

RELATION BETWEEN CASUAL BLOOD PRESSURE READINGS IN YOUTH AND AT AGE 40

A RETROSPECTIVE STUDY

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IT IS often believed that a transient or sustained systolic blood pressure in excess of 140 mm Hg in youth denotes that the young person is a candidate for later development of hypertensive vascular disease. The present study attempts to examine this postulate more closely. Records of a single casual blood pressure taken in the course of routine physical examinations during the period 1939-1942 at the University of Michigan Health Service were made available to us‡. Furthermore the present whereabouts of most of these individuals could be traced from records kept in the University Alumni Office.

METHODS

Two hundred and forty white male graduates from the schools of medicine, dentistry, and engineering, living within a radius of approximately 100 miles of Ann Arbor and known to have been examined in 1939-1942 on entrance to the University of Michigan were selected from files at the Alumni Office. They were asked by correspondence to provide us with their current blood pressure. These readings might be either those recorded within the previous year by their local physician or as obtained and forwarded to us for the purpose of the study. The subject was also requested to furnish information concerning his present body weight, height, present health, history of hypertension, or of cardiovascular disease. Useful data were received from 208 individuals of the 240 contacted. In these, 70 per cent of the current blood pressure readings were mailed to us from the local physician's records, 16 per cent from other hospital or health service records, and 14 per cent directly from the subjects, many of whom were physicians. The average time of follow-up was 20 years.

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At the first readings the students' average age was 19.8 years (range 17–21) and at time of follow-up was 40.1 years (range 36–43).

No claim is made that our results are representative of college graduate males, therefore several characteristics of the group should be noted. Their original blood pressure level would be considered within normal limits (121/76 mm Hg). About 25 per cent had a systolic pressure less than 111 mm Hg, while 13 per cent had levels over 130 mm Hg. As students, 81 per cent were either normal or underweight when judged according to Metropolitan Life Insurance standards. The group was homogeneous: college-graduated, professionally occupied, white males of similar age.

OBSERVATIONS

Blood pressure levels as students and 20 years later are summarized in Table 1 and Figs. 1 and 2. Groups with a low average blood pressure as students tended to show higher readings 20 years later while those with higher initial readings tended to be lower at follow-up; these changes are interpreted as a 'regression toward the mean.' They may also serve to emphasize the inadequacy of single casual readings as a basis for classification of blood pressure levels. Nevertheless, some correlation between the early and the current blood pressure reading should be noted. *Systolic* pressure taken in student days correlated better with the present diastolic level ($r=0.22$; $P<0.05$) than with the present systolic reading ($r=0.06$). *Diastolic* pressure taken in student days showed some correlation with present diastolic levels ($r=0.16$; $P<0.05$) but not with current systolic measurements ($r=-0.07$).

TABLE 1. RELATIONSHIP OF JUVENILE AND PRESENT BLOOD PRESSURE LEVELS (means) IN A MALE AGE-CONTROLLED 20-YEAR COHORT

Juvenile <i>systolic</i> levels	Number	Present systolic	Present diastolic	Change in systolic	Change in diastolic
<101	9	117.0	75.8	+16.0	+11.0
101–110	40	123.7	77.0	+12.0	+ 7.8
111–120	70	124.0	79.1	+ 6.8	+ 3.5
121–130	62	127.0	80.8	+ 2.8	+ 2.6
131–140	17	129.5	81.3	– 7.5	– 4.2
141–150	5	138.4	87.2	– 7.4	+ 0.5
>150–120.8	5	134.0	84.0	–21.0	– 1.0
Average	208	125.6	79.6	+ 4.8	+ 3.6
Juvenile <i>diastolic</i> levels					
<61	8	119.6	72.2	+11.6	+14.7
61–70	52	123.2	78.0	+ 8.0	+10.5
71–80	89	126.4	79.9	+ 7.0	+ 4.0
81–90	52	126.8	80.6	– 1.7	– 4.9
>90–76.0	7	130.0	83.7	– 8.7	– 8.1
Average	208	125.6	79.6	+ 4.8	+ 3.6

