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The Effect of Gymnastic Routines on Blood Pressure and Pulse Rate

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THE EFFECT OF GYMNASTIC ROUTINES ON BLOOD PRESSURE AND PULSE RATE

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The author wishes to express his appreciation to Dr. Carey, Dr. Ferguson, Dr. Lowell, and Jim Brown, Head Gymnastic Coach at Palatine, Illinois, for their help and instruction. Without their patient guidance, this paper would never have been completed.

Robert Ferguson

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CHAPTER I

INTRODUCTION

The author had found that blood pressure changes after gymnastic routines in an undergraduate problem. Throughout the study there was an indication that very little research had been done concerning the effect of gymnastic routines on blood pressure and pulse rate of gymnasts. The author believed that systolic pressure would rise and diastolic pressure would drop following gymnastic routines.

PROCEDURE

Fourteen members of the Palatine, Illinois 1963-64 varsity gymnastics team, fifteen to seventeen years of age, were used as subjects. They competed on the following pieces of apparatus: trampoline, side horse, horizontal bar, parallel bars, still rings and tumbling. The blood pressure of the boys was measured with the aneroid sphygmomanometer. The standing blood pressure of each boy was measured on the left arm with the cuff being placed over the biceps. Each boy had a minimum of six measurements taken to establish a normal standing pressure and pulse rate reading. This was found by determining the mean of the measurements.

A minimum of eight readings were taken under meet conditions and a minimum of four readings were taken under practice conditions. Under meet conditions, a preliminary reading was taken from sixty to ninety minutes before a boy performed his routine. A second reading was taken within one minute after the performer completed his routine. Normal standing blood pressure readings were taken in the afternoon right after school. The boys were told a day ahead of time when their pressure would be taken in an effort to have them watch their activity.

Pulse rate was determined by counting the number of heart beats within a ten-second period of time. Pulse was taken over the radial artery in the wrist immediately after blood pressure measurements. The same procedure was used under practice conditions.

Blood pressure and pulse rate was taken only after the first routine of each performer.

LIMITATIONS

The experiment was performed on a small number of gymnasts within a limited geographical area. Measurements were subject to error on the part of the experimenter, but it was hoped that enough readings were taken on each boy to reduce the margin of error in the blood pressure and pulse rate readings. Pressure readings should have been taken at three

minutes, five minutes, and ten minutes in order to give a more accurate picture, but the time element involved in taking blood pressure readings right after routines eliminated the researcher from taking any readings after one minute. The author also had to fulfill the dual role of coach as well as experimenter. Crowd noise sometimes interfered with the taking of readings right after a boy had finished his routine under meet conditions.

It was not possible to control the activities of the subjects during the period before the researcher measured normal standing blood pressure and pulse rate. The fact that pulse rate was measured after blood pressure would cause it to be lower than immediately after a routine, as pulse rate falls rapidly in the well-conditioned athlete following physical exercise.

CHAPTER II

REVIEW OF LITERATURE

All blood pressure measurements are sufficiently accurate to be of value in scientific studies according to Larson and McCurdy.[1] Many researchers have accepted the opinion of Larson and McCurdy. Much work has been done concerning the effects of exercise on the cardiovascular condition of man. As a result of these studies, there were many conflicting opinions concerning the effects of exercise on blood pressure and pulse rate. When pulse rate was mentioned, it was found to increase after exercise.

Bird's[2] study on varsity gymnasts, measured one-minute after an all-out treadmill run, resulted in a post-exercise increase of standing systolic pressure of 59.49 mm. Hg and a post-exercise decrease in diastolic pressure of 16.26 mm. Hg. After a five minute step test, systolic pressure increased 13.29 mm. Hg and diastolic pressure decreased 8.26 mm. Hg.

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[1] L. A. Larson and J. H. McCurdy, "The Reliability and Objectivity of Blood Pressure Measurements," Supplement to the Research Quarterly, VI (May, 1953), 10.

[2] Patrick Bird, "Comparison of Olympic-Level and Varsity Gymnasts on Physical Fitness Characteristics," (Unpublished Master's Thesis, Department of Physical Education, University of Illinois, 1962), pp. 37, 38, 40.

Bosco[1] ran champion, male gymnasts on a treadmill run to exhaustion (7 M.P.H., 8.6% grade) and discovered that one minute post-exercise systolic readings increased, on the average 72.96 mm. Hg and that diastolic readings decreased 3.63 mm. Hg.

