediatric weighing scales. The authors perceive that failure of the regulatory body to enforce the law could be the main reason for failing to do so.

Studies which assess the accuracy and precision of pediatric weighing scales in our city are nonexistent. Hence, the purpose of this study was to evaluate the accuracy and precision of pediatric weighing scales among health facilities in Addis Ababa.

Methods and Materials

Data were collected prospectively in May and June of 2016 in Addis Ababa. Because

of logistical reason, convenient sampling technique was used and 70 health institutions were included in the study. Of the included 54 were public and 16 were private-for-profit. At the time of the data collection a total of 167 weighing scales were being in use within the included health institutions and all of them were included in the survey.

Data were collected by a certified person on scale assessment and weight calibration who was actively working in the National Metrology Institute of Ethiopia at the time of the survey. Additionally, assistant data collector was trained and employed. Nationally certified International Organization of Legal Metrology (OIML), CLASS M1 1 kg, 5 kg, 10 kg and 15 kg weights with uncertainty coverage factor k 1, were used to assess the precision of the 167 weighing scales (a total of 141 weighing scales from public health institutions and 26 weighing scales from private-for-profit health institutions were included in the study). Factors that may lead to inaccuracy and imprecision were also assessed, which included scale location (Out Patient Department (OPD), Ward, vaccine room..), type of scale resting surface (i.e., tile, coach, concrete, other), overall condition of the scale (good condition, slightly worn, heavily worn), type of weighing scale (digital, balance beam, other), maximum capacity, and calibration history (no history of calibration, calibrated within the past year). Scale condition was determined by the consensus of the two data collectors and was based upon wear and tear of the scale, wearing off numbers on the scale face, and any other physical damage.

Before the placement of the standardized test weight, the data collectors checked if the scale was level at zero weight. Then the weight of the 10-kg standardized test weight was obtained. Following this, the standardized test weights were placed on the scale in ascending order of 1kg, 5 kg, 10 kg and 15 kg, and lastly the measurement of 10 kg was repeated to access precision.

Data were analyzed using Statistical Package for Social Sciences (SPSS) for windows version 21.0. Differences between the standardized test weights and the measurement of the weighing scales were determined by using the absolute difference between the scale reading and the standard weight. Wilcoxon Rank sum test was used to compare the mean differences between initial and final measurements of the weighing scales and to assess the mean difference between the displayed weight and actual weights of the calibration weights. Chi-square test was used to assess factors which could lead to inaccuracy or imprecision of the weighing scales. Statistical significance was considered when the p-value was less than 0.05.

Ethical clearance was obtained from the Institutional Review Board of St Paul's Hospital Millennium Medical College and from Addis Ababa Regional Health Bureau.

Result

Of the total 167 weighing scales that were evaluated, 128(76.6 %) were dial type, 30 (18%) were digital type and the remaining 9 (5.4%) were beam balance type. All the scales were never calibrated by a regulatory body. At the time of the survey locations of the weighing scales were: 99(59.3%) were at the outpatient department (OPD), 28(16.8%) at the vaccine room, 23(13.8%) at the delivery room, 8(4.8%) in the ward and 9(4.9%) at other places.

The condition of all the weighing scales was judged to be perfect by the data collectors except one which was slightly torn. The maximum weight capacity of the weighing scales ranges from 15 kg to 200 kg. Accordingly, 66(39.5%) weighing scales had a maximum weight capacity of 20 kg and 30(19.2%) had a maximum weight capacity of 16kg. Of the total weighing scales, 116(69.5%) were resting on table, 32(19.2%) were resting on tiles and the rest were resting on either concrete ground or examination couch.

Of the total weighing scales 87(52.1%), 55 (32.9%), 43(25.7%), and 25(15.0%) of the scales weighed the 1kg, 5kg, 10 and 15kg standard loads, respectively, accurately. The median of the difference of each scale compared to the weight of the respected standard load of 1kg, 5kg, 10kg and 15kg was 0.0kg (IQR=0.0,0.1), 0.1kg (IQR=0.0,0.2), 1.0kg (IQR=0.0,1.0) and 0.4kg(IQR=0.1,0.6) respectively. Wilcoxon Signed Rank test showed no statistically significant difference between the median weights of the 10kg standard load which was weighed twice using each weighing scale (p=o.971) indicating the weighing scales were precise (Table 1).

Table 1- Scale accuracy and precision: The standard weight scale compared with the mean of weight registered by the scales, Addis Ababa, 2016

Standard weighing scale applied	Number of weight scales assessed	Median of the difference (Inter-quartile Range)	P-value (Wilcoxon Signed Rank Test)
Weight of 5kg	167	0.1(0.0-0.2)	-
Weight of 10kg	167	1.0(0.0-1.0)	-
Weight of 15kg	167	0.4(0.1-0.6)	-
Weight of initial 10kg with weight of final 10kg	167	-	0.971

