The variability of blood pressure following repeated measurements

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Summary

Two series of Blood Pressure (BP) measurements were carried out to assess the variability in BP following repeated measurements in normotensive individuals. In one series, measurement of BP on three occasions three and seven days apart revealed a significant drop in BP in unaccustomed subjects ('untrained'). In a second series assessing the significance of time-interval between measurements or the number of measurements, it was found that a significant fall in BP occurred over the first four days in 'untrained' individuals, whose blood pressure was measured repeatedly for five consecutive days. A significant positive correlation was evident between the falls in systolic and diastolic pressures and the pressure at first screening. Assessment of the anxiety status revealed a significantly lower state anxiety in 'trained' subjects. It therefore appears that (a) BP in normotensive individuals previously unaccustomed to BP measurements, drops significantly with repeated measurements, (b) the number of measurements seem more important than the time-interval between measurements, (c) the largest falls occur in individuals with high initial pressures and (d) the fall upon repeated measurements may be due to reduced anxiety as familiarity with the procedure makes the subjects comparatively relaxed and less state anxious.

Key words: blood pressure, variability, time-interval, repeated measurements.

Introduction

Repeated measurements of blood pressure have been shown to cause values to decrease[1,2] more significantly, in individuals with relatively high pressures[1]. One epidemiological study revealed that of the 20% of individuals initially classified as hypertensives, only 11% were actually found to have sustained hypertension on repeated measurements[3]. The precise reason for the decrease in blood pressure following repeated measurements is uncertain, although it has been ascribed to the states of stress, anxiety[4,5] and personality type[6].

Studies investigating this variation in blood pressure readings are indeed very few[4,5]. Moreover, its clinical significance has not been fully defined. As the decrease in blood pressure upon repeated measurements has been observed to be greater in individuals with high pressures[1] the need for study of this becomes more important particularly in the diagnosis and management of cases with borderline hypertension. This study therefore attempts to assess the variability in repeated measurements of blood pressure in normotensive individuals previously not exposed or not accustomed to blood pressure measurements. It also attempts to relate this variability in blood pressure to the number of measurements and to the time-interval between measurements. In addition, the anxiety status of the participants is also assessed to correlate the level of anxiety to any variability in blood pressure measurements.

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Materials and methods

Subjects were healthy volunteers (Table 1) consisting of students and staff of University Sains Malaysia and employees of nearby electronic factories. They were seated in a quiet room for at least ten minutes before making the measurements. All blood pressures were measured using a Surgico Clinical Mercury Sphygmomanometer. The pressures were measured on a number of occasions and on each occasion three measurements were made over at least five minutes and the mean value was recorded. In between measurements the subjects were asked to clench their fists several times so as to prevent blood pooling and discomfort. To avoid the influence of diurnal variation[7] measurements were taken at the same time of the day on all occasions. As the difference in pressure between the points of muffling and disappearance was generally less than 10mm Hg, the latter was taken as the diastolic pressure. Two separate series of measurements were made (Series I & II).

Table 1
Demographic data of study subjects in Series I and II

Variable	Series I		Series II
	'Untrained'	'Trained'	'Untrained'
Age (years)	26.1 ± 0.6	26.2 ± 0.7	30.9 ± 0.7
Males	31	34	42
Females	60	36	–
Number	91	70	42

Series I

In this series, subjects were divided into two groups, 'trained' and 'untrained'. Those volunteers who had more than one week of controlled measurements are referred to as 'trained', whilst the others who had never before had their blood pressures measured are referred to as 'untrained'. Measurements were repeated over several days and for each subject they were carried out by the same observer, using the same instrument. At the end of each session the data were collected and filed so as to minimize any bias of the subsequent readings. Data collected during each visit for each group were pooled and expressed as mean ±S.E.M. After the first measurements the subjects returned three and seven days later for a second and third set of measurements respectively.

An anxiety test questionnaire consisting of a State-Trait Anxiety Inventory devised by Charles P. Spielberger and others[8] was also used in this series. The items on the questionnaire deal with two forms of anxiety, namely State and Trait anxiety. The State anxiety is defined as anxiety at a given time or in a given situation where the subjects simply answer how they feel at that very moment. The Trait anxiety relates to the stable personality characteristics for which the subjects answer according to what they generally feel about themselves. The questionnaire was in either English or in Bahasa Malaysia. All questionnaires were scored blind and analysis made without prior knowledge of group identities.

