ARM CIRCUMFERENCE AND BLOOD PRESSURE — A SURVEY EXPERIENCE

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SYNOPSIS

Arm circumference has always been a source of concern whenever indirect sphygmomanometry is considered in detail. With the use of standard cuffs (at least 12 cm wide), questions are raised concerning the effect of varying arm circumferences on the accuracy of blood pressure measurements. Is there a marked difference, and if so, should there be a correction factor? Arm girths are normally distributed. The overall mean for male adults in Singapore is 27.3 cm and 26.5 cm for females. Both sexes have the highest mean girths at 40-49 years, with the differences between them greatest in the 3rd and 4th decades.

Blood pressures are distributed over a range for specific arm girths within each age group. The mean systolic and diastolic pressures are highly correlated with mean arm circumferences for each decade from 20 to 69 years (some statistically significant at the 5% level). The average change of blood pressure is about 1 — 3 mm Hg for unit cm change in arm girth.

Although arm circumference does affect the accuracy of indirect sphygmomanometry, its influence is probably minimal in most situations. Thus, except for the minority with unusually small or large arms, there is no necessity for a correction factor to be applied in clinical or epidemiological work.

INTRODUCTION

Eversince indirect sphygmomanometry became a routine clinical procedure, much concern has been expressed over the extraneous factors which can influence the accuracy of the estimations. One of these factors is the arm circumference (girth), which is in turn related to the cuff size.

The present-day cuff for adults owes its dimensions to von Recklinghausen, who in 1901 determined that the critical factor in cuff size for the closest possible correlation between intra-arterial and indirect measurements was the width of the cuff. After studying various sizes, he concluded that the cuff width should be at least 12 cm. Thus, some of the criticisms against the smaller (3-5 cm width) Riva-Rocci cuff introduced earlier were resolved.

Nevertheless, questions about varying arm girths are still valid as standard sphygmomanometers are always used in clinical work. Is this problem more real than apparent? If real, what is the magnitude of the difference and should there be a correction factor based on arm girth for an individual's blood pressure?

The National Survey on Blood Pressures looked into this problem. The findings are presented according to the following objectives:

(1) To describe the distribution and mean levels of arm circumferences, by age and sex;

(2) To correlate the mean arm circumferences and mean systolic as well as diastolic pressures, by age and sex;

(3) To determine the average change in mean pressure according to unit difference in arm circumference, by age and sex.

MATERIAL AND METHODS

The method of sampling and characteristics of the survey population have already been described (Lee et al, 1977). All the subjects were aged 20 years and above, and for this part of the study, 1584 males and 1920 females responded.

After an interview taking about 10 minutes, 3 blood-pressure readings were taken on the bared right arm with the subject seated. 'Accoson' mercury sphygmomanometers with 12.5 x 22.5 cm inflatable rubber cuffs were used. Systolic and diastolic (phase 5) readings were taken to the nearest 2 mm. The mean of 3 estimations was calculated and recorded as the respondent's casual blood pressure.

The arm circumference (girth) was measured with a snuggly applied canvas tape on the same relaxed bared right mid-arm. Readings were taken to the nearest centimetre.

RESULTS

(1) Arm Circumference

(a) frequency distributions

The distributions of arm circumferences for both sexes are basically 'normal', with a slight skew to the right (Figure 1). On the whole, the modal girth range for males is 27-29 cm and 24-26 cm for females. The same pattern holds for each age-group with the males more to the right than the females. The range between subjects in the same age-group can be as much as 21 to 38 cm, a potential difference of 17 cm.

(b) mean levels

As a corollary of the distributions, the mean levels also show the males to be higher at nearly all age-groups, except for a negligible variation at 60-69 years (Figure 2).

The gap is wider in the earlier years, closing up after 50 years. For males, the overall mean is 27.3 cm (S.E . = 0.07) while the mean for females is 26.5 cm (S.E. =0.07).

Mean arm girths are higher at succeeding decades until 40-49 years, after which they decline to levels even below those of the earlier years. The highest for males is 28.0 cm and for females 27.5 cm.

Figure 1

Proportionate Distribution of Arm Circumferences, by sex.

