

Blood Pressure Levels in Koreans

Kwang Hyun Cho, Chung Chick Nahm,
Chung Sam Suh and Dai Youn Lee

*Department of Internal Medicine
Yonsei University College of Medicine*

ABSTRACT

The present study was undertaken in an attempt to establish the range of normal blood pressure levels in Koreans. A representative group of the working population, consisting of 39,859 persons (23,834 men and 16,025 women) who were able to work regularly on daily duty and who lived in various parts of the country, was studied, using casual blood pressure readings. The arithmetic mean, the standard deviation and the frequency distribution of the blood pressure readings were determined for each sex and for each age group from five to seventy nine years of age.

The normal range was assumed to include the 80% of all the readings which were within 40% of either side of the mean. Any blood pressure which was beyond two times the standard deviation from the mean was considered to be abnormal. The readings falling between these two limits were regarded as borderline. The limits of normal blood pressure, as determined by this method, were found definitely to vary with age and sex.

The effect of body weight on the blood pressure was investigated. It was found that the systolic and diastolic blood pressure were progressively increased with the increase in body weight regardless of sex and age.

The incidence of systolic hypertension was 6.0% in adult males and 6.2% in females, diastolic hypertension occurred 6.8% in males and 5.8% in females. The incidence of hypotension, below 90 mmHg. systolic, was 0.6% in males and 1.7% in females, and below 60 mmHg. diastolic was 6.6% in males and 9.1% in females.

A comparison of the mean blood pressure was made between the rural and the urban population of Koreans. The mean blood pressure readings in the urban population are higher than those in the rural population, both in systolic and diastolic blood

pressures and in all age groups.

A comparison of the mean blood pressure also was made between Koreans and Americans, Chinese, Japanese, Filipinos and Indians. The systolic and diastolic blood pressure in Americans (U.S.A.) is higher than that in Koreans. Those in the Japanese and Chinese are similar until the age of fifty, from the age of fifty, the pressures are higher than those in Koreans. The blood pressure of Filipinos is similar to the blood pressure of Koreans all through the age groups. In Indians, pressures are lower than in Koreans.

Every practitioner in clinical medicine uses a sphygmomanometer, and the blood pressure may frequently serve as an aid in diagnosis and prognosis if clearly-defined normal variations in the blood pressure levels are taken into consideration in each case. Hitherto, the almost universally accepted limits of normal blood pressure and of hypertension have been constants. They were fixed, unvarying criteria by which the normality of the blood pressure was determined. They were applied to adults of all ages, of both sexes, and of different weight.

In tracing the evolution of the concept of normal blood pressure in clinical medicine, it is surprising to find that the definition of normal depended largely on the results of statistical studies by life insurance companies (Fisher, 1914; Hunter, 1923; McKenzie, 1953). The conclusions drawn from such investigations, however, are obviously not applicable to clinical medicine and are derived from a statistical analysis of group mortality rather than from an examination of large numbers of unselected normal people.

In clinical medicine, it is advisable to make a diagnosis of a disease or pathological condition only when at least several signs or symptoms are present. Such a sound approach has been bypassed in cases of hypertension. Most physicians arbitrarily classify a person as "Hypertensive", if he has a systolic blood pressure of 150 mm. mercury and a diastolic blood pressure above 90 or 95 mm. mercury, in the absence of any other findings. This attitude is unsound, because unvarying blood pressure limits have been applied to all age groups and to both men and women, and numerous mistaken diagnoses of hypertension have been made in the past.

The present work was undertaken in an attempt to determine the distribution of blood pressure levels in Koreans and to establish true normal and abnormal blood pressure limits. A statistical study was made of 39,859 unselected individuals who represented the average healthy working Korean population.

MATERIAL AND METHODS

Altogether, unselected records 39,859 persons have been examined in several large cities; Seoul, Koon San, Inchon, and more than 40 different parts of small towns and villages and five small islands

off the western and southern coasts of the Korean Peninsula during the 4-year period between 1957 and 1960. They were all an unselected group, and the majority of those examined were at work. The data gathered were analyzed as a whole and then examined according to sex, age, body weight and regional distribution of the subjects.

The mean readings, the standard deviations, and the coefficient of variation of the systolic and diastolic measurements were computed directly from the data. In addition, the frequency of hypertension and hypotension were determined in reference to age and sex.

The influence of the body weight on the blood pressure was also investigated. The subjects of this group were 1,500 males and 1,500 females according to the same age groups. Comparing blood pressures between rural and urban populations, 6,702 urban males and 6,172 rural males and 3,479 urban females and 4,934 rural females, were examined and compared.

RESULTS

Normal Range of Blood Pressure Levels

The distribution of the blood pressure readings in 23,834 males is shown in Tables 1, 2.