Series II

In this series, measurements on 'untrained' subjects were on consecutive days for five days. Similarly, for each subject, measurements were made by the same observer using the same instruments and at the same time of the day over the five days.

The data was accepted as normally distributed as over 95% of the observations were within $2\pm$SD from the mean. Statistical comparisons between groups and between days for both series were by Students 't' -test, both paired and unpaired, or by analysis of Variance (ANOVA). The sub-programmes of the Statistical Package for the Social Sciences (SPSS) were used to compute the data. A 'p' value of less than 0.05 was considered significant. All data are presented as mean $\pm$S.E.M.

Results

The mean ages and standard errors of means of the subjects in the two series are presented in Table 1. Analysis is initially focused on Series I.

There is no significant difference between the mean ages of the 'untrained' and 'trained' subjects. The mean systolic pressure of the 'untrained' subjects decreased significantly in the time required to carry out three cuff inflations during the first visit (Table 2). By comparison, the mean systolic pressures of the 'trained' group showed no difference between the 1st and 3rd cuff inflations. The mean systolic pressure of the 'trained' group was significantly lower (p<0.001) than that of the 'untrained' group (Table 2).

Table 2

The 1st and 3rd cuff inflation measurements of 'trained' and 'untrained' subjects during the 1st and 3rd visits in Series I. Statistical significance between groups is indicated by the 'p' values for unpaired samples. *indicates difference between the first and third cuff inflations in the 'untrained' group during the 1st visit, (p < 0.001); paired samples)

	1st Visit			3rd Visit		
	'Untrained'	'Trained'	p	'Untrained'	'Trained'	p
1st cuff inflation						
Systolic	112 ± 2	100 ± 2	< 0.001	102 ± 2	99 ± 3	NS
Diastolic	64 ± 2	60 ± 2	NS	61 ± 1	61 ± 2	NS
3rd cuff inflation						
Systolic	108 ± 2*	98 ± 2	< 0.05	101 ± 2	99 ± 2	NS
Diastolic	64 ± 1	61 ± 2	NS	61 ± 1	60 ± 2	NS
Number	20	43		20	43	

The mean blood pressures of both groups over the three visits are shown in Table 3. The mean systolic blood pressure of the 'untrained' group was significantly higher (p<0.001) at the first visit. This significance decreased on a subsequent visit some three days later and on the 3rd visit (seven days later) the mean systolic pressures of both groups were no longer significantly different. No significant differences were evident in the mean diastolic pressures between the two groups. Mean diastolic pressure in the 'untrained' subjects, however, decreased significantly by the second visit.

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Table 3
Mean BPs (± S.E. Mean) of the 'untrained' and 'trained' groups taken on three seperate visits 3 and 7 days apart. Paired 't' test comparing 1st. and 2nd. visit and 1st. and 3rd. visits for 'untrained' subjects: Systolic (a and c) p<0.01; Diastolic (b and d) p< 0.01)

Subjects	1st Visit		2nd Visit		3rd Visit	
	Systolic	Diastolic	Systolic	Diastolic	Systolic	Diastolic
'Untrained'	117 ± 2	70 ± 1	111 ± 2^a	67 ± 1^b	108 ± 2	68 ± 1^d
Number	91		88		89	
'Trained'	107 ± 2	67 ± 1	106 ± 2	67 ± 1	105 ± 2	67 ± 1
Number	70		70		69	
p (unpaired)	0.001	NS	< 0.05	NS	NS	NS

Mean State-Trait anxiety scores of the 'untrained' and 'trained' groups are presented in Table 4. No difference was observed between the means of the Trait (Y2) anxiety scores of the two groups. On the other hand mean State (Y1) anxiety scores, were significantly lower in the 'trained' group. Mean blood pressure decreased significantly from the 1st day to the 4th day in the 'untrained' group whose blood pressure measurements were repeated on five consecutive days (table 5). Highly significant differences were observed for all variables. (For the systolic pressure: subjects, F=40.76, p<0.001; days, F=29.84, p<0.001, and for diastolic pressure: subjects, F=37.01, p<0.001 and days, F=1987, p<0.001).

