Seasonal Effects on Blood Pressure

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SEASONAL EFFECTS
ON
BLOOD PRESSURE

by

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The relationship of seasons and blood pressure was investigated. The individuals in the sample groups were of two types: normal individuals and individuals who have been diagnosed as hypertensives and under medical supervision. This was a seasonal study; measurements were taken during midsummer and early fall, 1979. Factors constituting the variable for individual differences included: sex, age, genetic factors, diet, general body build and managerial vs. laborer workload.

Individual differences were controlled by use of a randomized complete block design with each individual constituting a block. Season was the treatment factor, and individual was the blocking factor. Measurements were taken daily during the same time period on each working day over a six-week period in each season.

The results indicated that the average diastolic blood pressure was significantly higher in the summer than in the fall. The systolic pressure showed no differences in regard to seasons studied.

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CHAPTER I

INTRODUCTION

The Problem

This study was an attempt to measure the relationship of season to the average blood pressure. If seasonal variation in blood pressure is shown to occur, the possible environmental parameters which may be influencing blood pressure are barometric pressure, humidity and temperature. During summer the barometric pressure was found to be high in the first week of data collection and humidity more random with no major weather events. During the fall, the humidity was high at the end of the data collection, and barometric pressure was more random.

The sample group consisted primarily of healthy blue collar workers of adult middle age, and some academic professionals who were controlled hypertensives.

The blood pressure of each individual during both a summer seasonal period and a fall seasonal period was measured. Just before taking blood pressure measurements, barometric pressure and humidity were recorded. Blood pressure measurement was taken three times at three o'clock, each afternoon. The third measurement was regarded as most accurate. All measurements were done privately on each

individual. It should be noted that the sample size was not constant and that some individuals, ultimately, had to be dropped from the study. Of the final sample size, certain individuals were absent on some of the measurement days; and in certain instances as few as three measurements per week are seen to occur on some individuals. Some individuals were not loyal to the study and thus unconcerned about possible findings; this was a problem. In other cases, certain individuals had summer employment where the study was conducted and, when fall arrived, went back to college and had to be omitted from the study.

If environmental factors do have a relationship in altering blood pressure, then measurements of blood pressure and proper management of blood pressure in hypertensive people would be achieved, possibly by manipulating the environment (living quarters) in which the individual lives.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Halberg, Halberg, and Shankaraiah (1981) reported continual 10-minute around the clock measurements of blood pressure on two healthy individuals for 26 days. They reported both a circadian and ultradian component for systolic and diastolic measurements.

Blood pressure is defined as a mechanism made up of several phases. First, the aortic valves are opened and the blood pressure will be at its highest during ventricular ejection or systole; and when the valves relax, the pressure will decline; this is when arterial pressure is at its lowest, or diastole. Both the systolic and diastolic pressures show a circadian rhythm (Best, Taylor, 1963).

It has been found that deaths due to coronary heart disease and cerebrovascular accident (stroke), in the United States, increased sharply when daily temperatures rose above an optimum temperature (Tout, 1980). He showed that during a hot spell in the summer of (June) 1976, in London, mortality increased by 33 percent in one week, which is more than four standard deviations above the weekly mortality mean. This shows the temperature effect which may occur on blood pressure.

It has been found that death due to heart attack is increased by severe winter weather involving extremely low temperatures, high windspeed, and high humidity. This was found to be true using a multiple regression analysis on population data (Campbell, Beets, 1979).

By use of the least squares method and with a cosinor test, it has been shown that the maximal lengthening of LVET (Left Ventricular Ejection Time) occurred at 02.44 clock hour, but this was with healthy subjects put on three small protein meals per day (Sensi, Capant, DiNardo, Carosella, Cocchi, Carbonin, and Bellocci, 1977).

It has been shown that there is a mediocre significance between average daily barometric pressure and intraocular pressure. The correlation was of weaker validity in the younger age group, but of stronger validity in elderly patients and those elderly individuals with arterial hypertension (Follman, 1979).

Normal blood pressure in a young healthy male is 120/80 mmHg, as elucidated by the late Dr. Carl J. Wiggers, in his classic test of Physiology in Health and Disease (cited in Katz, 1977).