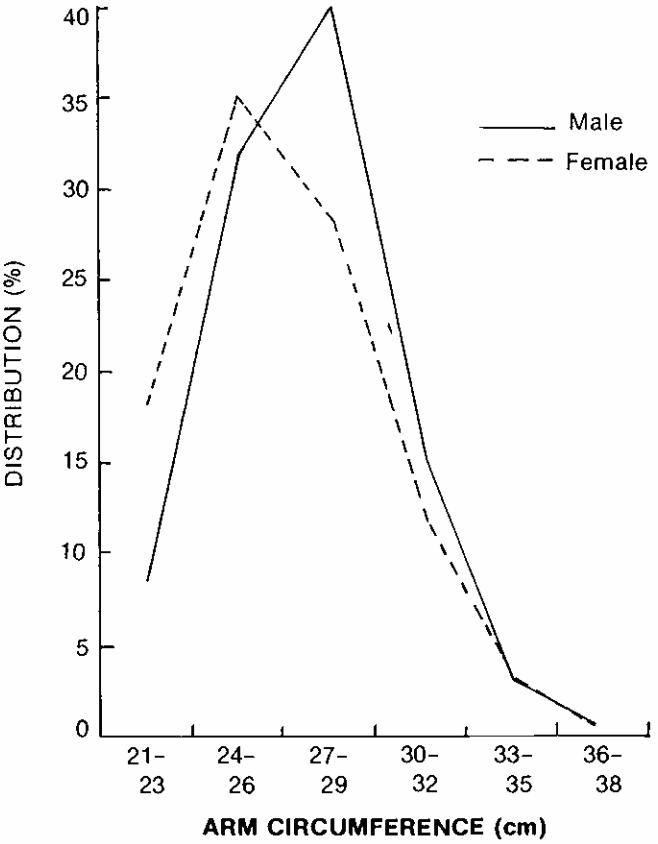
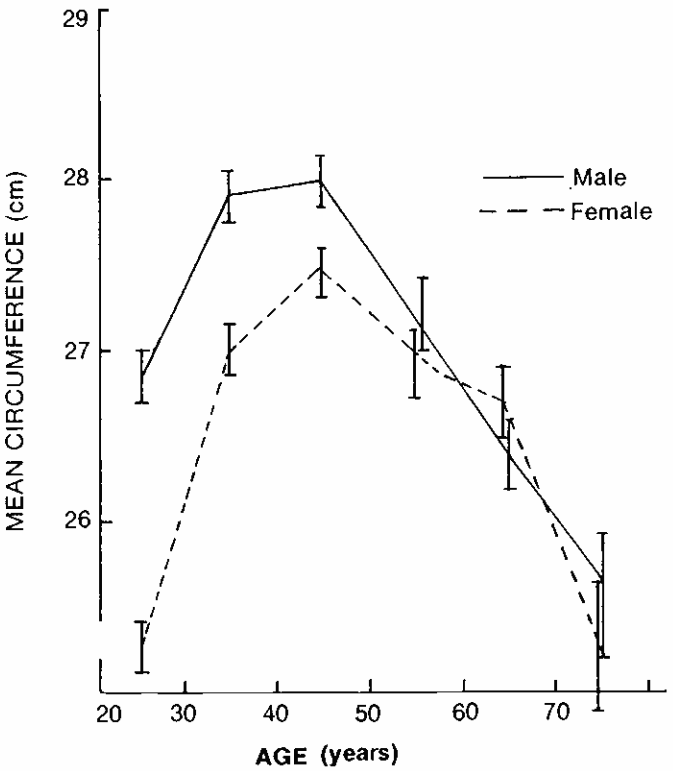


Figure 2

Mean Arm Circumference, by age-group and sex.
(± standard error of the mean)



(2) **Correlation with blood pressures**

For each age-group, there is a range of blood pressure readings for persons with the same arm girth. The mean systolic and diastolic pressures according to sex, age-group and arm girth are presented in Tables 1 and 2.

The general pattern of higher mean pressures at successive decades is obvious. The pressures are even higher with increasing arm girths. Within the 21-33 cm arm girth range, the correlation coefficients between mean girth and mean pressure for each age-group are positive and high, with some significant at the 5% level.

The average change in mean blood pressure per unit difference in arm girth, as represented by the regression coefficient, does not exceed 3 mm Hg for systolic and 2 mm Hg for diastolic pressure in both sexes. There is no consistent pattern with age and sex.

Table 1 Mean Systolic and Diastolic Pressures for Males, by age-group and arm girth

Arm-girth (cm)	Age-group (years)													
	20-29		30-39		40-49		50-59		60-69		20-29	30-39	40-49	50-59	60-69
	No	Mean SBP	No	Mean SBP	No	Mean SBP	No	Mean SBP	No	Mean SBP	Mean DBP	Mean DBP	Mean DBP	Mean DBP	Mean DBP
21 — 23	40	119.3	13	116.0	19	119.7	15	125.7	32	142.7	75.7	71.8	75.7	77.9	80.2
24 — 26	216	122.5	83	120.2	75	124.9	68	131.8	51	141.0	76.9	79.3	82.3	83.1	85.9
27 — 29	179	124.1	134	125.1	140	129.3	80	138.0	53	152.1	77.7	81.1	86.2	86.7	86.4
30 — 33	78	128.8	65	129.4	64	133.8	31	147.2	19	147.6	81.5	86.0	90.4	93.0	88.0
Correlation Coeff. 'r'		0.982*		0.999*		0.999*		0.994*		0.664	0.938	0.973*	0.992*	0.995*	0.907
+ Regression Coef. 'b'		1.003		1.503		1.557		2.357		0.860	0.607	1.480	1.600	1.630	0.797

