Variability in Blood Pressure Measurements from Recorded Auscultation Sounds

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Abstract

Blood pressure measurement is clinically important. The manual auscultation method is retained as the current "gold standard". This study was designed to evaluate the variability of repeat measurements by the same operator, and between operators, when evaluating the same data.

Ten young volunteer subjects with no known cardiovascular disease were studied. Korotkoff sounds were recorded from a standard stethoscope head connected to an acoustic microphone, and the audio sounds recorded during blood pressure measurements with cuff deflation, while subjects sat quietly on a chair. All recordings were replayed blindly and independently, to two trained operators. The operators identified systolic and diastolic blood pressure (SBP and DBP) without knowledge of the subject. After all recordings had been analysed once, the analysis was repeated.

SBP ranged from 95 to 112 mmHg, and DBP from 58 to 78 mmHg. The difference in repeat listening measurements for each observer was -0.8 ±3.3 and -0.5 ±2.1 mmHg for SBP, and -0.4 ±2.3 and 0.4 ± 1.7 mmHg for DBP. The difference between the two operators for each measurement was 0.7 ± 1.6 and 0.9 ± 3.6 mmHg for SBP, and -1.7 ± 2.3 and -1.0 ± 2.0 mmHg for DBP. We have shown similar variability between operators as between repeat measurements on identical recordings.

1. Introduction

The successful measurement of blood pressure with an occlusion cuff was advanced considerably after the publication and description of the classical sounds that are detected over the brachial artery during controlled deflation of the cuff around the upper arm. These sounds were subsequently termed Korotkoff sounds, named after the doctor from St Petersburg who published his description in 1906 [1].

Much clinical training has gone into the manual recognition of these sounds, but with the pervasive use of automated devices it is now felt by some in the clinical community that the ability to measure blood pressure (BP) with a stethoscope and cuff is being lost [2].

Graves and Sheps refer to specific measurement difficulties and emphasise that "Ample evidence has shown that physicians have not been adequately trained to measure BP and, therefore, rarely measure BP to the standards asked" [3].

Confidence is needed to show that blood pressure can, with suitable training, be measured with good repeatability and low variability for blood pressure measurements in individual subjects.

1.1. Reference measurements

Nevertheless, for the evaluation of automated blood pressure devices, a reference standard is required, and auscultation with a standard stethoscope is still the accepted method, and is referred to as the "gold standard". All published device evaluation standards have used this gold standard, as does the current international standard from the International Organisation for Standardisation (ISO), developed with the assistance of the European Hypertension Society and American Association for Medical Instrumentation.

This international standard requires comparative measurements using the manual blood pressure measurement technique [4,5].

1.2 Aim of study

The aim of this study was to evaluate variability in the measurement technique, using carefully recorded Korotkoff sounds so they could be replayed more than once, enabling repeatability of measurements to be evaluated, including for more than one operator.

2. Recording of auscultation sounds

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2.1 Subjects

Ten young volunteer subjects with no known cardiovascular disease were studied. Since they were young, this has a bearing on the range of blood pressure measured.

The study received ethical permission from the Newcastle & North Tyneside Research Ethics Committee. The investigation conformed with the principles in the Declaration of Helsinki.

2.2. Recording of Korotkoff sounds

Korotkoff sounds were recorded (figure 1) from a standard stethoscope head connected to an acoustic microphone, and the audio sounds were recorded to a computer during blood pressure measurements with cuff deflation, while subjects sat quietly on a chair.

The cuff pressure was recorded simultaneously to the computer.

3. Analysis

3.1. Determining blood pressure

All recordings were replayed blindly and independently, to two trained operators. Both operators used the same computer replay software and the same high quality headphones (Sony MDR-ZX100, 12 Hz to 22 kHz frequency range).

The operators identified systolic and diastolic blood pressure (SBP and DBP) manually without knowledge of the subject.

Analysis of all recordings was repeated on two completely separate sessions to ensure that there was no memory of the first analysis. All recordings were analysed once, and then the analysis was repeated a second time.

3.2. Operator training

The Korotkoff sounds were analysed by two experienced observers. Both observers had successfully completed the British and Irish Hypertension Society auscultatory measurement training package [6]. [https://bihsoc.org/resources/bp-measurement/bp-measurement-auscultatory-tutorials/]

4. Results

4.1. Average blood pressure measurements

For all individual blood pressure results, including repeat measurements, SBP ranged from 95 to 112 mmHg and DBP from 58 to 78 mmHg.

Figure 2 shown the average values of SBP and DBP for each subject, averaged across both operators and both measurements.

4.2 Repeat measurements

The difference in repeat listening measurements for each operator was -0.8 ±3.3 and -0.5 ±2.1 mmHg for SBP, and -0.4 ±2.3 and 0.4 ± 1.7 mmHg for DBP (all mean ± SD, standard deviation). This is shown in figure 3.