Blood pressure is developed when the left ventricle contracts; it forces blood under high pressure into the aorta, and blood goes into the arteries (systemic circulation). The walls of the arteries are elastic and the force upon them causes the walls to stretch. During the

diastolic phase of blood pressure, the relaxation phase of the heart cycle, the heart is not exerting pressure on the blood in the arteries and the pressure in them falls, but elastic recoil of the previously stretched artery walls maintains some pressure on the blood. Thus, there is a regular cycle of pressure in the larger arteries, the pressure reaching its highest point during the systolic phase and its lowest point during the diastolic phase (Keeton, 1972).

When the aortic valves are open and the ventricle contracts and forces blood into the arteries, it is apparent that the pressure in the arteries must reach its highest point. On the other hand, when the heart relaxes and the aortic valves close, the pressure must decline again. Just before the next contraction of the heart occurs, the arterial pressure must reach its lowest level. The highest point of pressure in the arteries is termed the systolic pressure and the lowest point is termed the diastolic pressure. The circulation of the body is divisible into a high pressure system -- the arteries, and a low pressure system -- the capillaries and veins. Between the two systems a number of small vessels are situated, which at one time may open widely, and at another time may be tightly closed. These vessels are called arterioles. They have circular muscles running around which, when contracted, reduces blood flow into

capillaries; when relaxed, the vessel dilates and more blood escapes into the capillaries. These arterioles act like small faucets in the circulatory system. The following factors are responsible for maintaining arterial blood pressure: pumping action of the heart, peripheral resistance, viscosity of blood, quantity of blood in arterial system, and elasticity of arterial walls. Other factors which attempt to maintain a constant blood pressure include baroreceptors and hormonal regulation (Best, Taylor, 1963).

Hormones which are important in maintaining a normal blood pressure include: 1.) Epinephrine, which is involved in the "fight or flight" reaction, causes rise in blood pressure (mainly systolic), acceleration of heartbeat, release of glucose into the liver, vasodilatation and increased blood flow in skeletal and heart muscle, and vasoconstriction to the smooth muscle of the digestive tract. The sympathetic nervous system will stimulate the same "fight or flight" reactions and cause blood pressure to rise. 2.) Aldosterone regulates sodium-potassium metabolism, stimulates the cells of the convoluted tubules in the kidneys to decrease reabsorption of potassium and increase reabsorption of sodium, which leads to increased absorption of water and chloride. The reabsorption of these substances causes a rise in blood volume and blood pressure. 3.) Angiotensin: when blood

flow is restricted to the kidney, the kidney cortex will secrete a protein (renin) which reacts with a protein in the blood to form angiotensin. The angiotensin is a vasoconstrictor. The vasoconstriction will cause the blood pressure to rise. The reason for the rise in blood pressure is due to constricted vessels offering more resistance to flow, and the heart compensates for the lessened flow by increased output. Angiotensin has been shown to increase secretion of aldosterone by the adrenal cortex. 4.) Vasopressin stimulates water reabsorption by the kidneys and stimulates constriction of blood vessels to give rise in blood pressure. Baroreceptors, in the aortic arch, will attempt to keep blood pressure normal, as does kidney function in removal of excess water and ions (Keeton, 1972). It should be noted that small doses of epinephrine will increase the cardiac output without an elevation in the blood pressure. In contrast, norepinephrine is a powerful vasoconstrictor and raises systolic and diastolic pressures, but norepinephrine does not produce much of a change in cardiac output. Norepinephrine causes a rise in blood pressure by constricting vessels in all muscles, skin and internal organs. Epinephrine is influenced by the environment to a great extent; others, by diet.

Arterial pressure is constantly changing throughout the cardiac cycle and the average pressure (mean pressure)

throughout the cycle is not merely a value halfway between systolic and diastolic pressure. This is because diastole usually lasts longer than systole. They (systolic -- ventricular ejection, diastolic -- heart at rest just before ventricles contract) are generally recorded as systolic over diastolic. That is 120/80 mmHg, as an example. The pulse which can be felt in an artery is due to the difference between systolic and diastolic pressure. The difference (125 - 75 = 50) is called the pulse pressure. Some of the factors which may alter pulse pressure are the following:

1.) An increased stroke volume will tend to elevate systolic pressure because of the greater arterial stretching by the additional blood.