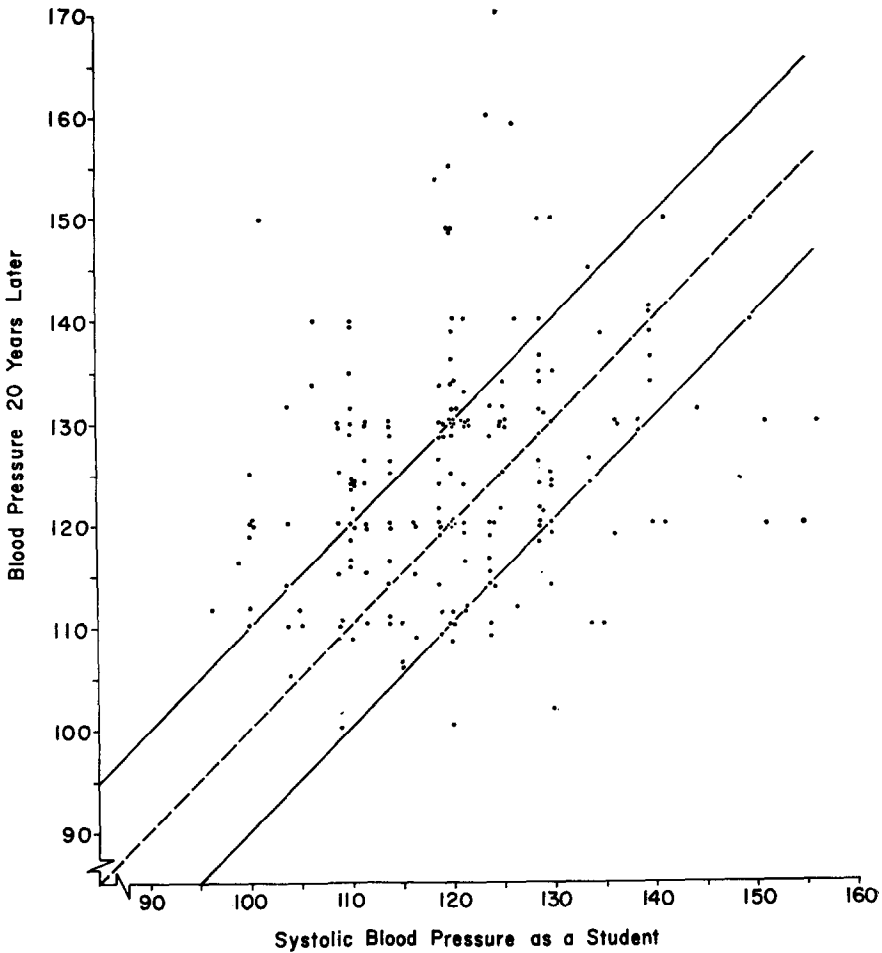


FIG. 1. Correlation of juvenile and adult systolic blood pressures ($r=0.06$). Limits of 10 mm increase (upper quadrant) or of 10 mm decrease (lower quadrant) delimited by the solid lines. If there had been no change in the blood pressure over the time interval of study, all points would fall on the interrupted center line.

Table 2 shows that there was little relation between juvenile blood pressure and the frequency of subsequent 'hypertension' when defined as a systolic blood pressure of 150 mm Hg or more and/or a diastolic level of 90 mm Hg or more. The blood pressures of 10 of the 29 current 'hypertensives' are 150 mm Hg or more systolic while all but five are 90 mm Hg or more diastolic. The average age of the 'hypertensives' is 40.5, not significantly different from the age of the remainder (39.9) at time of follow-up.