Table 4
State and Trait anxiety scores (mean ± S.E.M.) of 'untrained' and 'trained' subjects

Anxiety	'Untrained'	'Trained'	P
State (Y1)	39.6 ± 0.1	36.5 ± 1.0	< 0.05
Trait (Y2)	42.3 ± 0.9	40.9 ± 1.2	NS
Number	91	68	

Mean BP measurements ($\pm$ S.E.M.) of Series II over five consecutive days. Analysis of variance (ANOVA) indicte for systolic pressure: subjects, F = 40.76, p < 0.001; days, F = 29.84, p < 0.001, and for diastolic pressure: subjects F = 37.01, p < 0.001 and days, F = 19.87, p $\leq$ 0.001. Asterisks indicate statistical significance at p < 0.001 when compared to day 1 measurements.

Days	1	2	3	4	5
Systolic	119 $\pm$ 2	114 $\pm$ 2*	114 $\pm$ 2*	111 $\pm$ 2*	112 $\pm$ 2*
Diastolic	74 $\pm$ 2	73 $\pm$ 2	71 $\pm$ 2	68 $\pm$ 2	69 $\pm$ 2*
Number	42	42	42	42	39
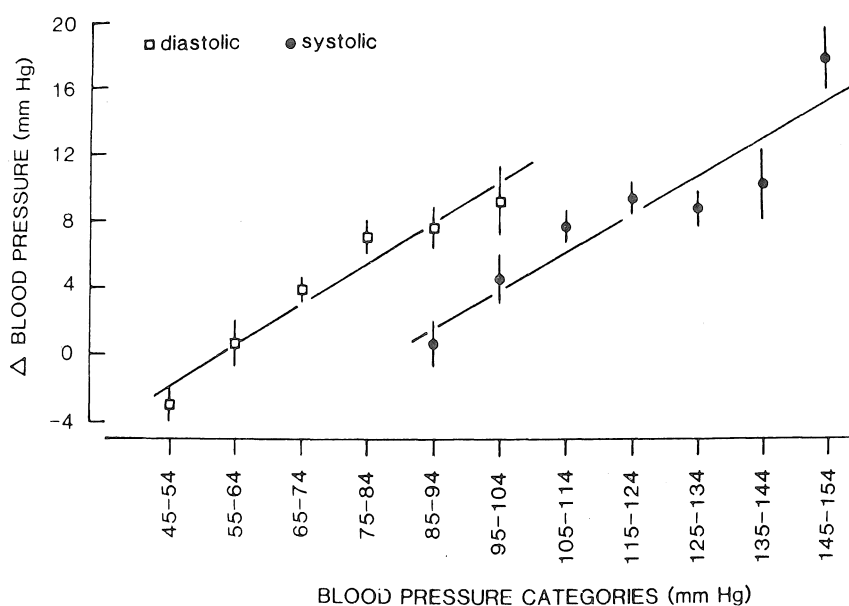
Fig. 1 :   Mean changes in systolic and diastolic blood pressures in 'untrained' subjects between the first and last visits expressed by pressure categories

The mean changes in systolic and diastolic pressures (ΔBP) between the 1st visit/day and the last visit/ day in the 'untrained' group of both the series are shown by category of blood pressure in Figure 1. The group that initially had the highest systolic and diastolic pressures showed the largest decrease in blood pressure between visits. The coefficient of linear regression of the change in systolic and diastolic pressures of the various blood pressure groups are: r=0.93, p<0.01 and r=0.97, p<0.01 respectively.

Discussion

An elevated systemic arterial blood pressure has long been recognized as a major contributor to morbidity and mortality in all groups of populations[9-13]. However, deaths due to hypertension and complications associated with hypertension have declined worldwide over the last two decades [12, 13]. This has been attributed to the importance given to early diagnosis and treatment.

Many studies however, have shown that there is now a tendency to overdiagnose and overtreat hypertension[14-16]. Moreover several of these studies have shown very little, if any at all, reduction in mortality and morbidity with early treatment of hypertension, especially mild hypertension[14,17]. This has led to the recommendation that prolonged observation must proceed initiation of drug therapy in mild hypertension unless, of course, there is evidence of end organ damage[15].

What has not been properly addressed by these studies, is the problem of determining the duration and frequency of the recommended prolonged observation.

The results of Series I (Table 3) and Series II (Table 5) showed that the blood pressure decreased with repeated measurements. The results also showed that the decrease was greater in individuals with higher initial pressure, be it systolic or diastolic (Figure 1). These findings confirmed the observations reported in some previous studies[1,2,5], and confirmed that the decrease in blood pressure with repeated measurements would be more significant in those who have pressures in the hypertensive range at the first recording.