Ferguson,[2] in working with eight untrained track performers found a one minute post-exercise average increase in systolic pressure of 35 mm. Hg and a decrease of 20 mm. Hg in diastolic pressure when comparing the results with standing blood pressure. Four trained high school trackmen showed a post-exercise increase of 46 mm. Hg for systolic pressure and a decrease of 54 mm. Hg for diastolic pressure. Systolic pressure indicated a rise of 36.5 mm. Hg after exercise in eight trained college performers in track. Their diastolic pressure revealed a post-exercise decrease of 42.6 mm. Hg.

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[1] James Bosco, "The Physical and Personality Characteristics of Champion Male Gymnasts," (Unpublished Ph. D Dissertation, Department of Physical Education, University of Illinois, 1962) pp. 63, 74.

[2] Max B. Ferguson, "Blood Pressure Measurements in Trained and Untrained Track Athletes," (Unpublished Material, Eastern Illinois University, 1963).

Subjects measured one to one and one-half minutes after a step test had a considerable rise in systolic pressure and a downward trend in diastolic pressure according to Cogswell.[1] After each step test, diastolic pressure reached its resting level by three minutes post-exercise.

Kilhardt[2] took blood pressure recordings after twelve minutes of water polo within fifteen seconds after a competitor left the pool. The systolic and diastolic blood pressures of thirteen subjects increased above those of twenty controls by an average of 38 mm. Hg and 9.6 mm. Hg, respectively.

Fraser[3] experimented with younger men and women on a treadmill run. Between ten and thirty seconds after exercise they failed to show a secondary rise in systolic pressure but demonstrated a gradual increase in both diastolic and mean pressures. The systolic pressure fell precipitiously and the diastolic pressure changed little in men during the first few seconds after the cessation of exercise.

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[1] Robert Cogswell, "Some Observations of the Effects of Training on Pulse Rate, Blood Pressure and Endurance in Humans Using the Step Test (Harvard), Treadmill, and Electrodynamic Brake Bicycle Ergometer," American Journal of Physiology CXLVI (1942), 422.

[2] W. F. Kilhardt and O. S. Orth "Effect of Water Polo on Blood Pressure and Pulse Rate," Research Quarterly VII (May, 1963) 99-101.

[3] Robert Fraser, "Studies on the Effect of Exercise on Cardiovascular Function," Circulation IX (1954), 193.

Haggard[1] believed that muscular exercise was variable. Moderate exertion such as walking caused the diastolic pressure to diminish without markedly influencing systolic pressure. Severe exertion tended to increase systolic and diastolic pressure.

Stamp[2], in measuring blood pressure after a 220 yard dash, found a rise in systolic pressure of 45 mm. Hg and a drop in diastolic pressure of 30 mm. Hg for Joe Gygon, an American Indian athlete who was in good condition.

Systolic pressure indicated an average rise of 25 mm. Hg and diastolic pressure indicated an average rise of 15 mm. Hg in two men who had just completed a twenty mile run, according to Lowsley.[3] Performers in the 100 yard dash had a rise, on the average, of 45 mm. Hg for systolic pressure and 17 mm. Hg for diastolic pressure after the completion of the race.

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[1]Howard Haggard, Man and His Body (New York: Harper and Brothers, 1938), p. 117.

[2]MacKenzie, R. Tait, Exercise in Education and Medicine (Philadelphia: W. B. Saunders and Company, 1915) p. 52.

[3]O. S. Lowsley, "The Effects of Various Forms of Exercise on Systolic, Diastolic, and Pulse Pressures and Pulse Rates", American Journal of Physiology, XXVII (1910-11), p. 66.

There was always a 50-55 mm. Hg rise in systolic pressure due to exercise in experiments done by Michael and Gallon.[1] There was never a return to normal within five minutes after a step test. Diastolic pressure changes were significant only when taken immediately after exercise.

Stevenson[2] used a test devised by Master and discovered that systolic pressure readings were higher than normal readings after the test in all but two subjects. Diastolic pressure reading dropped 1-5 mm. Hg from normal in five of twelve subjects after the test.

Schneider and Truesdell[3] compared post-exercise blood pressure with standing blood pressure. Immediately after exercise 75% of their 2000 subjects had an increase of 4-36 mm. Hg for systolic pressure, 10% had a fall of 4-20 mm. Hg, and 15% had no change. After two minutes, 28.7% were still above normal, 44.3% were subnormal, and 27% were back to normal. Immediately after exercise, diastolic pressure

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[1] Ernest Michael Jr. and Arthur J. Gallon, "Pulse Wave and Blood Pressure Changes Occurring During a Physical Training Program", Research Quarterly XXXI (March, 1960) pp. 43-57

[2] Ian Stevenson, "Circulatory Dynamics Before and After Exercise in Subjects with and without Structural Heart Disease During Anxiety and Relaxation", Journal of Clinical Investigations, XXVIII (1954) 1534.