2.) A decreased heart rate will tend to lower the diastolic pressure, since there is more time for the run-off before the next ventricular contraction.

3.) Decreased arterial distensibility as seen in arteriosclerosis may cause a marked increase in systolic pressure because the wall is stiffer.

Actually, the true mean arterial pressure can be obtained only by complex methods, but it is reasonably accurate to calculate the mean pressure as the diastolic pressure plus one third of the pulse pressure. The mean pressure (arterial) is extremely important in that it describes the average pressure driving blood into the

tissues throughout the entire cardiac cycle. Both systolic and diastolic blood pressure are readily measured in human beings. A hollow cuff is wrapped around the arm and inflated with air to a pressure greater than systolic pressure (Fig. 1A).

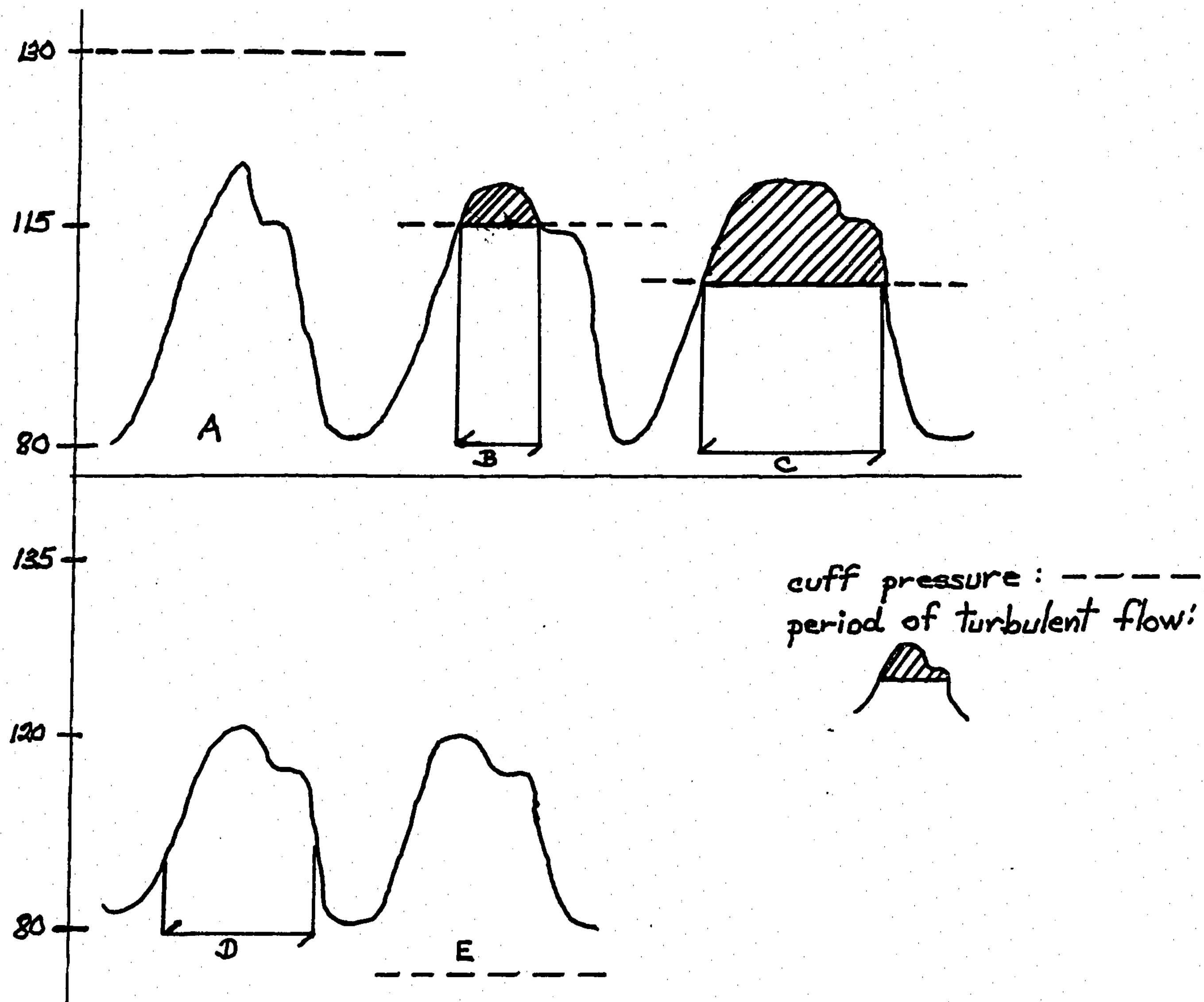

Figure 1: Sounds heard through a stethoscope while cuff pressure of a sphygmomanometer is gradually lowered. Systolic pressure is recorded at B and diastolic pressure at the point of sound disappearance.