In both series, blood pressure stabilized between the 3rd and 4th visits (Tables 3 and 5). The number of measurements is therefore more closely related to stabilization of blood pressure than is the time interval from initial recording.

The Australian therapeutic trial[14] showed that blood pressure stabilized on the 4th visit although this was four months after the initial measurement. The proportionate decrease in blood pressure at the 4th visit, in the Australian therapeutic trial is similar to that seen at the 4th visit in Series II of our study. It is conceivable that the observed decrease in blood pressures in the Australian study could have occured even if the blood pressures had been measured over a shorter time interval.

The higher blood pressure recorded at the initial measurement has been attributed to anxiety associated with the procedure with which the subject is not familiar[5]. In Series I the difference in the Trait anxiety between the 'trained' and 'untrained' subjects was not statistically significant. A significant difference was, however, evident in the anxiety State between the two groups (Table 4) where the 'trained' group had a lower mean score. These results confirm the findings of Burstyn et al[5]. Whilst in their study only the anxiety scores of subjects where a decrease in blood pressure of 10mm Hg or more were included, the anxiety scores in our study represent the mean scores of all the subjects, independent of the level of decrease in blood pressure.

In conclusion the results of this study confirmed that repeated blood pressure measurements were associated with a significant decrease in blood pressure, and that the decrease is greater when initial pressures are higher. The results also showed that the blood pressure stabilized by the fourth visit, and that the number of visits was more significant than the time intervals between visits. The hitherto advocated evaluation over many months is probably unnecessary.

Acknowledgement

References

1. Mathieu, G., Biron, P., Roberge, F., Picard, J.M., Goulet, C., Allard, C. Blood pressure determinations during examinations: how many? Can. J. Pub. Health 1974; 65: 447-58.

2. Kaufman, F.L., Hughson, R.L, Schaman, J.P. Effect of exercise on recovery of blood pressure in normotensive and hypertensive subjects. Med. Sci. Sports Exerc. 1987; 19: 17-20.

3. Carey, R.M, Reid, R.A., Ayers, C.R., Lynch, S.S., McLain, W.L, Vaughan Jr., E.D. The Charlottsville Blood Pressure Survey. Value of Repeated Blood Pressure Measurements. JAMA 1976; 236: 847-57.

4. Leading Article. Labile hypertension. Br. Med. J. 1980; 280: 4.

5. Burstyn, P., O'Donovan, B., Charlton, I. Blood pressure variability: the effect of repeated measurement. Postgraduate Med. J. 1981; 57: 488-91.

6. Ostfeld, A.M. Lebovits, B.Z. Blood pressure lability : A correlative study. J. Chron. Dis. 1960; 12: 428-39.

7. Waterhouse, J.M.: Altered time, in Variations in Physiology. Ed. R.M. Case: 1985; 134-157, Manchester, Manchester Univ. Press. Chapter 6.

8. Spielberger, C.D., Gorsuch, R.L., Lushene, R., Vagg. R.R., Jacobs, G.A. State-trait anxiety inventory. 1983, California, Consulting Psychologists Press Inc.

9. Kannel, W.B., Wolf, P.A., Verter, J. Epidemiology assessment of the role of blood pressure in stroke: The Framingham study. JAMA 1970; 214: 301-10.

10. Kanel, W.B, Dawber T.R.: Hypertension as an ingredient of a cardiovascular risk profile. Br. J. Hosp. Med. 1974; 11: 508-23.

11. Weismann, D.N.: Systolic or diastolic blood pressure significance. Pediatrics 1988; 82: 112-13.

12. World Health Statistics Annual, WHO Publications, Geneve, 1972.

13. World Health Statistics Annual, WHO Publications, Geneve, 1987.

14. Management Committee. The Australian Therapeutic trial in mild hypertension: report. Lancet 1982; 1: 1261-67.

15. Management committee of the Australian Therapeutic trial in mild hypertension. Untreated hypertension: a report. Lancet 1982; 1: 185-91.

16. Ramsay, L.E.: Managing mild hypertension. Medicine Digest Asia 1987; 5: 33-37.

17. Medical Research Council Working Party. MRC trial of treatment of mild hypertension: principal results. Br. Med. J. 1985; 291: 97-104.