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Performance of oscillometric blood pressure devices in children in resource-poor settings

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Abstract

Objective—To compare oscillometric blood pressure devices with mercury sphygmomanometry in children.

Patients and methods—Blood pressure measurements were obtained with a mercury sphygmomanometer and one of two oscillometric devices. Correlations within each device and agreement between the two devices were evaluated.

Results—In children, blood pressure measured by the oscillometric device was poorly correlated and had wide limits of agreements with the sphygmomanometer. Furthermore, the oscillometric devices overestimated systolic blood pressure in children with higher readings.

Conclusion—The applicability of automated blood pressure measuring devices in children has limitations and cannot be recommended.

Keywords

blood pressure determination; developing countries; epidemiologic methods; pediatric; Peru

Background

Current recommendations suggest the routine measurement of blood pressure in children as per the gold standard, the auscultatory method using a sphygmomanometer and a stethoscope; [1] however, oscillometric or automated devices are more practical in resource-poor settings [2]. To date, only a few oscillometric devices have been validated [3] and there is limited evidence to support their use in children [4]. The aim of this study is to test the usefulness of oscillometric blood pressure devices compared with mercury sphygmomanometer in children.

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Patients and methods

A random sample of 97 children was selected from a larger pediatric cohort study in a deprived peri-urban area of Lima, Peru. Auscultatory blood pressure measurements were made following guidelines for position and appropriate cuff sizes [1] using a mercury sphygmomanometer (Nova Presameter, Riester, Germany). Oscillometric measurements were made using two devices: 56 children were evaluated using an Omron M5-I (Omron, Tokyo, Japan) and 41 using a Riester Ri-Champion model (Riester, Jungingen, Germany).

Three blood pressure measurements were recorded with both the sphygmomanometer and one of the two oscillometric devices. Repeated measurements were taken at least 5 min apart, ensuring the patients were at rest. In all cases, oscillometric measurements were taken on the first home visit, whereas sphygmomanometer measurements were made approximately 2 weeks later on a subsequent visit.

Data were analyzed using Stata 8.0 (Stata Corporation, Texas, USA). Pearson's coefficient was used to evaluate within-device correlation, whereas Bland and Altman plots [5] were used to test agreement between the two methods. To account for the 'first reading effect' [4], repeated blood pressure measurements were summarized as the mean of all three measurements, as well as the mean of the second and the third measurement.

Ethical approval was obtained from the Universidad Peruana Cayetano Heredia, Peru.

Results

Ninety-seven children (46.4% male) between the ages of 2 and 12 years (mean age 6.6 years) were measured on two occasions. Blood pressure measurements obtained using the auscultatory method were highly correlated for both systolic and diastolic pressure ($r > 0.80$), whereas the oscillometric readings had poorer correlations ($r < 0.56$) (Table 1).

Furthermore, there was a significant first reading effect where the average of the second and the third readings was significantly lower than the average of all three readings. After considering the first reading effect, the Bland and Altman analyses showed agreement between the sphygmomanometer and oscillometric devices for systolic blood pressure (Fig. 1a) with a mean difference (95% CI) of -0.61 (-3.59, 2.36). The limits of agreement were however wide (-31.1, 28.9 mmHg) and the oscillometric device tended to overread higher systolic values. Bland and Altman plots of diastolic readings (Fig. 1b) demonstrate wide limits of agreement (-22.4, 28.6 mmHg) and a significant mean difference [3.13 (0.56, -5.69)].

The two oscillometric devices were comparable for both systolic [Omron model (mean ± SD) 103.72 ± 10.80 mmHg compared with 102.59 ± 15.42 mmHg for the Riester model] and diastolic readings (Omron 63.89 ± 9.94 mmHg compared with Riester 63.16 ± 11.60 mmHg).

Discussion

In children there is wide agreement between auscultatory and oscillometric measurements of blood pressure and bias toward the oscillometric devices overestimating systolic blood pressure in children with higher blood pressures. If used on a population level, oscillometric devices will tend to overestimate higher blood pressures and hypertension. Other larger studies comparing the two methods have found that systolic and diastolic readings were higher with the oscillometric device [6], providing stronger evidence that the two devices are not necessarily interchangeable. Furthermore, the US guidelines for hypertension in

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children [1] are based solely on readings obtained with mercury sphygmomanometry and are, thus, not appropriate for oscillometric devices.

A first reading effect, whereby the averages of the second and third measurements were significantly lower than the average of all the three rounds of measurement, was also observed. This has important implications for field studies and clinical practice, where it is often only feasible to obtain one measurement [4]. Although more time consuming, it is advantageous to obtain at least three readings and to exclude the first reading. In settings where single blood pressure measurements are obtained, a single sphygmomanometry reading is better, but still needs to be interpreted cautiously as the first reading effect could bias results.

This study was not designed to be a proper validation study and is specific to a particular developing country setting. The oscillometric devices used in this study are those readily available in our context, and other better devices might exist but were not available. In addition, the two different oscillometric devices used were not validated; however, our results were similar when stratified by equipment and are unlikely to be biased.

Conclusion

The applicability of automated blood pressure measuring devices for pediatric field epidemiological studies in resource-poor settings has limitations and cannot be recommended.

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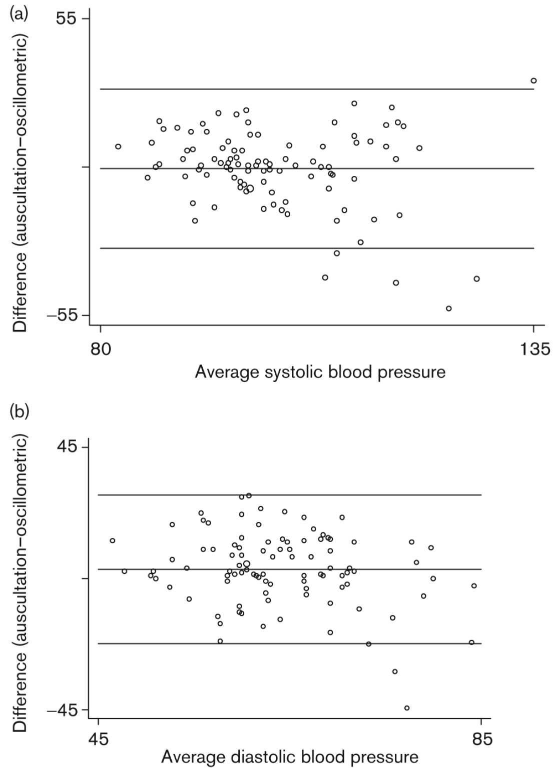

Fig. 1.
Bland and Altman plots of the average of the second and third systolic (a) diastolic and (b) readings. Central horizontal line represents mean difference between the two techniques (auscultation-oscillometric). Upper and lower solid lines represent the upper and lower limits of agreement of the comparison between techniques [5]. *x*-axis, mean auscultatory and oscillometric pressures (mmHg); *y*-axis, difference between auscultatory and oscillometric pressures (mmHg).

Table 1

Correlations (*r* coefficient) between repeated rounds of measurements within each type of device

	Systolic readings			Diastolic readings		
	First	**Second**	**Third**	**First**	**Second**	**Third**
Mercury sphygmomanometer						
First	1.0			1.0		
Second	0.88	1.0		0.85	1.0	
Third	0.83	0.91	1.0	0.82	0.87	1.0
Oscillometric devices						
First	1.0			1.0		
Second	0.56	1.0		0.54	1.0	
Third	0.43	0.51	1.0	0.19	0.31	1.0