[3] Edward Schneider and Dorothy Truesdell, "A Statistical Study of the Pulse Rate and the Arterial Blood Pressures in Recumbency, Standing and after a Standard Exercise" American Journal of Physiology, LXI (1922), 429.

showed a fall of 2-40 mm. Hg in 44.6% of the subjects, a rise of 2-24 mm. Hg in 22.8% of the subjects, and indicated no change in 32.6% of the subjects. After two minutes, 34.1% were still below normal, 31.5% were above normal, and 34.4% were back to normal.

The subjects investigated in a study by Cotton[1] lifted twenty pound dumbbells from the floor to the full stretch of the arms above the head. The number of repetitions depended upon the individual. One minute post-exercise systolic readings showed an average rise of 25 mm. Hg.

In a study of the effect of exercise on blood pressure in undernourished and subsequently well nourished civilians in German prison camps, Glaser[2] discovered both increases and decreases in diastolic pressure during recovery from stair climbing. He concluded that there was no diagnostic value to blood pressure measurements after exercise.

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[1] T. F. Cotton, and Others, "After Effects of Exercise on Pulse Rate and Systolic Blood Pressure in Cases of 'Irritable Heart'" Heart, VI (1922) 270-71.

[2] E. M. Glaser, Response of Blood Pressure to Posture and Exercise, Special Report Number 275 (London: Medical Research Council, 1951), p. 280.

McCourney[1] stated that readings taken after exercise had ceased did not mean very much since blood pressure returned to normal very quickly in some people.

The authors in this review of literature indicated a general agreement as to exercise causing a rise in systolic pressure and pulse rate in post-exercise measurements except for Fraser. There seemed to be a great deal of controversy over post-exercise changes in diastolic pressure.

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[1] Russell DeCourney, The Human Organism (New York: McGraw-Hill Book Co., 1955) p. 282.

CHAPTER III

ANALYSIS OF DATA

When considering the average scores for all of the subjects of this study there was a marked increase in systolic pressure of 22 mm. Hg after meet routines and 15 mm. Hg after practice routines. The diastolic pressure average showed a decrease of 63 mm. Hg after meet routines and a decrease of 38 mm. Hg after practice routines. The pulse rate showed an increase of 59 after meet routines and an increase of 44 after practice routines. Pre-meet measurements showed a rise of 6 mm. Hg, 3 mm. Hg, and 10 respectively over normal readings (Table 1). Pre-practice measurements showed a rise of five, one, and three respectively over normal readings. These rises could be attributed to an increase of adrenalin produced by the adrenal gland because of the emotional state of the individual.[1]

TABLE 1

THE MEAN SCORE OF ALL COMPETITORS

	Normal	Pre-Meet	Post-Meet	Pre-Practice	Post-Practice
Systolic	118	124	146	123	138
Diastolic	76	79	16	77	39
Pulse Rate	87	97	156	90	134

[1] Lawrence Morehouse, and Augustus Miller, Physiology of Exercise (St. Louis: C. V. Mosby and Co., 1963), p. 107.

Systolic pressure measurements taken before practice and meet routines indicated a rise from the normal in seven of the subjects. The same ones did not necessarily show a rise before both routines. It is possible that these subjects may have gotten away from the researcher at times and run through the locker room or taken a short turn on the apparatus and failed to tell the author because they didn't want to miss having their pressure taken.

The systolic pressure of four subjects was considerably higher after a meet routine than after a practice routine. This may have been merely because these subjects loafed through practice routines or because they were emotionally and physically excited before a meet causing an increase of adrenalin in their systems.

In one subject systolic pressure was 18 mm. Hg lower after meet routines than after practice routines. It is interesting to note in the case of this subject that he told the researcher he had been more concerned over his practice routines on the days his blood pressure was measured because he was competing in practice to see if he would compete in the meet. This fact was not true of the others when their practice readings were taken.

Diastolic pressure was found to decrease, on the average, 63 mm. Hg after meet routines and 38 mm. Hg after

practice routines in all subjects but two. One of these subjects had a small decrease of 3 mm. Hg after a practice routine, and the other subjects maintained the same diastolic pressure under all conditions.