Table 1. Distribution of Blood Pressure Readings, Systolic, Males (Males)

Systolic B.P. (mmHg)	Age	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	%	Total No.
		9	14	19	24	29	34	39	44	49	54	59	64	69	74	79		
51~60		4															0.0168	4
61~70		27	4														0.13	31
71~80		95	47	2							2						0.60	146
81~90		224	200	45	7	11	14	4	2	3	11	3					2.2	524
91~100		187	442	274	108	59	98	49	31	40	33	12	1	1	2		5.6	1337
101~110		44	496	1036	617	336	350	203	232	162	41	33	10	45	9		15.3	3614
111~120		5	284	1549	1081	633	920	549	573	238	204	223	70	71	42	3	27.6	6485
121~130			94	1119	806	549	687	727	457	261	377	265	295	95	115	36	24.6	5881
131~140			31	540	446	324	382	290	265	187	240	209	250	151	139	105	14.8	3549
141~150			9	145	175	104	132	232	118	88	88	58	42	95	54	41	5.5	1351
151~160			3	49	41	31	41	49	38	47	24	29	25	56	29	16	1.7	478
161~170				10	20	13	25	31	17	31	15	23	20	41	24		1.13	270
171~180				2	9	4		10	14	5	15	16	15	10	10		0.5	110
181~190					5				11	3	6	8	3	2	3		0.3	41
191→									6	2	2						0.1	13
Total No.		586	1610	4771	3315	2064	2649	2144	1764	1067	1058	880	731	567	427	201		23834

Table 2. Distribution of Blood Pressure Readings, Diastolic, Males

Systolic		(Males)														%	Total	
B.P. (mmHg)	Age	5	10	15	20	25	30	35	40	45	50	55	60	65	70			75
		9	14	19	24	29	34	39	44	49	54	59	64	69	74	79		
←30		21	2														0.1	23
31~ 40		62	27	23	2	9	1		1		2		2				0.5	129
41~ 50		147	188	136	50	47	35	15	5	3	7	2	4	1			2.7	640
51~ 60		203	514	663	352	162	177	70	29	26	85	16	14	45	6		9.9	2362
61~ 70		131	535	1447	884	356	636	386	315	157	112	61	52	96	13	4	21.8	5185
71~ 80		18	271	1587	1191	649	1070	918	839	331	412	526	292	122	107	45	35.1	8378
81~ 90		4	65	705	638	530	516	469	338	291	295	160	316	203	262	105	20.6	4942
91~100			7	186	166	234	165	200	149	166	77	59	41	78	35	46	6.7	1564
101~110			1	19	28	65	41	63	55	69	41	37	8	18	4	1	1.9	450
111~120				5	3	11	7	15	33	22	27	19	2	4			0.6	168
121~130					1	1	1	8		2							0.1	13
131~140																		
Total		586	1610	4771	3315	2064	2649	2144	1764	1067	1058	880	731	567	427	201		23834

Most systolic pressures in males were in the range of between 80 mmHg. and 140 mmHg.; most diastolic pressures were in the range of between 50 mmHg. and 90 mmHg.

The distribution of the blood pressure readings in 16,025 females is shown in Tables 3, 4.

Most systolic pressures in females were in the

range of between 80 mmHg. and 140 mmHg.; most diastolic pressures were in the range of between 60 mmHg. and 90 mmHg.

Mean Blood Pressure Values

Mean blood pressure readings, with increase with age in both sexes, are shown in Fig. 1. The average systolic reading in men showed a fairly smooth rise

Table 3. Distribution of Blood Pressure Readings, Systolic, Females

Systolic		(Females)														%	Total	
B.P. (mmHg)	Age	5~9	10	15	20	25	30	35	40	45	50	55	60	65	70			75
			14	19	24	29	34	39	44	49	54	59	64	69	74	79		
51~ 60		41	3														0.2	44
61~ 70		131	22														0.9	153
71~ 80		183	70	6	7	2	4	6			2	1					1.7	281
81~ 90		118	188	39	58	22	20	47	16	31	14	6	2	2	1		3.5	564
91~100		60	285	235	265	58	177	152	57	89	100	42	21	44	4		9.9	1589
101~110		14	20	668	766	151	312	315	196	72	71	111	117	112	13	3	19.5	3127
111~120		1	88	751	929	204	265	251	512	221	347	197	140	109	84	24	25.7	4122
121~130			21	361	531	197	179	165	406	250	264	305	284	124	132	28	20.0	3187
131~140			13	107	140	49	147	66	57	160	158	166	148	98	196	28	9.5	1533
141~150			4	30	41	27	35	40	37	83	124	98	46	74	38	22	4.3	699
151~160				7	17	5	22	38	25	49	64	22	63	84	11	1	2.6	408
161~170				4	2	4	10	16	15	36	47	20	20	18	12	1	1.2	205
171~180				1		2	13	13	7	9	7	9	8	5	1		0.4	74
181~190						1	2	10	3	2	1	4	4	1			0.2	30
191→							3			2		2	2				0.0	7
Total		584	900	2209	2756	666	1189	1119	1331	1004	1199	983	855	671	492	107		16025

Table 4. Distribution of Blood Pressure Reading, Diastolic, Females

Diastolic		Females																%	Total
B.P. (mmHg)	Age	5 { 9	10 { 14	15 { 19	20 { 24	25 { 29	30 { 34	35 { 39	40 { 44	45 { 49	50 { 54	55 { 59	60 { 64	65 { 69	70 { 74	75 { 79			
<30		84	12															0.6	96
31~40		120	26	6	17	6	4	5	2		2							1.2	188
41~50		179	128	48	80	16	14	12	11	1	7	5	6					3.2	507
51~60		108	269	286	382	54	173	113	33	81	105	29	22	60	2			11.2	1787
61~70		40	300	760	1077	179	480	338	373	263	276	114	138	166	56	22		28.5	4585
71~80		15	109	791	881	278	354	431	668	290	366	440	340	192	129	31		32.8	5245
81~90		2	42	277	282	81	94	130	163	185	306	313	290	173	280	52		16.6	2670
91~100			8	35	35	37	39	47	48	86	71	45	40	60	18	1		3.6	510
101~110			4	3	2	6	17	24	26	52	53	20	9	17	4	1		1.5	238
111~120			2	3		4	8	15	3	20	13	11	9	2				0.6	90
121~130						1	5	4	2	18		6	1	1				0.2	38
131~140							1		2	8								0.0	11
Total		548	900	2209	2756	662	1189	1119	1331	1004	1199	983	855	671	492	107			16025