*Sd-Standard Deviation

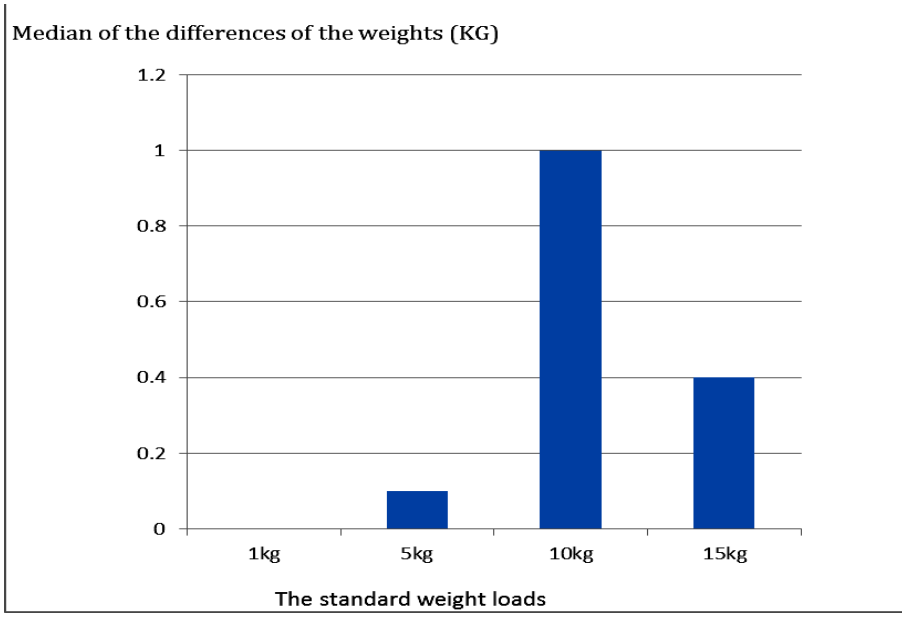
The median of the weight differences between the standard load and the measured one by the scales was within the range of 0.0 -1 kg, with the largest weight difference occurred at 10 kg calibration weight (Bar chart 1). Name of institution and type of weighing scale, were significantly contributing the differences in measurements as shown in Table 2

Table 2- Factors affecting scale accuracy assessed for 10-kg measurement Addis Ababa, 2016

Factor	**Number of**	**Mean**	**Sd***	**P-value**
Typeof institution				
Health center	115	9.80	0.54	
Government hospital	26	9.73	0.73	0.02
Private institution	26	9.90	0.94	
Type of weight scales				
Digital	30	9.82	0.64	
Dial	128	9.72	0.67	0.001
Beam balance	9	9.92	0.67	
Location in the facility				
OPD	99	9.80	0.58	
Ward	8	9.78	0.60	
Vaccine room	28	10.00	0.59	0.128
Delivery	23	9.68	0.70	
Other	9	9.51	1.19	
Resting surface				
Concrete	11	9.81	0.46	
Examining couch	3	10.03	0.18	
Tile	32	9.70	0.45	0.199
Table	116	9.84	0.69	
Other	5	9.82	0.47	

*sd-Standard Deviation

Bar chart 1: The median of weight differences between the measured one and the standard weight loads, Addis Ababa, 2016.



Discussion

This study was conducted with the aim of assessing the accuracy and precision of pediatric weighing scales which were in use by the health institutions in Addis Ababa.

The study demonstrated that the pediatrics weighing scales were not accurate which could be because of lack of regular recalibration. A Norwegian study showed there was overestimation of the prevalence of overweight and obesity because of instrumental errors and suggested the need for regular maintenance or recalibration of instruments to reduce instrument error (9).

Previous study done at Kansas City on Precision in weighing scales found out that scales in healthcare settings did not have higher accuracy than scales in fitness or weight loss centers (11). In the same study they identified decreased accuracy with increased weight capacity of the scales which was also shown in our study in the 15-kg calibration where the deviation from the standard load was high (see bar chart1).

In our study, type of health facility was significantly associated with inaccurate measurement. Weighing scales which were used by the private for-profit health facilities were more accurate than the weighing scales used by the public health facilities (p=0.02). This could be because of the existing difference between the two types of health institutions in handling equipment's and frequency of usage (Table 2).

The type of weighing scale was another factor which had statistically significant association with inaccurate measurement. In our study we found out that beam balance weighing scale were more accurate than the other type of weighing scales (P=0.001).

Similar finding was reported by previous study conducted in Norway (9) which showed that beam balance weighing scale were more accurate as compared to electronic weighing scales and hence overweight and obesity were overestimated because of instrumental errors. In our study, the fact that we included smaller number of beam balance weighing scales (9 weighing scales) could be another reason for the significant statistical association.

In our study, even though those scales which rest on examining couch had a better mean value compared to other resting surfaces, the resting surface of a weight scale didn't show any significant statistical association. But in another study, the resting surface of the scale was found to be significantly associated with measurement precision; carpeted surfaces providing more exact readings than those found on tiled surfaces (11).

The strengths of the current study include data was collected prospectively allowing to maintain the quality of the data and included all types of health facilities in Addis Ababa helping to understand the situation in the city. The main limitation of the study was it didn't assess the accuracy and precision of weighing scales with weight capacity above 15 kg. The fact that we used convenient sampling technique could also affect the external validity of the findings.