We found 27 cases with blood pressure levels in excess of 139 mm Hg systolic or 89 mm Hg diastolic in youth. Of these, 7 showed 'hypertension' (over 149 mm Hg or over 89 mm Hg) later in life, but except in 3 cases there has been no substantial increase. The juvenile and adult blood pressure readings in these seven cases were: 160/86—170/100, 142/90—150/100, 140/90—142/92, 138/94—128/90, 128/94—150/84, 126/90—159/120, 126/90—140/90. Of 9 cases in which both systolic and diastolic juvenile

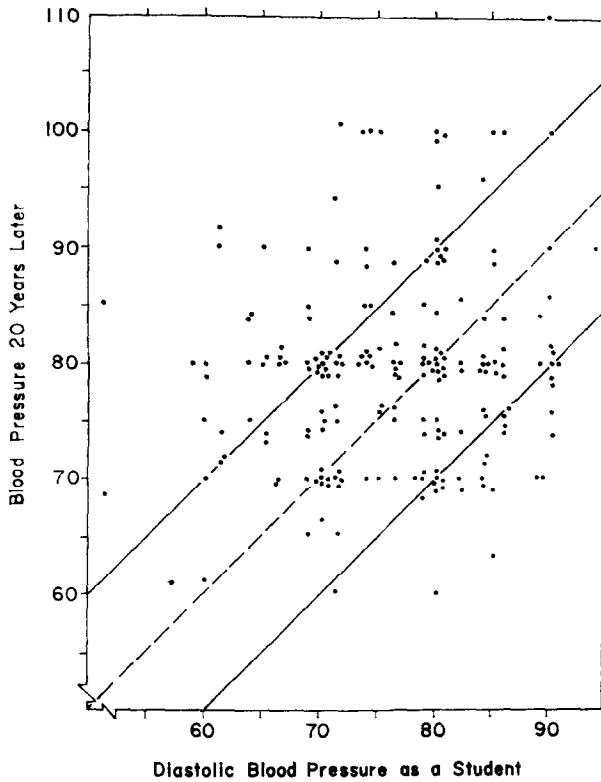


FIG. 2. Correlation of juvenile and adult diastolic blood pressures ($r=0.16$).

TABLE 2. RELATIONSHIP OF JUVENILE BLOOD PRESSURE LEVELS TO ADULT 'HYPERTENSION' IN AN AGE-CONTROLLED 20-YEAR COHORT

Juvenile systolic levels	No.	Elevated adult blood pressure*			
		Systolic or diastolic		Both	
		No.	%	No.	%
<101	9	0	0	0	0
101-110	40	6	15	1	3
111-120	70	7	10	2	3
121-130	62	11	18	4	6
131-140	17	2	12	0	0
141-150	5	2	40	1	20
>150	5	1	20	1	20
Total	208	29	14	9	4

Juvenile diastolic levels	No.	No.	%	No.	%
<61	8	0	0	0	0
61-70	52	6	11	3	6
71-80	89	13	15	3	3
81-90	52	8	15	3	6
>90	7	2	28	0	0
Total	208	29	14	9	4

*'Elevation' is defined as a current reading of 150 mm Hg and over (systolic) and/or 90 mm Hg or over (diastolic).

blood pressure levels were high, 2 exhibit high readings, as adults; of 11 subjects with only diastolic elevations in youth, 4 exhibit later 'hypertension'; of 8 with juvenile systolic blood pressure elevations, 2 as adults show an abnormal reading. If a juvenile diastolic reading above 89 mm Hg be taken as evidence of 'prehypertension,' then 6 of 19 youthful 'prehypertensives' (32 per cent) exhibit some degree of blood pressure elevation at age 40. This is to be contrasted with an overall incidence of 14 per cent in the 208 subjects who were followed over the 20-year interval, and a frequency of 13 per cent in 149 subjects with a juvenile diastolic reading below 81 mm Hg.

It is recognized that the definition of 'hypertension' in the adult was quite arbitrary. In 11 cases the only reason for classifying the subject as hypertensive was a diastolic blood pressure of 90 mm Hg. Of all 29 adult 'hypertensives,' 5 exhibited diastolic and 2 systolic abnormalities in youth. In 7 of the adult cases the readings are sufficiently high as to suggest the presence of hypertension of possible future clinical importance; 3 of these 7 showed a slight deviation from normal in youth. The juvenile and current readings in these cases are as follows: 125/70—170/110, 160/86—170/100, 124/74—160/90, 126/90—159/120, 120/80—155/90, 118/80—154/100, 142/90—150/100.