Bird[1] concluded, in his paper, that gymnasts are only average in cardiovascular testing. According to Cureton,[2] better endurance goes with low diastolic pressure which in turn would denote that capillaries and arterioles are relatively open and more blood goes through. This would mean that a rise in body temperature accompanied by vasodilation of blood vessels located in the skin to provide for heat loss[3] would not necessarily have a great effect on distance runners in lowering their pressure. The vessels might even constrict slightly after running because of less need for blood. This may account for the rise in diastolic pressure for distance men in Lemley's study. At the same time, this line of reasoning may also have been one reason why the gymnast's in this study have lower diastolic pressure after exercise. Their capillaries and arterioles would be small allowing for considerable vasodilation because of heat loss right after their routine if their cardiovascular condition

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[1] Bird, 23.

[2] T. K. Cureton, Physical Fitness of Champion Athletes (Urbana: University of Illinois Press, 1951) p. 269.

[3] DeCoursey, 282.

was below average, there seems to be no common demoninator that would indicate why one subject's blood pressure remained the same under the conditions presented in this study other than the fact that the subject's blood pressure returned to normal faster than the other subject's readings.

A noticably lower drop in diastolic pressure after meet routines than after practice routines on the average of 25 mm.Hg. in eight of the performers might have been the result of harder work causing greater heat loss, or it might have been caused by an increase in muscle tension and emotional preparation before meets.

There was a considerable rise in pulse rate after both meet and practice routines (Table 4). Before meet routines, pulse rate was noticably higher than normal in every subject but four. The subjects were carefully monitored before meets until their blood pressure and pulse rate were taken. An increase in muscle tension and emotional preparation might have been the reason, since increased activity on the part of the performers can be ruled out. The fact that the average pulse rate was twenty-two counts higher after a meet routine than after a practice routine may be accounted for with the possibility that the subjects may have increased the length of the routine by one or two moves or they may have

experienced an increase in adrenalin in their system.

The following tables represent the mean scores of each competitor. The results on the graphs were determined by finding the mean of the measurement taken. A noticable change from the normal averages was picked at random to be nine degrees.

TABLE 2

AVERAGE SYSTOLIC PRESSURE READINGS
OF EACH COMPETITOR

Competitor	Normal	Pre-meet	Post-meet	Pre-Practice	Post Practice
1	109	116	136	115	142
2	110	107	145	110	134
3	133	145	173	136	149
4	112	129	144	128	141
5	137	132	163	135	167
6	114	119	111	115	103
7	123	124	126	126	126
8	118	121	167	122	131
9	129	140	170	140	166
10	115	121	152	127	122
11	116	112	149	120	143
12	107	103	116	105	134
13	116	131	141	121	133
14	114	132	152	128	147

TABLE 3

AVERAGE DIASTOLIC PRESSURE READINGS
OF EACH COMPETITOR

Competitor	Normal	Pre-meet	Post-meet	Pre-practice	Post-practice
1	75	74	-*	74	27
2	78	80	27	77	74
3	81	85	—	87	72
4	78	78	—	77	63
5	75	78	—	75	—
6	73	79	47	79	39
7	75	82	—	80	32
8	68	87	—	67	—
9	75	76	—	75	—
10	71	72	—	70	45
11	73	78	21	73	43
12	80	79	—	75	—
13	75	80	48	80	67
14	83	84	84	83	83

*Denotes a pressure reading of 0 on the Aneroid Syphgmomanometer.

TABLE 4

AVERAGE PULSE RATE READINGS
OF EACH COMPETITOR

Competitor	Normal	Pre-Meet	Post-Meet	Pre-Practice	Post-Practice
1	75	95	150	96	140
2	87	98	164	86	133
3	93	92	153	96	114
4	71	75	122	75	98
5	81	90	159	82	130
6	87	105	164	78	140
7	92	121	146	105	150
8	92	107	152	98	148
9	93	96	167	94	144
10	78	90	142	82	122
11	76	86	176	77	144
12	97	107	157	104	146
13	91	94	167	92	137
14	82	104	160	90	130