The high pressure in the cuff is transmitted to the tissues of the arm and completely collapses the arteries under the cuff, thereby preventing flow into the lower arm. The air in the cuff is now released slowly, causing the pressure in the cuff and the arm to drop. Bringing the cuff pressure to a point below the systolic pressure (Fig. 1B), the arterial pressure at the peak of systole will be greater than the cuff pressure, causing the artery to expand and allow blood flow for this brief time. During this interval, blood flow through the partially occluded artery occurs at an extremely high velocity. The high velocity blood flow produces turbulence and vibration, which can be heard through a stethoscope placed over the artery. Pressure measured on the manometer at which sounds are first heard, as the cuff pressure is lowered, is identified as the systolic blood pressure. These first sounds are soft tapping sounds corresponding to the peak systolic pressure reached during ejection of blood from the heart. As cuff pressure is further lowered, the time of blood flow through the artery during each cycle becomes longer (Fig. 1C). The tapping sound becomes louder as the pressure is lowered. When the cuff pressure begins to reach the diastolic blood pressure, the sounds become dull and muffled, as the artery remains open throughout the cycle and allows continuous turbulent flow (Fig. 1D). Just below diastolic pressure, all sound

ceases as flow is now continuous and non-turbulent through the completely open artery. Thus, the systolic pressure is measured as the cuff pressure at which sounds first appear and the diastolic pressure as the cuff pressure at which sounds disappear (Vander, Luciano, 1970).

Hypertension is defined to the various degrees by Hutchinson (1975) in a numerical fashion: borderline hypertension 140-160/90-100 mmHg; mild hypertension, diastolic reading of 100-110 mmHg; moderate hypertension, diastolic reading of 110-120 mmHg; and severe hypertension, diastolic reading of greater than 130 mmHg. It is important to recognize these numbers when doing a study of this type to enable one to discover "unknown" hypertensives in the population.

Very few investigations have been made as to blood pressure changes in normal, healthy individuals due to environmental factors of seasons. However, several investigations have confirmed that blood pressure varies significantly within a 24-hour period. Halberg's laboratory has been very active in the measurement of human blood pressure circadian rhythms. In a paper (Halberg, 1981), it was shown that a statistically significant rise in diastolic blood pressure, found in a clinically healthy woman, age 60, occurs between the clock hours 2 - 4 p.m., and this is a rhythm relating a day-night photo period.

This review of the literature located little that was relevant to this study.

CHAPTER III

DESIGN AND METHODOLOGY

Subjects

The sample group consisted of 17 individuals. There were a total of 15 males and 2 females. The sample group was made up mainly of middle-aged males, with the age range being 20 to 65, and two females, ages 32 and 46. In the blue collar division of the group, the age range was 20 to 65, and the sex ratio was 1F/13M. In the academic professional group, the age range was 46 to 63, and the sex ratio was 1F/2M. The major number of individuals were healthy. Two of the blue collar population, ages 59 and 48, had endured open heart surgery (subjects #4 and #6).

As can be seen from table 1, of the academic professionals (subjects #1, #15 and #17), one is known hypertensive. Of the professionals, none are known to be under medical supervision, two are on an exercise regime, two are on a diet program, none are involved in a heavy work schedule, and only one shows a positive assessment of daily vigor.

Of the blue collar individuals (subjects #2, #14 and #16), one is a known, controlled hypertensive. Three are under medical supervision, nine are on an exercise regime,

eight are on some form of a diet program, seven are on a heavy work schedule, with one a partial heavy work schedule. Twelve showed a positive assessment of daily vigor. Table 1 gives summary of important characteristics of the sample group: age, sex, medically diagnosed hypertension, lifestyle (diet, exercise regime, recreation, work schedule), and personal qualitative daily assessment (daily vigor).

