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Brief Report

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BRIEF REPORT

Assessing Community Health: An Innovative Tool for Measuring Height and Length

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ABSTRACT

Anthropometric measurements, including height and length, are routinely needed for health research worldwide. Measurement boards are the current gold standard for obtaining the height and length of children. In community-based research, however, the size and weight of the measurement boards make them difficult and cumbersome to carry in the field. In addition, children and infants may express an unwillingness to be placed onto the measurement board. Electronic measuring tools commonly used in industry and contracting work are precise and portable. This study piloted a protocol to use an adapted laser measurement tool, the anthropometric measurement assist (AMA), to obtain height and recumbent length in children in Western Kenya. Intra- and inter-observer variability were determined and compared with measurement board measurements. Results of this initial pilot indicated that the AMA may be a viable alternative to measurement boards. The AMA can measure height/length accurately and reliably, is portable and is equivalent in price to measuring boards, making it a viable option for fieldwork in low-resourced countries.

KEYWORDS: anthropometry, body composition, children, height measurement, length measurement

INTRODUCTION

Anthropometric measurements are a standard aspect of health research indicating both individual- and community-level well-being [1, 2]. Obtaining accurate and reproducible measurements, however, can prove difficult [3–10]. While advances have been made to minimize error when weighing subjects, e.g. improved seats for spring scales, digital and self-zeroing mechanisms, minimal advancements have been made for height/length measuring tools [10, 11]. For >30 years, the standard for capturing height/length has been measurement boards. Weighing ~12.5 pounds and ~2.5 feet in length, measurement boards are relatively large, difficult to carry and prone to parallax [12, 13]. Alternative measurement tools that are lighter and more easily packable and provide accurate and reproducible results are needed. Laser measuring technology may be one viable alternative. We compared measurements of children's height/length from a standard measuring board with a laser-based measurement tool designed by our team.

METHODS

The pilot study took place from July–August 2014 in Kenya as part of a malaria research study.

Participants, aged 1 month to 8 years, were recruited from an elementary school or clinic. Schoolmasters and parents granted permission for the study. The University of Arizona Institutional Review Committee and the Kenyan Medical Research Institute approved the study.

Data Collection

The anthropometric measurement assist (AMA) design includes a Leica Disto D2 distance meter (battery operated), measuring range 0.05–60 m and accuracy ± 0.06 cm, and a hinge locks at 90° headpiece to act as a surface to reflect the laser (Fig. 2).

Height was measured for children >2 years of age by placing the headpiece atop and behind the child's head. The laser was placed 3–4 inches in front of the participant's feet. Length was measured for children <2 years of age by placing the headpiece on top and side of the child's head creating a 90° angle. Child was adjusted for Frankfort plane, with feet placed together and flat on the ground. Measurements for recumbent and standing were taken by targeting the laser's beam near feet to headpiece for head-to-heel measurement (Fig. 3). The measurement board used was a Shorr Board® [1]. Pairs of trained individuals were used to conduct measurements for both instruments to ensure correct positioning and recording of the height/length [1].

To assess accuracy, children < 8 years ($n = 62$) of age were measured once using both instruments. To minimize bias toward similarity, the AMA measured in imperial units, while the measuring board used metric units, and tool sequence varied. Descriptive statistics, two-sample *t*-tests with equal variance, Pearson's r, Bland–Altman plots and corresponding statistics and Lin's (overall) concordance correlation coefficients (OCCCs) were calculated to determine differences between the two instruments with the measuring board treated as 'gold standard'. Finally, a linear mixed model was used to assess if the type of tool was associated with height measurement after adjusting for age of child, sex of child, personnel conducting the measurement and day the measurement took place.

To evaluate reproducibility of measurements, study staff ($n = 6$) was trained on the use of both tools. Then, children ($n = 15$) from a participating school were recruited and assigned identification numbers to maintain anonymity. Over 3 days, each field assistant measured each child three times with both tools. Lin's overall OCCCs were calculated for intra- and inter-rater reliability.

RESULTS

The mean age of participants was 50 months and height/length was 48 m. Recumbent length was measured in the 15 children <2 years of age, and standing height was measured in 62 children ≥2 years of age.