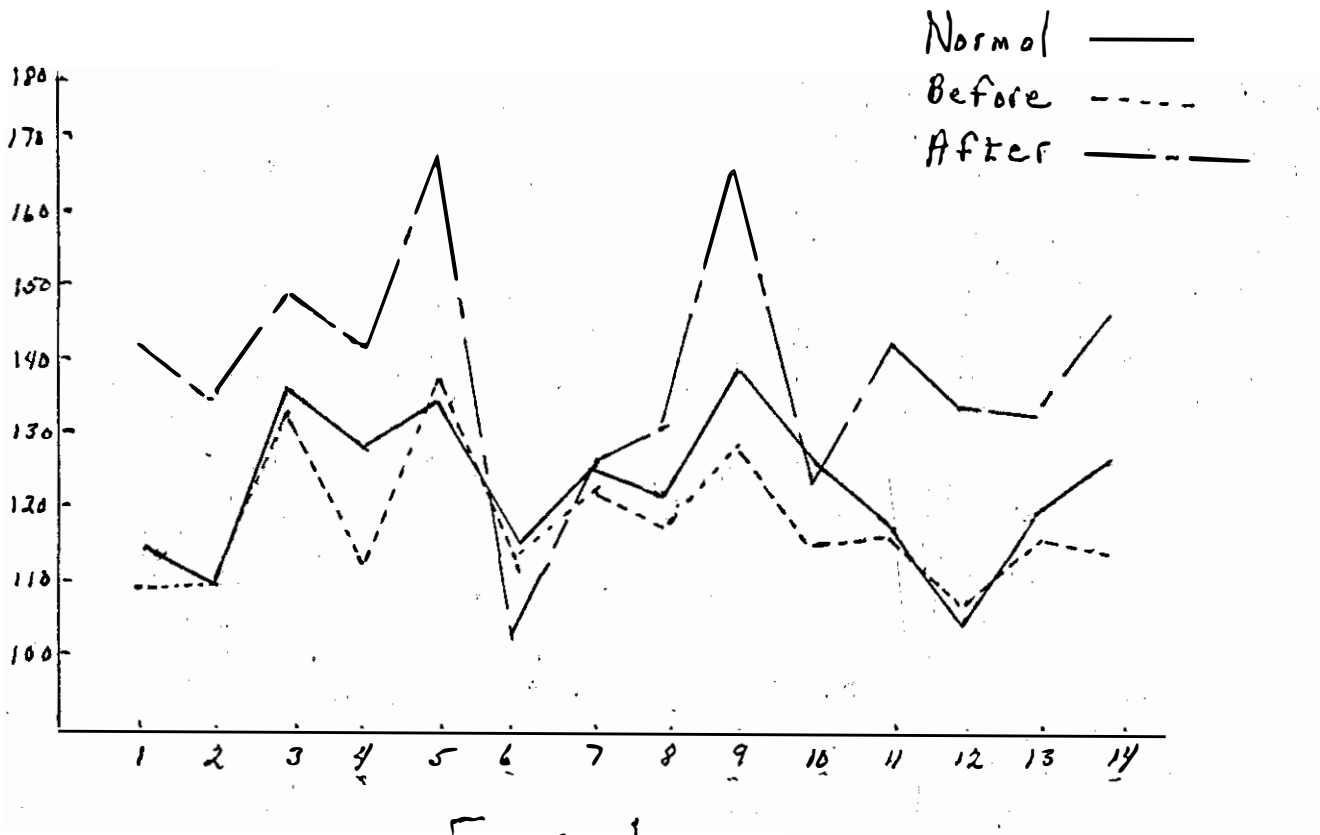

Figure 1.
Systolic Pressure Under
Practice Conditions

Before practice routines, systolic pressure did not vary noticably from normal except for 4, 6, 9, 10, 14.

After practice routines, systolic pressure increased noticeably from the normal except for 6, 7, 10.

