Comparison of blood pressure measurements on the bare arm, below a rolled-up sleeve, or over a sleeve

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**Background.** This study examined the effect of measuring blood pressure below subjects’ rolled-up sleeves, over the sleeve, or on the bare arm. This is an important day-to-day issue for the busy GP.

**Methods.** The sample consisted of 201 subjects in family practice clinics and residents of a senior citizens’ home. A digital device was used in all cases. Each participant underwent three blood pressure measurements in each of the following conditions in random order: cuff on bare arm; cuff over the sleeve; and cuff below the rolled-up sleeve. Differences between measurements were plotted against the mean blood pressure. Confounding factors controlled for were age, sex, clothing pressure and skin-fold thickness.

**Results.** Differences in mean blood pressure readings between the clothed and bare arm were 0.5 mmHg (SD 7.5) for systolic pressure and 1 mmHg (SD 5) for diastolic pressure; neither difference was significant. However, in hypertensive subjects (>140 mmHg systolic), although the mean difference remained small (systolic pressure, 2 mmHg, SD 10), the range of difference for individual subjects was −32 mmHg to +22 mmHg.

**Conclusion.** The degree of clothing under the sphygmomanometer cuff does not have a clinically important effect on the blood pressure measurement. In patients known or found to be hypertensive, measurement on the bare arm is recommended.

**Keywords.** Blood pressure, blood pressure cuff, family medicine, measurements, screening.

**Introduction**

Many factors influence the accuracy of blood pressure measurement, such as inadequate rest, white-coat effects and end-digit preference. Most studies recommend that blood pressure be measured on the bare arm,1–4 although one small study found no significant effect of clothing on blood pressure recordings.5 The present study was undertaken to determine the effect of different methods of blood pressure measurement in ambulatory care.

**Methods**

**Sample** Subjects (*n* = 201) were recruited from consecutive patients attending a family medicine practice and from residents of a nursing home. All patients were over 15 years old and consented to participate. The sample size was calculated to obtain the number of subjects needed for statistical significance when the estimated proportion of individuals with significant differences between the methods for blood measurements is 50% (‘safest’ choice),6 confidence level of 95% and absolute variation of 10% points (40–60%). The result (*n* = 96) was then doubled to increase the power in the event of individual variations.

The Association of Advancement of Medical Instrumentation (AAMI) standard for comparison of blood pressure measurement methods7 requires a minimum of 85 patients and at least 225 measurements with each technique. Good agreement is defined as a mean
difference of less than 5 mmHg between measurements with a standard deviation of less than 8 mmHg.

Procedure

Subjects rested for 5 minutes before all measurements. They were asked not to smoke, physically exert themselves or eat for 30 minutes before the examination. To avoid measurement and observer biases, the following conditions were set:

(i) only one observer (HK-L), a physician researcher specially trained for this study, performed all the blood pressure measurements;

(ii) all measurements were made with the subject seated and his/her arm resting on a smooth surface, with the forearm bent at the level of the heart; and

(iii) a digital recording sphygmomanometer (UA-767, A & D Engineering, Inc., Milpitas, CA, USA), equipped with an oscillometric pressure sensor was used in all cases.

Nine measurements were taken consecutively without delays for each subject, three in each of the following three situations, in random order:

With the subject’s sleeve rolled above the upper border of the blood pressure cuff (‘rolled sleeve’).

With the cuff placed over the sleeve on the subject’s upper arm (‘sleeve’).

With the cuff placed on the subject’s bare and unclothed arm (‘bare arm’).

The first of each set of three readings was discarded, and the average of the second and third readings was used for comparison with the readings made in the other two situations.

Other measurements included body mass index (BMI), skin-fold thickness, clothing thickness, and manometric assessment of clothing pressure on the arm.

Statistical analysis and interpretation of data

All data were analysed using analysis of variance (ANOVA) for repeated measures for type of measurement (‘rolled sleeve’, ‘sleeve’ or ‘bare arm’) on blood pressure after controlling for the effects of the confounding factors of age, sex, use of medications, body fat (assessed by BMI and skin-fold thickness), and clothing thickness (for measurements made on the sleeve). Differences between pairs of readings were plotted against the mean of the two readings to assess agreement between the methods of measurement, as described by Bland and Altman.8 Results were considered significant when \( P < 0.05 \).

Agreement of readings was compared to the AAMI standard for comparison of blood pressure measurement methods7 and the British Hypertension Society (BHS) protocol for the evaluation of blood pressure measuring devices.9,10 The BHS standard rates devices into four categories (A to D) according to the distribution of the readings made by the different methods within 5, 10 or 15 mmHg of each other. The subjects served as their own controls.

Results

Characteristics of the study population (201 subjects) are shown in Table 1. Mean age was 46 years, 66% were female and mean BMI was 26. Nineteen percent of the patients were obese (BMI > 30), and 17% were receiving antihypertensive medication.

Table 2 shows differences in blood pressure by method of measurement. For systolic pressure, the mean difference between measurements made on the bare arm compared with a rolled sleeve was \(-0.54\) mmHg (SD 7.4), and for diastolic pressure, 0.56 mmHg (SD 4.6). Corresponding values for ‘bare arm’ versus ‘sleeve’ were 0.02 mmHg (SD 7.6) and 1.27 mmHg (SD 5.6), and for ‘sleeve’ versus ‘rolled sleeve’, 0.51 mmHg (SD 7.5) and \(-0.7\) mmHg (SD 5.8). All findings fell within the AAMI standard for good agreement of blood pressure measurement methods. On the BHS protocol, differences between methods fell into category B for systolic pressure and category A for diastolic pressure, indicating an acceptable level of agreement. The Bland-Altman plots indicated a greater deviation from the
mean difference for higher systolic blood pressures (above 140 mmHg) between readings on the bare arm and rolled-up sleeve (Fig. 1). This difference was not apparent for diastolic pressure.

Using ANOVA, the interaction of type of measurement on the variation of systolic and diastolic blood pressure by order of measurement (controlled for covariants age, body fat, clothing thickness) did not significantly affect the observed differences in blood pressure by method of measurement.

Discussion

This study did not demonstrate a significant effect of the degree of clothing (‘rolled sleeve’, ‘sleeve’ or ‘bare arm’) on the results of the blood pressure measurements. This confirms the findings of an earlier small and underpowered study (36 subjects) by Holleman et al. The implication of these findings for the busy practitioner is that pedantic concern with technique should not take precedence over performance of the measurement. Our study also showed that in patients with hypertension (systolic blood pressure over 140 mmHg), there may be a greater deviation from the mean difference between clothed and bare-arm readings seen at lower pressures. Therefore, when the blood pressure reading indicates hypertension, or in patients with known hypertension, measurements should be taken under standardized conditions (i.e., on the bare arm), as suggested by Holleman et al.

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References