We found no statistically significant difference in accuracy for the mean height/length measurements between instruments; however, AMA slightly underestimated height/length with mean difference of 0.003 ± 0.004 m standard error (Table 1). The variance between AMA measurements was 0.05 m and that for measurement board was 0.05 m; therefore, a two-sample *t*-test with equal variance was used. The model showed *t*-statistic value of −0.07 and *p*-value of 0.94. One outlier was documented possibly because of a child's movement or a recording error. The Pearson's r for only recumbent length between AMA and measurement board was 0.98. The Pearson's r for only standing height between AMA and measurement board was 0.99. A Bland–Altman assessment for agreement indicated that measurements fall within the acceptable limits of agreement −0.033 to 0.028 (Fig. 1). To determine the difference between tools, a Lin's OCCC for validity was carried out. The strength of agreement between the

Table 1. Average measurement differences by sex and age group for accuracy measurement pilot

Groups (n)	Measurement board (m) $X \pm 1$ SD	AMA laser (m) $X \pm 1$ SD	Mean difference (m)
Total (62)	0.978 ± 0.225	0.975 ± 0.221	0.003 ± 0.004
Girls (31)	0.997 ± 0.210	0.993 ± 0.207	0.004 ± 0.003
Boys (31)	0.959 ± 0.245	0.957 ± 0.236	0.002 ± 0.009
2–8-year-olds (height) (45)	1.101 ± 0.096	1.096 ± 0.091	0.005 ± 0.005
<2-year-olds (length) (17)	0.651 ± 0.123	0.656 ± 0.120	−0.005 ± 0.003

Table 2. Correlation statistics between tools by different users

Measurement	Measuring board	Laser measurer (AMA)
Bland–Altman	−0.018 to 0.004 (95% limits of agreement)	
Lin's RhoC	0.983 (0.996, 0.999)	
OCCC	0.955 (0.733, 0.995)	0.948 (0.910, 0.975)
Overall precision	0.961	0.956
Overall accuracy	0.993	0.992

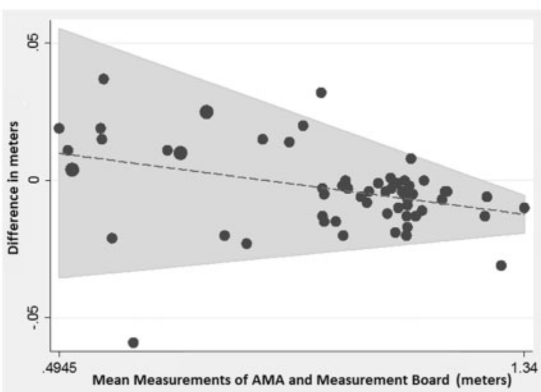

Fig. 1. Bland–Altman plot.

tools was substantial with a RhoC of 0.998 (95% confidence interval 0.996–0.999) (Table 2).

The linear mixed model analysis produced similar results for reproducibility showing no difference between height/length taken with the measurement board and the AMA after accounting for the correlation between the measurements made by the same personnel across 3 days ($p = 0.27$). To determine the difference between tools, an overall OCCC for validity was carried out for each of the measurement methods across the six observers. For AMA, the OCCC = 0.948 (95% confidence interval 0.910, 0.975), overall precision = 0.956 and overall accuracy = 0.992. For the measurement board OCCC = 0.955 (95% confidence interval 0.733, 0.995), overall precision = 0.961 and overall accuracy = 0.993 (Table 2).

Fig. 2. Rendering of AMA.

DISCUSSION

The AMA design proposed may be a lightweight, highly portable alternative to the current measuring board standard (Table 3). Even with the most rudimentary headpiece design and commercially available laser distance meter, individuals with a day-long training were able to record accurate and reproducible measurements. Though small and statistically insignificant, AMA measures height/length slightly under the measurement board measurements. If the consistency of the under-measurement is demonstrated in follow-up studies, it could be added as a simple offset to the laser measurements. During the pilot phase, we identified several potential improvements to the design's durability and accuracy including mounting a bubble level to the headpiece and using weather-durable plastic at a standard right angle.

Fig. 3. Investigators using AMA with young girl.

Limitations

Personnel had previously used measurement boards to record height/length in previous research but had not used AMA previously. Therefore, our estimates of error for the AMA may be over-estimated.

Conclusion

Overall, AMA was accurate and reproducible for measuring height/length. With further validation and testing, this tool could be an alternative to current measuring methods and ideal for fieldwork in limited-resourced countries.

SUPPLEMENTARY DATA

Supplementary data are available at *Journal of Tropical Pediatrics* online.

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Table 3. Comparison of AMA and measurement boards based on ease of use and cost

Factors	Measurement boards[a]	Laser measurer (AMA)
Cost	>$100–400	$179
Weight	4082.33 g	100 g
Dimensions	13×20 inch[b]	Headpiece: 1×14 inch Leica meter: 4.4×1.7×0.90 inch
Digital reading	No	Yes

Note:
[a]The range for the cost of measurement boards varies, and not all models have been tested for accuracy in practice.
[b]When the board is folded for transport.

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