Key implication

The fact that the weighing scales had low accuracy has different implication. The first and the most important thing is, it can affect quality of patient management. Unlike the practice in adult settings, every drug dosing for the pediatric patient is based on the weight of the child. Some drugs have a narrow margin of safety and hence kids are prone to toxicity if the weight is overestimated due to the inaccurate and imprecise weighing scale. The drug chloroquine can be mentioned as a good example as such. This drug is used for treatment of malaria and autoimmune disorder and there are many death reports in children because of the narrow margin between therapeutic and toxic doses of this drug (14). On the other hand, emergence of antibiotic resistant bacteria is becoming a global public health problem. Under dosing of antibiotics which can happen because of inaccuracy of the weighing scales is one of the reasons for emergence of drug resistant bacteria. Research has shown that increased pharyngeal carriage of penicillin-resistant Streptococcus pneumoniae can occur because of lower doses of antibiotic prescription (15, 16). Other important implications of our finding include growth monitoring of children where accurate and precise weight measurement is needed (17).

In conclusion, our finding showed that the pediatric weighing scales were inaccurate. The finding emphasizes the need for regular.

recalibration of weighing scales to obtain more accurate estimates as it affects the quality of care being provided. We recommend the regulatory body to implement a national policy on monitoring and calibration of weighing scales. We also advise the health institutions to work closely with the regulatory body and comply with the requirements on calibrating weighing scales. Further research is also recommended to identify the reasons why health care providers are not regularly calibrating the weighing scales.

Acknowledgment

We would like to thank St Paul's Hospital Millennium Medical College for funding the research.

Authors' contributions

All authors involved in writing the proposal and the manuscript. They have read and approved the final manuscript. Additionally, Atafu Mekonnen conceived the idea and Yemisrach Mekonnen did the analysis.

Disclosures

The authors declare no conflict of interest.

REFERENCES

1. Alvero Cruz J, Diego Acosta A, Ferna´ndez Pastor V, Garcı´a Romero J. Body composition assessment methods: Actual trends (III). AMD 2005; 22: 121–7.
2. Mercedes de O, Monika B. WHO global database on child growth and malnutrition; methodology and application, international journal of epidemiology 2003; 32(4):518-526.
3. Crespi CM, Alfonso VH, Whaley SE, Wang MC. Validity of child anthropometric measurements in the Special Supplemental Nutrition Program for Women, Infants, and Children. Pediatric Res. 2012; 71(3):286-292.
4. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC Growth Charts for the United States: methods and development. Vital Health Stat 2002; (246):1–190.
5. Mwangome MK, Fegan G, Mbunya R, Prentice AM, Berkley JA. Reliability and accuracy of anthropometry performed by community health workers among infants under 6 months in rural Kenya. Tropical Medicine and International Health 2012; 17(5):622-629.
6. Huybrechts I, De Bacquer D, Van Trimpont I, De Backer G, De Henauw S. Validity of parentally reported weight and height for preschool-aged children in Belgium and its impact on classification into body mass index categories. Pediatrics 2006; 118(5):2109-18.
7. Scholtens S, Brunekreef B, Visscher TL, et al. Reported versus measured body weight and height of 4-year-old children and the prevalence of overweight. Eur J Public Health 2007; 17:369-374.
8. Akerman A, Williams ME, Meunier J. Perception versus reality: an exploration of children's measured body mass in relation to caregivers 'estimates. J Health Psychol 2007; 12:871-882.
9. Biehl A, Hovengen R, Meyer HE, et al. Impact of instrument error on the estimated prevalence of overweight and obesity in population-based surveys. BMC Public Health 2013, 13:146.

10. Himes JH. Challenges of accurately measuring and using BMI and other indicators of obesity in children. Pediatrics 2009; 124(1):3–22.
11. Stein RJ, Haddock CK, Poston WS, Catanese D, Spertus JA. Precision in Weighing: a comparison of scales found in physician offices, fitness centers, and weight loss centers. Public Health Reports 2005; 120:266-270.
12. Selbst SM, Fein JA, Osterhoudt K, Ho W. Medication errors in a pediatric emergency department. Pediatr Emerg Care. 1999; 15(1):1-4.
13. Education level of the Flemish population (25-34 years old). [http://aps. vlaanderen.be/ sitemap.htm].
14. Kelly JC, Wasserman GS, Bernard WD, Schultz C, Knapp JF. Chloroquine poisoning in a child. Annals of Emergency Medicine 1990; 19(1):47-50.
15. Guillemot D, Carbon C, Balkau B *Et al.* Low dosage and long treatment duration of beta-lactam: risk factors for carriage of penicillin-resistant *Streptococcus pneumoniae*. *JAMA* 1998; 279: 365–370.
16. Ekins-Daukes S, McLay JS, Taylor MW, Simpson CR, and Helms PJ. Antibiotic prescribing for children. Too much & too little? Retrospective observational study in primary care. Br.J. Clin. pharmacol.2003; 56(1):92-95.
17. K. Vijayaraghavan. Anthropometry for assessment of nutritional status. Indian J Pediatr 1987;54:511-520.