TABLE 3. RELATIONSHIP BETWEEN PRESENT 'HYPERTENSIVE' BLOOD PRESSURE LEVELS AND IDEAL WEIGHTS AS STUDENT AND ADULT*

Ideal weight	Present blood pressure levels (%)	
	Normotensive (n = 160)	Hypertensive† (n = 29)
<i>As students</i>		
8 lb underweight	45%	23%
Normal	38%	47%
8 lb overweight	17%	30%
<i>As adult</i>		
8 lb underweight	12%	10%
Normal	40%	20%
8 lb + overweight	48%	70%

*Of the 208 reports 19 failed to report their weights, leaving 189 cases. Ideal weights were computed from Metropolitan Life Insurance Standards.

†'Hypertensive' is defined as a current reading of 150 mm Hg or more (systolic) and/or 90 mm Hg or more (diastolic).

TABLE 4. RELATIONSHIP BETWEEN AVERAGE BODY WEIGHT CHANGES OVER 20 YEARS AND PRESENT AVERAGE BLOOD PRESSURE LEVELS

Student to adult weight change	No. (n = 190)	Present mean systolic	Present mean diastolic	Mean systolic change	Mean diastolic change
>20 lb loss	2	148.0	89.0	+ 1.0	+3.0
11-20 lb loss	2	122.0	80.0	+12.0	+3.0
1-10 lb loss	8	122.9	78.0	+ 7.4	+3.5
0- 9 lb gain	18	122.7	78.2	- 1.6	+3.7
10-19 lb gain	42	125.8	78.5	+ 3.7	+2.8
20-29 lb gain	45	123.9	78.9	+ 5.1	+1.8
30-39 lb gain	41	125.5	80.3	+ 4.8	+3.3
40-49 lb gain	25	128.6	82.7	+ 5.0	+5.9
>49 lb gain	7	128.3	78.5	+10.0	+4.3

Table 3 shows that adult subjects with blood pressures in excess of 149 mm Hg systolic or 89 mm Hg diastolic were more prone to overweight as students and tend still to be more overweight than their peers with more normal blood pressure levels. Table 4 examines the relationship between change in body weight and present blood pressure levels. It shows that the average systolic blood pressure increased with the amount of weight gained over the years ($r=0.42$; $P<0.01$). The correlation of weight change with present diastolic levels was negligible ($r=0.06$).

DISCUSSION OF RESULTS

We prefer not to apply the term 'hypertensive disease' to the 29 middle-aged subjects with systolic blood pressure in excess of 150 mm Hg or diastolic pressure of 90 mm Hg or more. The individuals are chosen for closer analysis of their antecedent history only because their blood pressure on a single occasion exceeds a currently conventional 'cutting point.' Possibly from among these 29 subjects hypertensive disease may later emerge. In the 20-year interval between the ages 20 and 40, the variability between two single casual blood pressure readings is so great as to mask any significant upward trend in an individual's blood pressure readings with age. A more accurate evaluation of blood pressure levels than a single casual reading is necessary before defining an individual as 'prehypertensive.'

It is possible that our population was biased by reason of the mode of selection. However, the mean blood pressure at age 20 of 121/76 and at age 40 of 126/80 is not far from the accepted value for a white male population [1] and shows the usual upward trend in mean blood pressure with age. Although, as PLATT [2] has suggested, one may have to wait until the sixth decade for the full expression of hypertension, one would expect the youthful 'prehypertensive' at least to maintain a high normal blood pressure level at age 40 if he were destined to acquire hypertension later in life.

The presently 'hypertensive' group were heavier as students than were the present normotensives. At their present age, the 'hypertensives' are also definitely more overweight than the normotensives. The increase in actual body weight from student to adult ages showed a significant correlation with present systolic levels. The observations reported by STAMLER [3] agree with our data that formerly obese subjects in later years show a higher prevalence of clinically confirmed 'hypertension.'