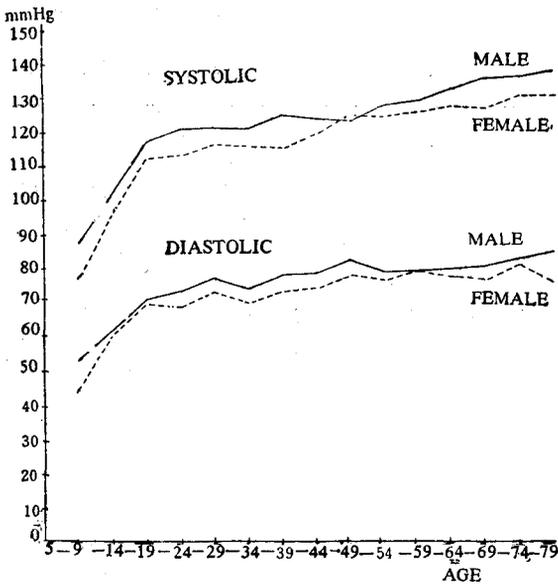


Fig. 1. Mean Blood Pressure Readings

up to the age of fifty; after fifty, the rise was accelerated. In women, the rise in the average systolic pressure with age was somewhat less smooth, but was also accelerated after the age of fifty. After the age of twenty, the rise in diastolic pressure with age was fairly steady in both sexes; a consistent acceleration of the average diastolic pressure was not found over any broad age period.

Among boys and girls between the age of five and twenty, an upward trend in the average of both the systolic and diastolic pressure was found. A rise of blood pressure was rapid in both boys and girls. Among girls, on the other hand, the diastolic pressure remained practically unchanged until the age of thirty. The average systolic reading in men showed an accelerated rise between the age of five and twenty and from the age of fifty and up; between the age of twenty and fifty, the rise was fairly smooth. In women, a rise in the average pressure both systolic and diastolic, with age was accelerated between the ages of five and twenty; it was fairly smooth between the ages of twenty and forty, and accelerated again from the age of forty and up.

The average blood pressure readings of women, both systolic and diastolic, were lower than those of men through all age groups. In systolic pressures, the maximum difference between men and women, about 6 mmHg. was found between the age of thirty and thirty five years. In diastolic pressures, the maximum difference, about 5 mmHg. was found between the age of twenty five and thirty years.

The figures for the standard deviation indicate that there was an absolute increase in the range of the readings with increasing age. The relative varia-

tion, moreover, as measured by the coefficient of variation, also has an upward trend with age. This increase begins after the age of twenty, and was found in both the systolic and diastolic pressure readings. For example, among men between the ages of fifteen and twenty years, the standard deviation of the systolic readings around the mean was 12.0 mmHg. or 10 per cent of the mean figures, while among men from sixty five, to sixty nine, the standard deviation was 17.6 mmHg. or 13 per cent of the mean figure.

The absolute range of diastolic readings was, of course, smaller than was the range for systolic readings. The relative variation between sexes, however, was larger for diastolic than for systolic readings, up to the ages of forty and fortyfour. For example, the standard deviation of the systolic pressure was 11.4 mmHg. or 15 per cent of the mean value.

In men between the ages of fortyfive and forty-nine, however, the standard deviation of the systolic pressure was 16.7 mmHg. or 13.3 per cent of the mean value, while the standard deviation of the diastolic pressure was 12.9 mmHg. or 15.7 per cent of the mean value.

1) The mean blood pressure reading, both systolic and diastolic, increases with age in both sexes. The increase in the systolic pressure was more marked between the age of five and twenty, and fifty and over. The rapid increase in diastolic pressure is present between the age of five and twenty; there was no systolic acceleration following twenty years and over.

2) The range of blood pressure readings also increases with age, as does the relative variation, measured by the coefficient of variation.

3) The mean blood pressure readings of men, both systolic and diastolic, was higher than that of women through all age groups, between five and seventy nine.

4) The normal range of systolic and diastolic pressures, as determined by this study, is given in Fig. 2, 3, Table 5.