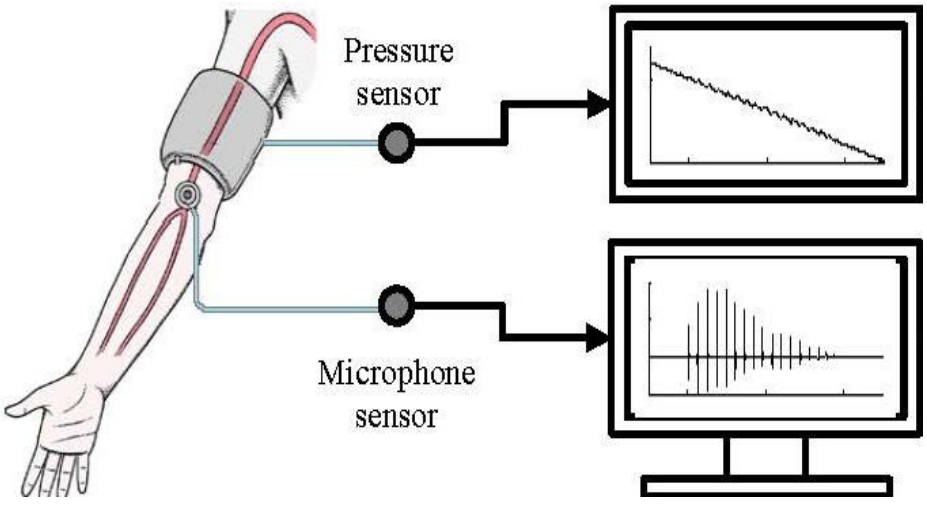

Figure 1. Recording of cuff pressure with a low frequency sensor, and stethoscope acoustic sounds with a microphone.

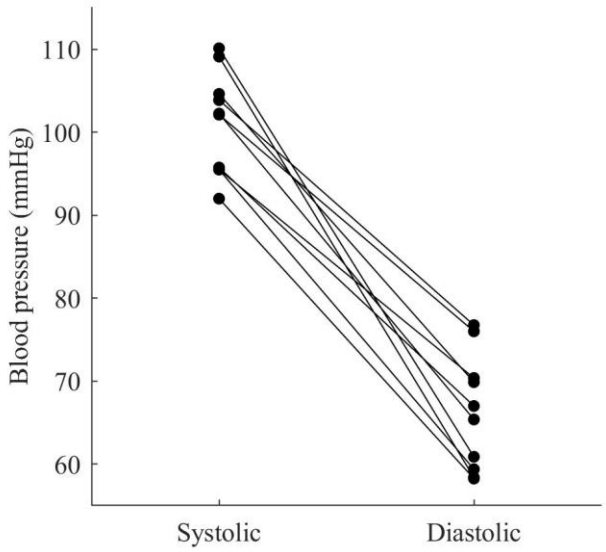

Figure 2. The average values for SBP and DBP for both operators and both measurements, plotted for all 10 subjects.

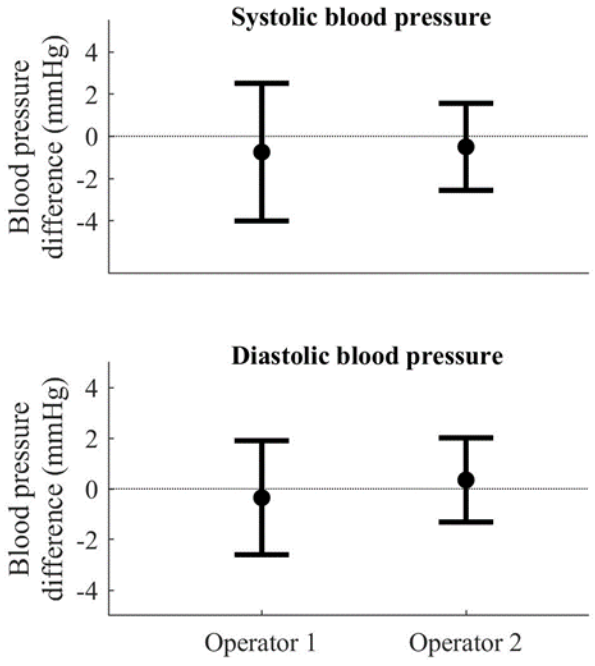

Figure 3. The blood pressure differences for repeat measurements from the same recordings, (mean ± SD). Both measurements are included.

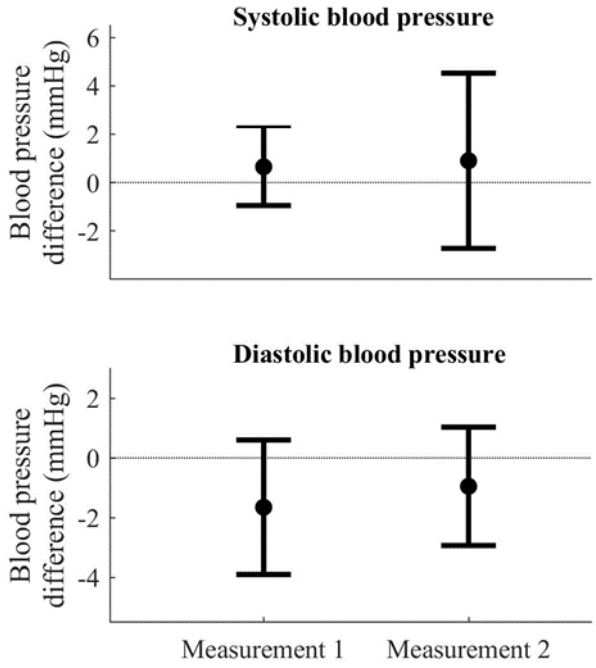

Figure 4. The blood pressure differences between the two operators, separately for the two measurement recordings, (mean ± SD). Both repeats are included.

4.3 Difference between the two operators

The difference between the two operators for each measurement was 0.7 ± 1.6 and 0.9 ± 3.6 mmHg for SBP, and -1.7 ± 2.3 and -1.0 ± 2.0 mmHg for DBP (all mean ± SD). This is shown in figure 4.

5. Conclusion

We have shown similar measurement variability between operators as between repeat measurements on identical recordings. We did, however, see a small difference between operators.

Acknowledgment

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