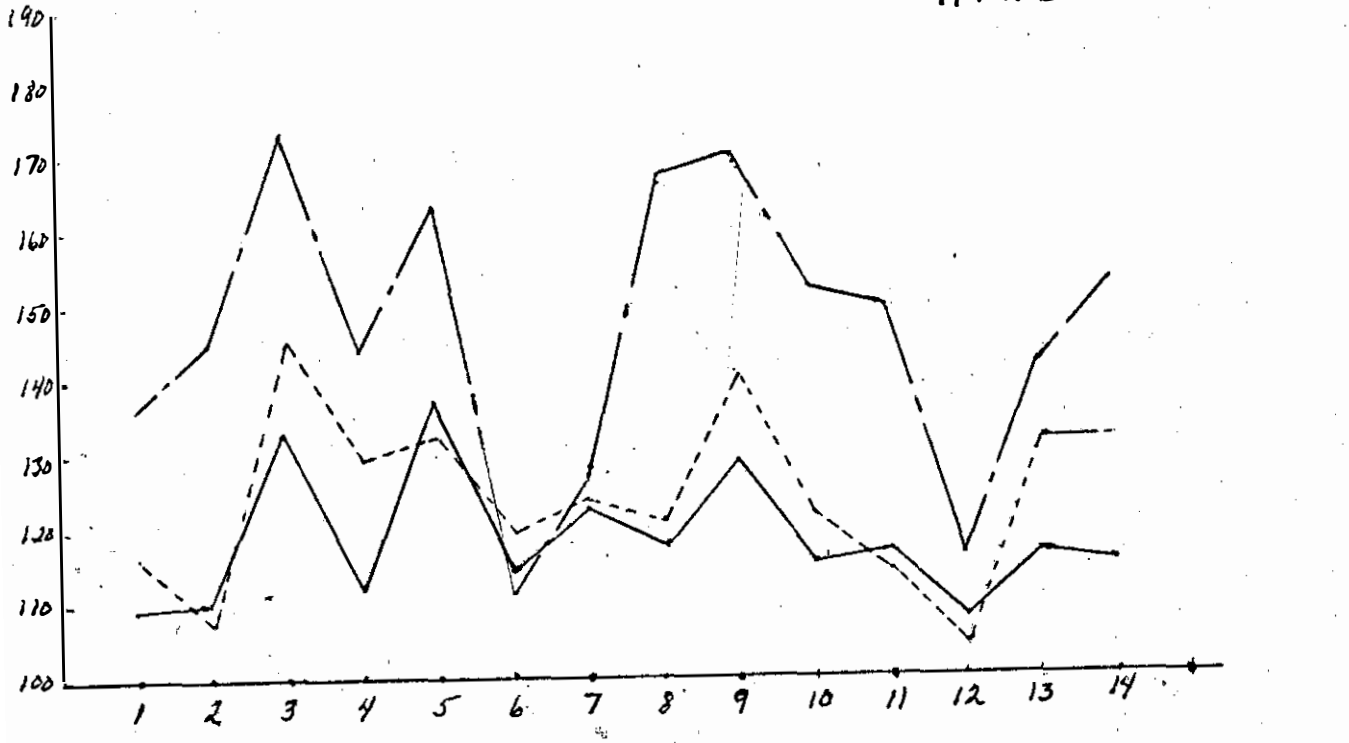

Figure 2.
Systolic Pressure Under
Meet Conditions

Before meet routines, systolic pressure did not vary noticeably from normal except from 3,4, 9, 13, 14.

After meet routines, systolic pressure increased noticeably from the normal in every subject but 6 and 7.

The systolic pressure of twelve was noticeably lower after a meet routine than after a practice routine.

The systolic pressure of 2, 3, 8, and 10 was noticeably higher after a meet routine than after a practice routine.