Table 5. Normal Range and Limits of Hypertension

Age	Normal Range		Hypertension Lower Limit	
	Male	Female	Male	Female
	Systolic			
5~9	74.1~100.3	61.0~91.6	107.9	100.1
10~14	85.9~119.5	78.2~114.2	128.9	124.2
15~19	100.9~133.9	97.0~127.8	143.2	136.4
20~24	102.3~138.1	97.5~128.9	148.0	137.6
25~29	103.8~138.0	97.4~135.4	147.5	146.0
30~34	103.8~137.8	92.7~137.7	147.2	150.4
35~39	106.7~142.9	90.6~139.4	153.0	153.0
40~44	104.3~142.5	101.4~136.0	153.1	145.7
45~49	101.8~146.5	99.7~148.9	158.4	162.7
50~54	107.4~146.4	99.8~149.2	157.0	160.9
55~59	108.2~148.4	104.0~146.2	159.5	157.9
60~64	115.6~147.8	105.2~148.2	156.7	160.3
65~69	112.4~157.6	101.3~151.7	170.2	165.7
70~74	115.3~154.9	113.5~145.9	165.9	154.3
75→	121.9~151.1	114.6~144.6	153.5	
Diastolic				
5~9	41.3~67.6	27.8~60.4	80.8	69.1
10~14	47.4~75.6	44.0~76.8	83.5	86.0
15~19	55.5~85.5	54.7~85.1	94.2	90.5
20~24	58.0~87.8	54.9~82.1	96.3	89.7
25~29	59.6~94.0	57.1~87.9	103.6	96.5
30~34	60.4~88.8	54.6~85.4	96.8	94.2
35~39	62.8~92.6	56.6~89.0	100.9	98.0
40~44	63.3~92.7	61.3~87.1	100.8	94.4
45~49	65.1~98.3	57.5~98.5	107.5	110.0
50~54	61.3~95.1	59.5~92.9	104.4	102.2
55~59	64.5~92.5	64.8~92.2	100.3	99.9
60~64	67.8~91.2	60.6~94.8	97.7	104.3
65~69	63.3~96.1	59.9~92.3	105.1	100.7
70~74	72.4~92.2	69.9~90.9	97.9	96.2
75→	75.6~94.0	65.3~86.7	99.2	

The range of normal blood pressure was defined statistically and was based upon the distribution of blood pressure readings around the mean, according to age and sex. The closer a reading was to the mean, the greater was the chance of its being normal; conversely, the further the reading was from the mean, the greater was the chance of its being abnormal. The standard deviation was the yardstick commonly used to measure the amount

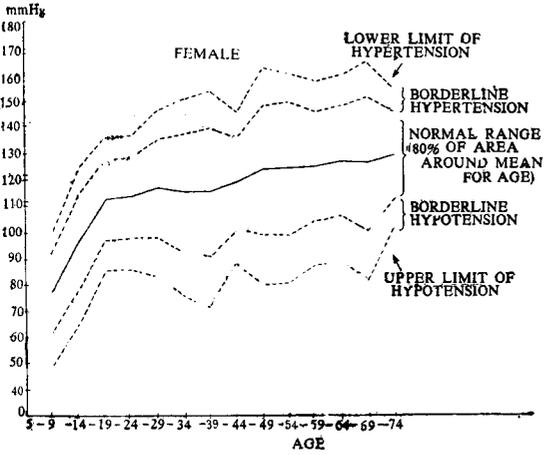


Fig. 2. Range of Normal Systolic Pressure and Limits of Hypertension and Hypotension (Males)

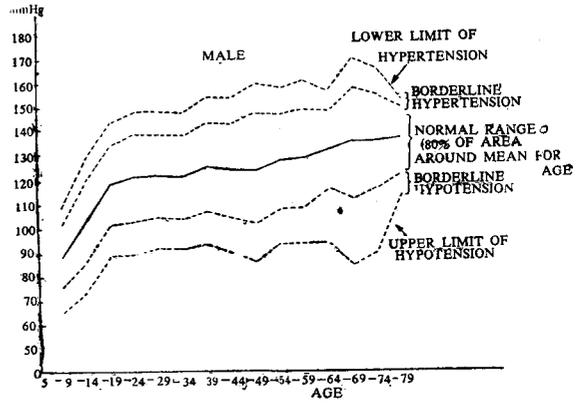


Fig. 3. Range of Normal Systolic Pressure and Limits of Hypertension and Hypotension (Females)

of deviation from the mean.

In a normal distribution, roughly two-thirds (68.27 per cent) of all the observations are found to be within one standard deviation from the mean (mean $\pm \delta$); and approximately 95 per cent of all the observations are found to be within two times the standard deviation from the mean (mean $\pm 2\delta$).

Statistically speaking, one may assume that any

readings within one standard deviation is within the normal range. Indeed, the normal range may reasonably be extended to include 80 per cent of all observations 40 per cent either side of the mean ($\pm 1.282\delta$).

All blood pressure readings which are found to be beyond two times the standard deviation from the mean are probably abnormal. These include 2.5 per cent of all observations at either extreme. The area

Table 6. Systolic and Diastolic Blood Pressure according to Weight

Sex Age Weight	Systolic			Diastolic		
	Mean	Stand. Dev.	Coeff. of Variation	Mean	Stand. Dev.	Coeff. of Variation
Males(1500)						
25~30						
50 kg and under	123.0	14.74	11.96	75.0	10.36	13.80
50~60 kg	122.8	13.60	11.45	78.3	10.32	13.18
65 kg and over	125.2	10.44	8.37	79.2	10.36	12.21
40~50						
55 kg and under	126.8	19.41	15.29	81.9	11.60	14.73
60~65 kg	126.3	15.26	12.09	82.4	11.38	14.13
70 kg and over	129.6	17.13	13.14	83.6	11.02	13.44
Females(1500)						
20~30						
45 kg and under	115.8	12.49	10.76	71.6	10.63	14.78
50~55 kg	118.1	12.49	10.55	73.4	9.37	12.76
60 kg and over	122.3	13.24	10.83	76.7	9.71	12.34
40~50						
50 kg and under	119.3	15.04	12.61	74.4	11.71	15.76
55~60 kg	126.3	17.41	13.72	78.2	11.15	14.24
65 kg and over	126.6	16.88	13.33	78.7	8.88	10.17

between the limits of the normal and the probably abnormal constitutes a narrow borderline range.