Table 1

Characteristics of Subjects

	*1	*2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SEX	M	M	M	M	M	M	M	M	M	M	M	F	M	M	M	M	F
AGE	52	54	53	59	58	48	58	60_s	20_s	28	38	32	65	50	63	26	46
UNDER MEDICAL SUPERVISION	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
EXERCISE REGIME	+	+	+	-	-	-	+	+	+	-	+	-	+	+	+	+	-
DIET	+	+	+	+	-	+	-	-	-	+	+	-	-	+	-	+	+
WORK SCHEDULE	-	-	+	+	+	+	+	+	+	-	-	-	-	+	-	+	-
QUALITATIVE ASSESSMENT (DAILY VIGOR)	-	+	+	+	+	-	+	+	+	+	+	+	-	+	-	+	+

*Individual is known hypertensive

Methods

Equipment used included one calibrated Marshall Sphygmomanometer, with standard adjustable arm cuff, and one stethoscope. After proper placement of arm cuff on upper left arm, it is important to recognize the Korotokoff sounds. The first is an indication of systolic, and the fifth phase, or disappearance of sound, is the indicated diastolic reading (Hutchinson, 1975). Daily readings were taken in the mid-afternoon between 3 and 4 p.m. This was the end of the workday for the individuals in the study. The readings were done privately on each individual, to eliminate any kind of uneasiness which might occur due to others being present. Proper technique and procedure are extremely important to the accuracy of the study, and are described according to Catch Nurses (1970) in the Procedure for Taking Blood Pressure. The method was developed by the nurses to screen for hypertensive individuals, primarily on college campuses. This method was followed exactly.

1. The left arm was used at all times. The arm was firmly and fully supported on the table slightly abducted and flexed, except for noted exception on blood pressure record.

2. The compression cuff was placed on the upper arm one inch above the antecubital fossa. The rubber bladder

of the cuff was centered over the brachial artery which extended along the inner aspect of the arm. The cuff was applied evenly, without any constriction. The cuff is always placed at the same level as the heart of the individual.

3. Gauge of manometer was within an accurate eye reading distance.

4. Fingers were used to palpate for the brachial pulse in the antecubital fossa, and thus location for placement of the stethoscope was easily discerned over this artery.

5. After palpating radial artery pulse, the compression cuff was inflated 20-30 mmHg over the point at which the pulse beat ceases on compression, followed by placement of stethoscope lightly over the artery in the antecubital fossa. The diaphragm of the stethoscope should not touch the compression cuff or the client's clothing. To get accurate readings, the decompression should be at a slow rate, 2-3 mmHg per second.

6. As soon as cuff pressure fell just below systolic pressure, the arterial pressure would be greater than the cuff and blood would flow at an extreme velocity through the partially occluded artery (Vander et. al 1970).

Due to the high velocity of the blood through the small opening of the artery, the first sharp, high tone (Korotokoff sound) appeared in relation to manometer

calibrations and was recorded as systolic pressure. Third blood pressure measurement is most accurate and recorded.

7. When continuous non-turbulent flow resumed or when sound ceased through stethoscope and artery was completely dilated, as described by Vander (1970), that point at which sound just ceased was recorded as diastolic.

8. The failure of stethoscope sounds to disappear at the fifth phase for diastolic pressure might necessitate the recording of diastolic pressure at the <u>fourth phase</u> -- onset of muffled sound, one of the Korotokoff sounds (Hutchinson, 1975).

9. Should a poor measurement be obtained on first attempt, the arm cuff was deflated and a one minute wait was used before repeating the procedure.

10. Should the individual show an ausculatory gap in manometer reading, the first disappearance of sound was not recorded as the fifth phase diastolic reading. Sound will return, and did, when decompression was resumed.

Measurements were taken 5 days per week, Monday through Friday. Each blue collar worker had an identification number which would be called, at which time the individual would come into the main office of the carpenter shop at Western Michigan University to have blood pressure taken. Professional workers' blood pressure was taken in each of their offices. Each person in the sample

group was approached in a cordial, friendly manner and many seemed to enjoy their participation in the study.