+ Regression of mean blood pressure (y) on mean arm girth (x)

* indicates $p < 0.05$

Table 2

Mean Systolic and Diastolic Pressures for Females, by age-group and arm girth

Arm-girth (cm)	Age-group (years)													
	20-29		30-39		40-49		50-59		60-69		20-29	30-39	40-49	50-59	60-69
	No	Mean SBP	No	Mean SBP	No	Mean SBP	No	Mean SBP	No	Mean SBP	Mean DBP	Mean DBP	Mean DBP	Mean DBP	Mean DBP
21 — 23	197	112.0	58	112.4	35	119.5	24	130.3	23	135.3	70.4	71.9	76.7	81.7	80.2
24 — 26	256	113.8	151	114.5	113	127.6	88	134.7	46	147.9	70.2	73.2	79.8	81.5	86.2
27 — 29	127	115.3	160	120.2	137	128.6	76	135.0	47	151.8	71.8	76.8	82.3	83.5	87.2
30 — 33	38	123.6	81	123.7	73	133.6	31	135.7	18	157.1	77.6	81.8	85.6	87.8	86.2
Correlation Coeff. 'r'		0.914		0.987*		0.958*		0.869		0.964*	0.864	0.972*	0.999*	0.899	0.766
+ Regression coeff. 'b'		1.212		1.317		1.448		0.551		2.316	0.768	1.113	0.971	0.684	0.633

+ Regression of mean blood pressure (y) on mean arm girth (x)

* indicates $p < 0.05$

DISCUSSION

That there is a near-normal distribution of arm circumferences for each age-group is to be expected. The range can be wide, with a potential difference of as much as 17 cm, for persons in the same age-group. Such unusually large differences are especially important with regard to the main subject of study.

The overall mean arm girth for males is 27.3 cm and for females 26.5 cm. Both show a peak in the 5th decade: 28.0 cm among males and 27.5 cm among females. It is interesting to note that the values after the peak go down to levels even below those of the earlier years. The variations between mean values, by age and sex are minimal.

In the absence of any other references, the results can be taken as rough estimates of arm-sizes among adults in Singapore. The method of measurement and approximation used do not allow for further refinement in analysis.

This study has confirmed the findings of others elsewhere in showing a definite relationship between arm girth and indirect blood pressure readings. The correlations demonstrated between the mean values for each age-group are positive and high, some with significance at the 5% level.

On the other hand, one cannot fail to note that even for persons in the same age-group and with the same-girth, there is a range of blood pressure readings (also Pickering et al, 1954). Obviously, there are many other factors influencing blood pressure estimation. Arm girths as a cause of errors is most probably a minor one.

What guidelines are there for the medical practitioner? Must a correction factor be applied to persons with varying arm girths? Most of the authors on this subject are doubtful of the need for this particular refinement in the face of other more important factors (Ragan & Bordley, 1941; Holland & Humerfelt 1964; US Dept. of Health, Education & Welfare, 1964; Burch & Shewey, 1973).

The reasons are as follows:—

(a) the differences in blood pressures measured are small, in the region of 1-3 mm Hg for each cm difference in arm girth. Such variations in casual sphygmomanometry need not be refined, as most individuals have arm girths within 2-4 cm of each other;

(b) there is no virtue in correcting single readings of blood pressure, especially in the presence of more important "errors". Diagnosis in clinical practice should be based on multiple readings and other clinical assessments;

(c) there is also little value in correcting readings for epidemiological work. Knowing the existence of more important systematic and physiological "errors", it would be futile to put in minor corrections that will not eventually influence grouped results. This was very ably demonstrated by Pickering et al (1954), who showed differences of up to 40 mm Hg between individual readings when corrected, but no significant differences in the group means. The effect of age on blood pressure was maintained — corrected or otherwise.

The only practical suggestion refers to persons with unusually small or large arms, where indirect measurement may be a gross under-or over- estimation. In such instances a rough "correction" may help, and even then, only after multiple readings.

Ragan and Bordley (1941), by comparing direct and indirect measurements, concluded that the "standard" arm circumference for the usual von Recklinghausen cuff should be about 28 cm, especially for systolic readings. Thulin et al (1975) determined that the width of the cuff be 40% of the arm circumference.

Thus, for adults with arms markedly different from 28 cm circumference, a correction factor of about 2 mm Hg per cm girth difference may be applied for systolic readings (subtraction for large arms and addition for small arms). Although there is no rule for diastolic readings, extra care must be taken when interpreting measurements made on far-from-usual arm sizes. All these must be complemented by multiple readings and clinical assessments before any conclusion can be made.

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ACKNOWLEDGEMENTS

This paper is compiled from the results obtained by the Hypertension Study Group comprising C.S. Seah (Chairman), L.P. Low, H.P. Lee and W.Y. Chng. Miss P.C. Lim typed the manuscript.