The calculated mean, the normal, the borderline, and the abnormal range, according to the definitions given, are based upon the given statistical definition.

5) Influence of weight on blood pressure.

Table 6 shows the relation of weight to blood pressure. The subjects were divided into two different age groups in both sexes, and each group was divided again into three different weight groups. A total of 1500 males was divided into two groups of 750 persons, the age of twenty to thirty being one group and the age of forty to fifty the other. In males, the twenty to thirty age group was again divided into three weight groups, viz., 50 kg and under, 55-60 kg, and 65 kg and over.

In females, a total of 1500 was divided into three groups in the age of twenty to thirty years, viz., 45 kg and under, 55-60 kg, and 65 kg and over. In the same age group, in both sexes, the mean blood pressure readings were higher in the heavy weight group than those in the light group, both for systolic and diastolic blood pressures.

6) A comparison of blood pressures as between rural and urban populations.

A comparison of blood pressure readings found in rural and in urban populations was made between 6702 urban males and 6172 rural males, and between 3479 urban females and 4934 rural females, from

the ages of twenty five to sixty nine. Mean blood pressures, both systolic and diastolic, in the urban population were higher than those in the rural population in each age group (Table 7). The difference in systolic mean blood pressure was 8 mmHg. at the age of forty four and 10 mmHg. at the age of sixty five to sixty nine in the male; the difference in systolic blood pressure was greater in the female than in the male.

7) A comparison of blood pressures as found in various countries.

A comparison of the mean blood pressure was made between Koreans and Americans, Japanese, Filipinos, Chinese and Indians (Fig. 4). In a comparison of the mean pressures between Koreans and Americans (U.S.A.), the blood pressures of Koreans were remarkably lower than those of Americans in all age groups, in both systolic and diastolic measurements.

The mean blood pressure levels of the Japanese and Chinese were similar to the Koreans until the age of forty in males, and then the blood pressures of both Japanese and Chinese rise rapidly and higher than in Korean males from the age of forty and over. The diastolic pressure curves were similar in all age groups in males. The mean blood pressure reading of Filipinos was similar to Koreans in all age groups. The mean blood pressure of Indians was slightly lower than that of Koreans in all age groups.

Table 7. Mean Blood Pressure of Korean Population in City and Country

Age	Males						Females						
	City(Urban)			Country(Rural)			City(Urban)			Country(Rural)			
	#	S.B.P.	D.B.P.	S.B.P.	D.B.P.	#	#	S.B.P.	D.B.P.	S.B.P.	D.B.P.	#	
25 ~ 29	1549	122±14	78±14	119±13	71±14	465	456	115±16	72±13	117±16	73±10	206	
30 ~ 34	1718	122±12	77±12	118±11	70± 8	931	525	119±20	74±14	112±15	67± 9	664	
35 ~ 39	1491	125±15	80±12	125±12	72± 8	653	483	123±23	75±16	109±14	71± 9	636	
40 ~ 44	707	128±18	83±13	120±12	75± 8	1057	385	126±10	73± 8	116±20	69±14	346	
45 ~ 49	597	129±12	85±14	119±14	77± 8	470	572	129±19	83±17	118±17	71±11	432	
50 ~ 54	315	135±23	84±16	127±12	75±10	743	288	133±27	80±15	123±17	75±12	911	
55 ~ 59	117	138±21	89±11	127±15	78±10	763	386	134±22	79±15	126±12	78± 7	597	
60 ~ 64	151	142±19	81±16	128± 8	79± 6	580	216	131±25	78±16	125±14	77± 7	639	
65 ~ 69	57	144±19	86±14	134±17	78±12	510	168	131±21	83±12	131±18	74±11	503	
Total Number	6,702						6,172			3,479			4,934

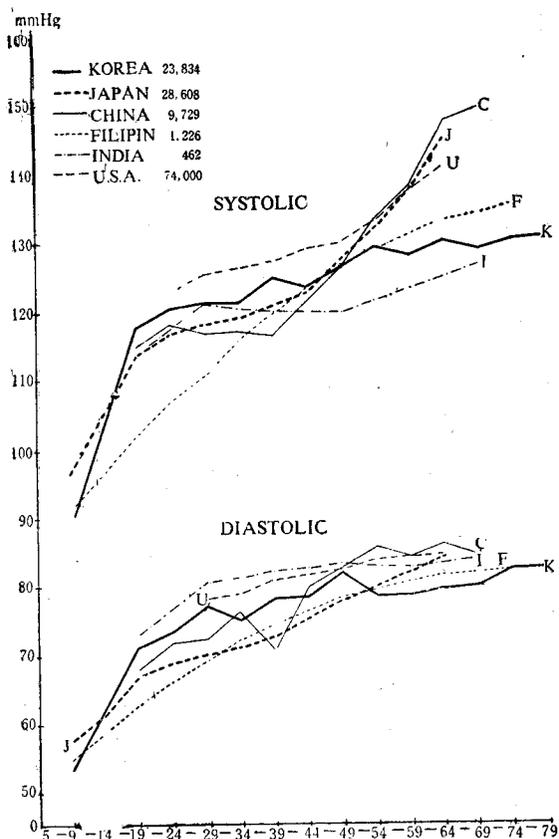


Fig. 4. Mean Blood Pressure Readings in Selected Studies(males) in Korea and in Foreign Countries