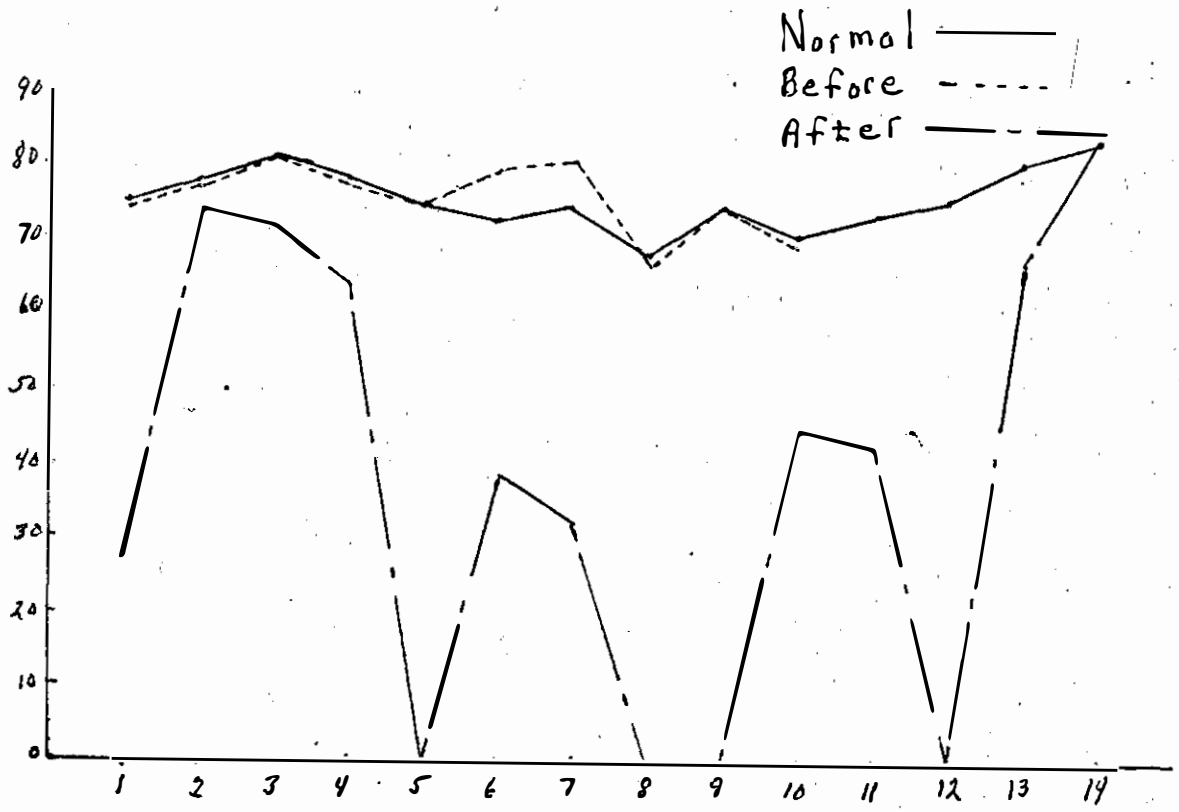

Figure 3.
Diastolic Pressure Under
Practice Conditions

Before practice routines, diastolic pressure changes were not noticeable in any of the performers when compared with normal average.

After practice routines, there was a noticeable decrease in diastolic pressure in every subject but 2 and 14.

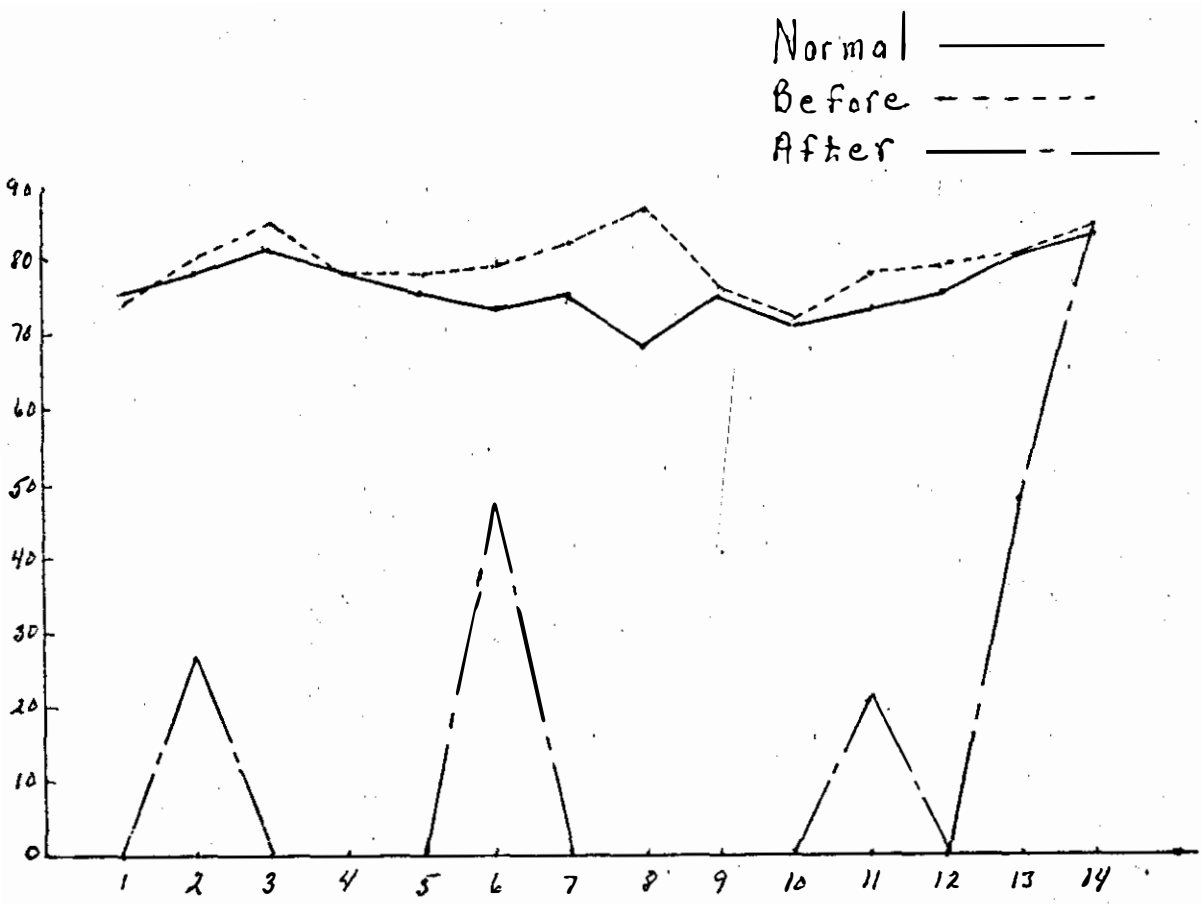

Figure 4.
Diastolic Pressure Under
Meet Conditions

Before meet routines, diastolic pressure changes were not noticeable in any of the performers except 8 when compared with normal.