Statistical Methods

Blood pressure taken over 30 days in mid-summer and early fall were averaged for systolic and diastolic readings. A randomized complete block design was used to control for differences between individuals and days of measurement. From a statistical point of view, the randomized complete block design allows for individual differences to be controlled, and the effect on averaged blood pressure due to season to be determined. Individual differences such as weight, sex, age and other physiological factors are controlled in this statistical design. Any variation seen would be due to the two seasons.

A randomized complete block design with block size two was used, and the resultant data was analyzed by using a paired t-test to determine any differences in systolic and diastolic measurements between the two seasons. The following hypotheses were tested using the paired t-test with a significance level of 0.05:

H_0: There is no effect on average blood pressure due to season.

versus

H_1: Season has an effect on average blood pressure.

Separate t-tests were made for the systolic readings and the diastolic readings.

The t statistic for the paired t-test is:

$$t = \frac{\bar{X} - u}{\frac{s}{\sqrt{n}}}$$

CHAPTER IV

FINDINGS

Table 2 gives the average systolic blood pressures for each individual for summer and fall. To obtain table 2, the daily systolic blood pressure readings in each season were averaged for each individual in columns one and two; and column three gives the difference in systolic blood pressure between seasons for each individual.

Table 2

Summer, Fall Average Systolic Blood Pressures

Person	Summer	Fall	Difference between seasons (d_i)
1	133.72	134.11	-0.388
2	129.35	129.70	-0.456
3	120.90	137.80	-6.887
4	132.75	123.20	9.583
5	135.44	141.20	-5.777
6	125.27	120.14	5.135
7	119.44	117.00	2.444
8	114.47	112.30	2.221
9	126.60	121.20	5.421
10	112.15	115.50	-3.313
11	118.44	117.30	1.152
12	99.00	104.80	-5.800
13	129.30	137.12	-7.784
14	127.72	129.50	-1.739
15	109.40	106.43	2.960
16	119.40	118.83	0.611
17	115.31	106.90	8.446

Table 3 gives the average diastolic blood pressures for each individual for summer and fall. To obtain table 3, the daily diastolic blood pressure readings in each season were averaged, and difference in diastolic blood pressure between the seasons was computed for each individual.

Table 3

Summer, Fall Average Diastolic Blood Pressures

Person	Summer	Fall	Difference between seasons (d_i)
1	87.11	88.61	-1.500
2	90.13	90.53	-0.404
3	82.64	79.71	2.922
4	84.33	81.83	2.500
5	79.83	80.40	-0.556
6	92.00	87.62	4.385
7	68.00	67.94	0.059
8	78.00	75.63	2.375
9	83.82	78.83	4.990
10	81.92	80.60	1.323
11	82.13	79.30	2.839
12	67.88	74.66	-6.791
13	67.60	62.40	5.235
14	78.44	79.54	-1.094
15	74.00	71.00	3.692
16	82.00	78.00	4.000
17	90.50	80.50	10.033

Table 4 gives the summary of statistics used: mean for paired differences, standard error of mean, and paired t-test statistic.

To obtain table 4, data from tables 2 and 3 were used. The difference in the pressure, either systolic or diastolic, between the seasons was summed and mean for paired differences calculated. Then the standard error of this mean was calculated and the paired t-test was performed.

Table 4

Table of Summary Statistics

I. Summer, Fall Average Systolic Pressure

Mean for paired differences	0.3432
Standard error of mean	1.2540
Paired t-test of statistic	0.2737

Individuals #4 and #17 show a large difference between seasons.

II. Summer, Fall Average Diastolic Pressure

Mean for paired differences	2.001
Standard error of mean	0.900
Paired t-test statistic	2.254

Individual #17 shows a large difference between seasons.

III. Summer, Fall Average Diastolic Pressure with exclusion of individual #17

Mean for paired differences	1.500
Standard error of mean	0.780
Paired t-test statistic	1.924

Conclusions in Regard to Table 4

Season does not have a significant effect on the systolic blood pressure. Season has a significant effect

on the diastolic blood pressure of humans taken at 3:00 p.m. The diastolic blood pressure is normally higher in the summer than in the fall.