8) A comparison of blood pressure readings between the rural and urban population in Korea and those in India was made. The mean systolic and diastolic blood pressure curves of urban populations of Korea and of India were similar in all age groups in males. In the rural populations, the mean systolic pressure reading was higher in the Koreans than in the Indians, however, the diastolic pressure reading was similar in all age groups.

9) The incidence of hypertension and hypotension. The incidence of hypertension has been computed according to both systolic and diastolic readings, for example, 140 mmHg. and over for systolic, and 95 mmHg. and over for diastolic pressures. The subjects were divided into three different age groups, 15 to 29 years—group I; 30-44 years—group II; 44 years and over—group III. The lower limits of hypertension were assumed to be 140 mmHg. in group I, 150 mmHg. in group II, and 160 mmHg. in group III. Accordingly, the incidence of systolic hypertension was 6.4% in group I,

4.6% in group II, 7.0% in group III in males, and 4.7% in group I, 7.0% in group II, and 6.8% in group III in females. Diastolic hypertension was present in 7.6% in the 15-to-34 year age group and 6.0% in the 35-and-over group in males, and among females, in 4.7% in the 15 to 34 years age group and in 9.1% in the 35-and-over group. Systolic hypertension, on the average, was present in 6.0% of males and in 6.2% of females, diastolic hypertension in 6.8% of males and in 5.4% of females.

DISCUSSION

Present-day sphygmomanometry has evolved as the result of almost a century of clinical and physiological research (Poiseulle, 1829; Herrison 1834). During this period, a large number of devices have been produced by many workers in different parts of the world. Hitherto, the commonly accepted limits of normal blood pressure 140-150/90-95 mmHg. was initially introduced by a few early workers (Alvarez, 1920; Fishberg, 1939; Wiggers, 1950; White, 1944; Friedberg, 1950), and these normal pressure limits have been established by an analysis of blood pressure findings in relation to mortality rates (Fisher, 1914; Hunter, 1923; Mackenzie and Walls, 1953). We believe the conclusions drawn from these actuarial studies are not applicable to clinical medicine, since they were based on findings in a selected group rather than from a consideration of individual unselected cases.

1) **The range of normal pressure:** The range of normal pressure in our studies was defined statistically and was based upon the distribution of blood pressure readings around the mean according to age and sex. The closer a reading is to the mean, the greater is the chance of its being normal; conversely, the further a reading is from the mean, the greater is the chance of its being abnormal. In a normal distribution, roughly two-thirds (68, 27 per cent) of all the observations were found to be within one standard deviation from the mean ($\text{mean} \pm \delta$), and approximately 95 per cent of all the observations were found to be within two times the standard deviation from the mean ($\text{mean} \pm 2\delta$). Statistically speaking, one may assume that any reading within

one standard deviation from the mean is within the normal range. Indeed, the normal range may reasonably be extended to include 80 per cent of all observations, with 40 per cent on either side of the mean ($\pm 1.282\delta$). All blood pressure readings which are found to be beyond two times the standard deviation from the mean are probably abnormal. These include 2.5 per cent of all the observations at either extreme. The area between the limits of normal and the probably abnormal constitutes a narrow borderline range.

2) The blood pressure readings and age, sex: Many workers, Fishberg(1939), White(1944) and Allen(1945), Best(1950), minimize the influence of age on the blood pressure. A systolic pressure of 140 to 150 mmHg. and a diastolic pressure of 90 to 95 mmHg. are usually accepted as the upper limits of normal in adults at the age of forty as well as in those at the age of sixty-five. Wolfensohn-Kriss (1910), Faber(1921), and Graham(1945) have shown in their studies made on children that the systolic pressure gradually increases with age. Peters, in 1925, stated that the normal systolic pressure ranged from 90 to 130 mmHg. plus one-half the patient's age in years; thus, for a man of forty, its normal range was between 110-150 mmHg. Alvarez and Stanley(1930), on the contrary, stated that "a pressure of 115 mm. is just as normal, and a pressure of 140 is just as abnormal in an old man as in a young man".

Observations reported by numerous investigators over the course of many years, however, disproved the concept that the blood pressure is normally altered little by age. Potain(1902) found that the systolic pressure normally did increase with age. Similar results were obtained in studies on older age groups by Wildt (1921), Wikner(1916), Saller(1928) found a gradual increase in blood pressure after the age of forty seven, the rise being higher in females than in males. Bordley and Eichna(1938) presented a table arranged from material collected by Weatherby, which demonstrates nicely the rise in blood pressure with age. Similar reports were reported by many workers, Lewis(1938), Miller(1941), Russek(1946), Gover (1948), Master(1929). Our present study shows a result similar to Master, however, in that the mean

blood pressure readings of women are lower than those of men in all age groups.