Some reported longitudinal studies of the outcome of 'juvenile hypertension' are reviewed in Table 5. A greater frequency of subsequent hypertension appears among subjects with juvenile blood pressure elevations. However, most studies have compared the frequency with which the 'cutting point' in youth is equalled or exceeded in later life. Thus a student with a higher than normal blood pressure need only remain at the same level to qualify later as a 'hypertensive,' while the control population must exhibit a substantial rise in blood pressure to reach the 'hypertensive' classification. When this definition is used, it is not surprising that more of the 'prehypertensives' than of the normotensives achieve such a status.

Further study of these longitudinal evaluations reveal: that special populations, usually males, were selected; that the definition of later hypertension varied widely, and often barely exceeded the original limits; and that the frequency of vascular complications was not given. STAMLER [3], however, cites an increased frequency of 'hypertensive heart disease' (31.8 per cent) in the 22 middle-aged subjects with young

TABLE 5. FOLLOW-UP STUDIES OF THE RELATIONSHIP BETWEEN JUVENILE HIGH BLOOD PRESSURE AND LATER HYPERTENSION

Reference	JUVENILE STATUS			FOLLOW-UP STATUS			Remarks
	JUVENILE STATUS Criteria for selection	Age	Sex	No. of cases	% of 'hypertension' after follow-up period of:	Criteria of adult 'hypertension'	
					5 yr 10 yr 15 yr 20 yr		
HINES [4]	Diastolic: <70 70-84 84-99	? ? ?	? ? ?	198 878 446	0% 4% 57%	Diastolic >100	'10-20 yr later' retrospective study
DIEHL [5]	Systolic: <130 once 130 occas. 130 130-140 >140	21 20 18 21 21	M M M M M	55 45 24 16 15	0% 5% 8% 12% 53%	Systolic >140	7-year follow-up college students
LEVY [6]	No casual reading >150 or >90 One reading >150 or >90	25-29 25-29	M M	31,072 2,127	0.05% per person-year 0.24% per person-year	>150/or >90 on re-examination	Army officers. No. of cases expressed as person-years
STAMLER [3]	Diastolic <80 Diastolic >90	30 30	M M	392 61	16% 38%	Diastolic >90 at age 50	Utility company workers. Approx. entry ages given
VANCURA [7]	Transient systolic '130-170' probably 145-155	15-24	?	150	6% 21% 29% 43%	Systolic >120+age, thus >155-165 at 20 yr follow-up	No control group
PALMER [8]	Systolic <140 Systolic >140	21 21	M M	49 66	2% 10%	Systolic >150	Unknown no. cases lost to follow-up
Present study	<140 and <90 >139 and >89	20 20	M M	181 27	12% 26%	Either >150 and/or >89 at age 40	College graduates-University of Michigan

adult diastolic blood pressure in excess of 90 mm Hg as compared to the low incidence (6.3–7.2 per cent) of this complication among 121 young men with lower diastolic levels.

SUMMARY AND CONCLUSIONS

1. The casual blood pressure of 208 male college subjects was redetermined after a 20-year interval (at an average age of 40). The frequency of 'prehypertension' in youth was 13 per cent (systolic over 139 mm Hg or diastolic over 89 mm Hg) and for the 40-year olds was 14 per cent (systolic over 149 mm or diastolic over 89 mm.).

2. Although the average systolic blood pressure of the group as a whole rose from 121 mm to 126 mm and the diastolic from 76 mm to 80 mm there was a poor correlation between the initial and final readings for the individual subject and the data showed a marked 'regression toward the mean.'

3. Among 27 subjects with juvenile elevations in excess of 139 mm or 89 mm, seven (26 per cent) showed adult 'hypertension' (in excess of 149 mm or 89 mm). This was about twice the frequency as for the group as a whole.

4. The reported relationship of overweight in youth, and of gain in weight to the later development of systolic 'hypertension' is confirmed in our studies.

5. Other follow-up studies of juvenile 'hypertension' are reviewed and compared with the present report.

6. It is suggested that 'casual' blood pressure readings may be of limited prognostic significance, and that efforts to identify by multiple blood pressure readings the 'usual' or 'sustained' youthful hypertensive may be more meaningful in prognostic studies.

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