CHAPTER V

DISCUSSION

There have been some studies performed which deal with blood pressure, including parameters such as circadian rhythm (Halberg, Halberg, and Shankariah, 1981), hypertension, a concomitant approach in regard to kidney function and stroke (Davis, Laragh, and Selwyn, 1979; Kolata, 1979); but no studies were located that dealt with the idea as to whether blood pressure varies due to season. In Southwest Michigan, mid-summer feels stressful, due to high humidity, temperature and rapid barometric pressure changes. It was hypothesized that blood pressure might reflect these environmental parameters. The following seasonal differences in blood pressure were found: there is no difference from summer to fall in average systolic blood pressure. This conclusion was based upon the paired t-test which was calculated to be 0.2737 with a 95% level of confidence. The mean for paired differences for summer, fall average systolic pressure was 0.3432, with standard error of 1.254. Individuals #4 and #17 showed a large difference between seasons (individual #4 $d_i = 9.583$ and individual #17 $d_i = 8.446$), and this contributed to the value of the standard error substantially. There is a difference in average diastolic blood pressure between the two seasons -- the diastolic is found to be higher in the

summer than in the fall. This conclusion was based upon the paired t-test which was calculated to be 2.254 with a 95% level of confidence. The mean for paired differences was 2.001 with a standard error of 0.900. Individual #17 showed a large difference between seasons and contributed to the standard error. With the exclusion of individual #17, there is some evidence for a difference in average diastolic blood pressure due to season. This conclusion was based upon the paired t-test which gave a value of 1.924 with a 95% level of confidence. The mean for paired differences was 1.500 with a standard error of 0.780.

It should be realized that not all individuals were measured on each weekday, but individuals who did not show enough data were eliminated from the study. Weekends were never measured, and may have shown some differences, also.

The paper of Halberg's is interesting for this study, since he found that the normal circadian rise was between 2-4 clock hours, the very time the measurements were made in this study. If this was the time of maximal diastolic rise in the subjects in my study, it possibly could give significant variables to results in this study. It has been shown that the daily maximum in physiological variables (Halberg, 1981) shows a greater change than one sees when comparing weekly or yearly

changes. Since the comparison of differences was made at this time, possibly the time of maximal daily change, differences could have been smoothed out and could have been more difficult to be seen. Future studies should take into consideration the circadian variations, and a comparison of readings should be measured at the time of the day for the lower readings. More significant differences possibly could be noted.

It seems possible, where blood pressure is monitored over appropriately long spans of time, the data would provide potentially useful indices in quantifying health and in recognizing risk, as well as for screening for asymptomatic disease. Seasonal monitoring could provide even further value for determining the degree of health of individuals.

Borderline hypertension is difficult for the physician to diagnose. A recent investigation was conducted over a period of several years and was published to show that if these persons are medically treated for hypertension, a significant number of deaths was prevented (Hutchinson, 1975). Yet, if seasonal fluctuations occur, a borderline hypertensive might be missed. Data showing seasonal and other environmentally induced blood pressure fluctuations would help to produce a true average or normal profile of blood pressure in adults. The data could help the physician to provide the correct dosage of medication,

which, in the long run, might prevent a seasonal elevation sufficient to cause significant pathology, such as strokes.

More and more patients and others are monitoring their own blood pressures. If they were aware of changes due to seasons, and other parameters, they may better understand their blood pressure fluctuations.

Hypertension is of general interest to society because it is ranked along with "other diseases of the heart" as a leading cause of death in the United States. Hypertension nationwide in 1976 causes 10.7 deaths per 100 people (Bureau of Census, 1978). In Michigan, there were 6.1 deaths per 1,000 people. In rank order, Michigan people are first in having hypertension as a major cause of death (Bureau of Census, 1978), along with other cardiovascular disease.

There are two forms of heart disease which have higher rates of mortality in Michigan than hypertension: acute myocardial infarction and chronic ischemic heart disease. Combined, they make up 90.7% of all Michigan heart disease; the rest is due to hypertension (Michigan Department of Public Health, 1975).

Most clinical investigations of environmental causes of hypertension have centered around social behavioral stresses, such as diet, obesity and other factors.

What causes the seasonal variation and whether this variation contributes to hypertension is not known, but

it may be due to such factors as humidity, barometric pressure and temperature; and more research is needed in this area.

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