3) The blood pressure and weight: The blood pressure tends to increase with increasing weight. This has been shown to be true by many investigators, and has been generally accepted. Symonds(1923) found that there was an average increase of 10 mmHg. in the systolic pressure in the heaviest groups of all ages, and a proportional increase in the diastolic pressure. Huber(1927) found that 49 per cent of those who were more than 10 per cent under-weight had a subnormal blood pressure. Hartman and Christ (1929), in the Mayo Clinic, found a step-like increase in systolic blood pressure with increase in body weight at the age of 15 and over. Short and Johnson(1931) obtained similar results in their studies. Conversely, reduction in weight produces a lowering of the blood pressure. Preble(1923) demonstrated that a reduction of 10 pounds in weight caused an average drop of 18 points in the systolic pressure and 10 points in the diastolic pressure. Similar results were reported by Terry(1923), Bauman(1929), Moschowitz(1945), and Master(1952). Our present study also shows an increase of blood pressure on increasing the weight.

4) The blood pressure and emotional state, race, geographic location: It has long been known that a nervous or emotional upset, particularly fear, may cause a transient increase in the blood pressure. Kamsame(1899) asserted that the true level of the blood pressure can be determined only after many blood pressure readings have been taken in order to avoid variations due to psychic factors. This observation was confirmed and emphasized by many workers, Jellinek(1900), Potain(1902), Janeway(1913), Zabel(1910), Schrupf(1910), Tixier(1919), Dihel (1929), Landis, et al. (1925), Dumas, et al.(1927), Grollman(1929), Marston(1929), Scott(1930), Ayman and Goldshine(1940). The blood pressure level seems to vary with race and geographic location. According to the following reports of McCay(1907), Chamberlain (1911), Kilborn(1926), Ashford(1930), Hudson(1931), Lantin(1933), Salcedo(1932), Nye(1937), and Williams (1944), certain groups of Chinese, Filipinos, Puerto Ricans, East Africans, Indians, Arabs, and Aborigine Austrilians seem to have a lower blood pressure and

less hypertension than do the North American or other Western peoples. In U.S.A., Alvarez and Stanley(1930) found that blood pressure rises more rapidly with age in negroes than in whites. Adams (1932) found that the blood pressures of the colored were higher than those of whites. Donnison(1929) found that the blood pressure among African negroes was about the same as that among whites up to the fourth decade, after which it is distinctly lower. Cadbury(1922) found that the systolic and diastolic pressures were lower when compared to the pressures of European or American youths of similar age, weight and height. Tung(1927) studied the blood pressure of 58 Americans before and after they resided in China. He found that the average systolic pressure decreased 9 mmHg., and that the diastolic pressure decreased 11 mmHg. during their residence in China.

Tung(1927) also found that occidentals living in China have lower blood pressures than Americans in the U.S.A., the average for the foreigners being the same as for the local Chinese. Conversely, Krakower (1934) has stated that the blood pressure of Chinese, after long residence in Canada, approximates that of other Canadian residents, and that essential hypertension was common among them.

In our study, the blood pressure of rural populations was lower than that of urban populations. In Koreans, the average weight among rural population was lower than that among the urban population, and this was one of the important factors affecting the blood pressure; the difference in pressure may be related to physical environment. The slower tempo of life and the decreased amount of psychic stress among rural people undoubtedly have an important effect on blood pressure.

REFERENCES

- Adams, J. M.: *Am. J. Med. Sc.*, 184:342, 1932.
- Allen, E. V.: *Diagnosis and Treatment of Cardiovascular Disease*. Edited by Stroud, W. D., 3rd Ed., Vol. II, p. 1346, Philadelphia, 1945, F. A. Davis Co.
- Alvarez, W. C.: *Arch. Int. Med.*, 26:381, 1920.
- Alvarez, W. C., and Staley, L.: *Arch. Int. Med.*, 46:17, 1930.
- Ashford, B. K., and Dowling, G. B.: *J. Pub. Health & Trop. Med.*, 5:477, 1930.
- Ayman, D., and Goldshine, A. D.: *Am. J. Med. Sci.*, 200:465, 1940.
- Best, C. H., and Taylor, N. B.: *The Physiological Basis of Medical Practice*, Baltimore, Williams & Wilkins Company, p. 149, 1950.
- Bauman, L.: *J. A. M. A.*, 90:22, 1929.
- Bordley, J., III. and Eichna, L. W.: *Internat. Clin.*, 1:175, 1938.
- Cadbury, Wm. M.: *Arch. Int. Med.*, 20:362, 1922.
- Chamberlain, W. P.: *Philippine J. of Sci.*, 6:467, 1911.
- Dihel H. S., and Lees, H. D.: *Arch. Int. Med.*, 44:229, 1929.
- Donnison, C. P.: *Lancet*, 1:6, 1929.
- Dumas, G., Lamache, A., and Dubar, J.: *Compt. rend. Soc. de Biol.*, 96:159, 1927.
- Ehrstrom, M. C.: *Acta Med. Scandinav.*, 119:122, 1945.
- Faber, H. K., and James, C. A.: *Am. J. Dis. Child.*, 22:7, 1921.
- Faber, A.: *Skandinav. Arch. Physiol.*, 45:189, 1924.
- Fisher, J. W.: *J. A. M. A.*, 63:1752, 1941.
- Fishberg, A. M.: *Hypertension and Nephritis*, 4th Ed., Philadelphia, Lea & Febiger, p. 213, 1939.
- Friedberg, C. K.: *Disease of the Heart*, Philadelphia, W. B. Saunders Co., p. 854, 1950.
- Gover, Mery: *Pub. Health Rep.*, 63:1083, 1948.
- Graham, A. W., Hines, E. A., and Gage, R. P.: *Am. J. Dis. Child.*, 69:203, 1945.
- Grollman, A.: *Am. J. Physiol.*, 89:584, 1929.
- Herrison, J.: *Le Sphygmometer, Instrument quitraduit a l'oeil tuotel action des arteres. Utilite de cet instrument dans L'etude de toutes les maladies (memoire presents a Institut 1847)*. Cited by Marey, J., *La Circulation du Sang a Etat Physiologique*, Paris, G. Masson, 1881.
- Huber, E. G.: *J. A. M. A.*, 88:1554, 1927.
- Hartman, H. R., and Christ, D. G.: *Arch. Int. Med.*, 44:877, 1929.
- Hudson, E. H., and Young, A. L.: *Am. J. Trop. Med.*, 11:297, 1931.
- Hunter, A.: *Trans. Actv. Soc. Amer.*, 24, 378, 1923.
- Janeway, T. C.: *Arch. Int. Med.* 12:755, 1913.

- Jellinek, S.: *Ztschr. f. Klin. Med.*, 39:447, 1900.
- Judson, C. F., and Nicholson, P.: *Am. J. Dis. Child.*, 8:257, 1914.
- Kapsammer, G.: *Wien, Klin. Wschr.*, 12:1279, 1899.
- Kilborn, L. G.: *China M. J.*, 40:1, 1926.
- Krakower, A.: *Am. Heart J.*, 9:396, 1934.
- Lantin, G. T.: *J. Philippine Islands M. A.*, 13:191, 1933.
- Landis, C.: *Am. J. Physiol.*, 73:551, 1925.
- Lewis, W. H. Jr.: *Am., J. Physiol.*, 122:491, 1938.
- Mackenzie, L. F., and Wells, P. V.: *Proceedings of the Association of Life Insurance Medical Directors of America. Vol. XIX, New York, p. 89, 1953*
- Marston, W. M.: *Psyche. London*, 10:70, 1929.
- Master, A. M., and Oppenheimer, E. T.: *J. A. M. A.*, 92:1652, 1929.
- Master, A. M. and et al.: *Normal Blood Pressure and Hypertension Lea & Febiger, Philadelphia, 1952.*
- McCay, D.: *The Lancet*, 1:1483, 1907.
- Moschowitz, E.: *J. Mt. Sinai Hosp.*, 12:828, 1945.
- Miller, I.: *New York State J. Med.*, 41, 1631, 1941.
- Nye, L. J. J.: *M. J. Australia*, 2:1000, 1937.
- Peters, J. T.: *Med. Wchnschr.*, 72:503, 1925.
- Poiseuille, J. L. M.: *Journal de physiologic Experimentale et Pathologique par F. Magendie*, 9:341, 1829.
- Potain, C.: *La Pression Arterielle du L'homme, Paris, G. Masson, 1902.*
- Preble, W. E.: *Boston M. & S. J.*, 188:617, 1923.
- Russek, H. I., Rath, M. M., Zohmen, B. L., and Miller, I., *Am. Heart J.*, 32:468, 1946.
- Schrumpf, P.: *Deutsche Med. Wchnschr.*, 362:2385, 1910.
- Scott, J. C.: *J. Comp. Psychol.*, 10:97, 1930.
- Salcedo, J., Jr., and Pascual, W.: *J. Philippine Islands M. A.*, 12:494, 1932.
- Saller, K.: *Ztscher f. d. Ges. Anat.*, 14:1, 1928.
- Short, J. J., and Johnson, H. J.: *Am. J. Med. Sc.*, 198:220, 1939.
- Symonds, B.: *J. A. M. A.*, 80:232, 1923.
- Terry, A. J., Jr.: *J. A. M. A.*, 81:1283, 1923.
- Tixier, L.: *Arch. d. Mal. du coeur.*, 12:337, 1919.
- Tung, C. L.: *Arch. Int. Med.*, 40:153, 1927.
- White, P. S.: *Heart Disease 3rd Ed., New York. The Macmillan Company, P. 97-98, 1944.*
- Williams, A. W.: *East African M. J.*, 21:328-368, 1944.
- Wiggers, C. J.: *Physiology in Health and Disease, 3rd Ed., Philadelphia Lea & Febiger, p. 854, 1950.*
- Wildt, H.: *Zentralbl. f. Herzkrankheiten und Gefässkrankheiten*, 4:41, 1912.
- Wikner: *Sevenska Lakeresallskepets Handl*, 42, 1489, 1916, cited by Fleisch, A.: *Handbuch der Normalen und Pathologischen Physiologie, Vol. VII, part 2, Berlin, Julius Springer, p. 1276, 1927.*
- Wolfensohn-Kriss, P.: *Arch. f. Kinderh.*, 53:332, 1910.
- Zabel, B.: *Munchen Med. Wchenschr.*, 572:2278, 1910.