After meet routines, there was a noticeable decrease from normal in every diastolic reading except 14.

There was a more noticeable drop in diastolic readings after a meet routine than after a practice routine in all subjects but 6. Also, 5, 8, 9, and 12 maintained zero readings after both routines.

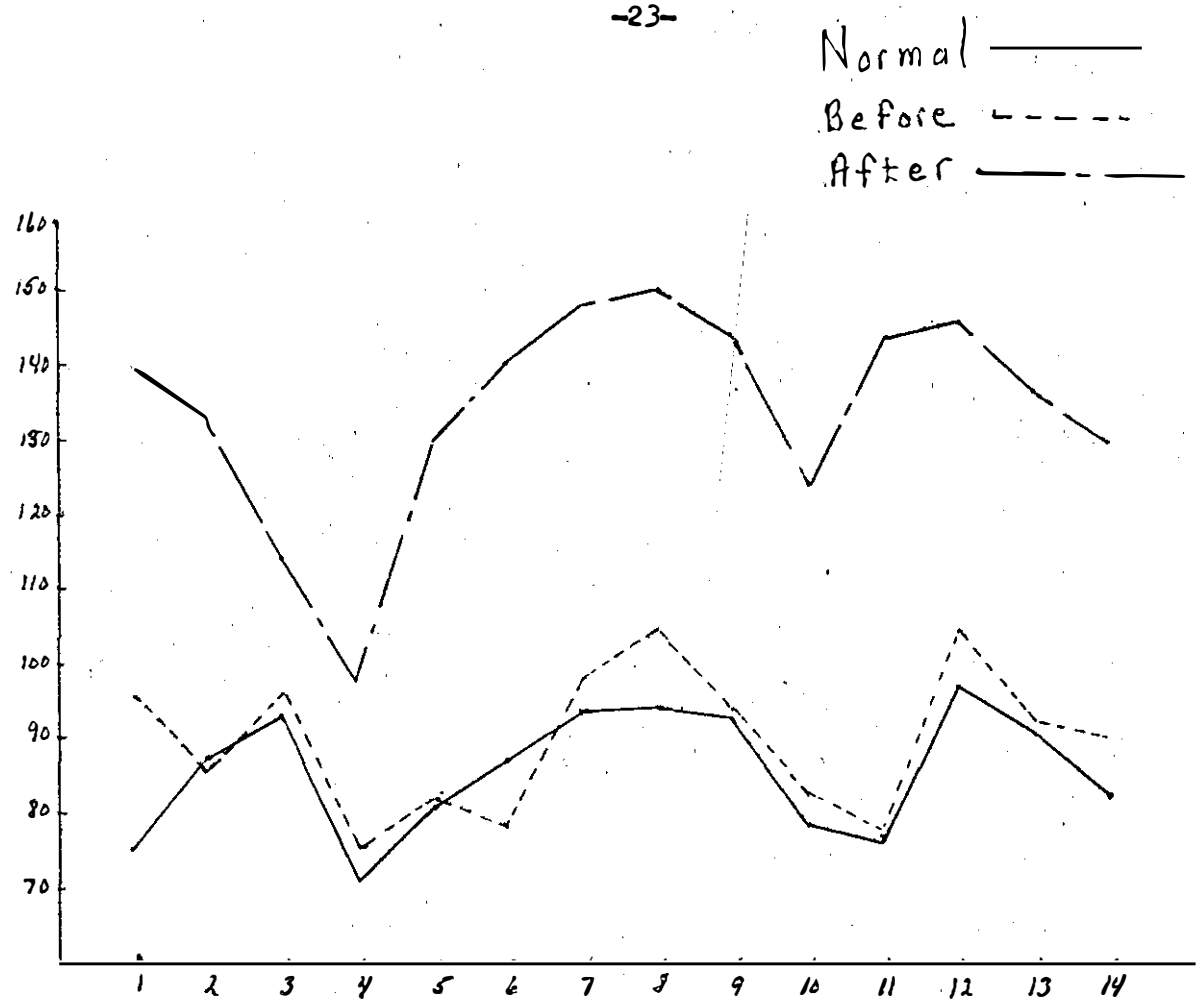

Figure 5.
Pulse Rate Under
Practice Conditions

Before practice routines, pulse rate changes from normal were not noticeable except for 1 and 8.

After practice routines, pulse rate increased noticeably from normal in every subject.

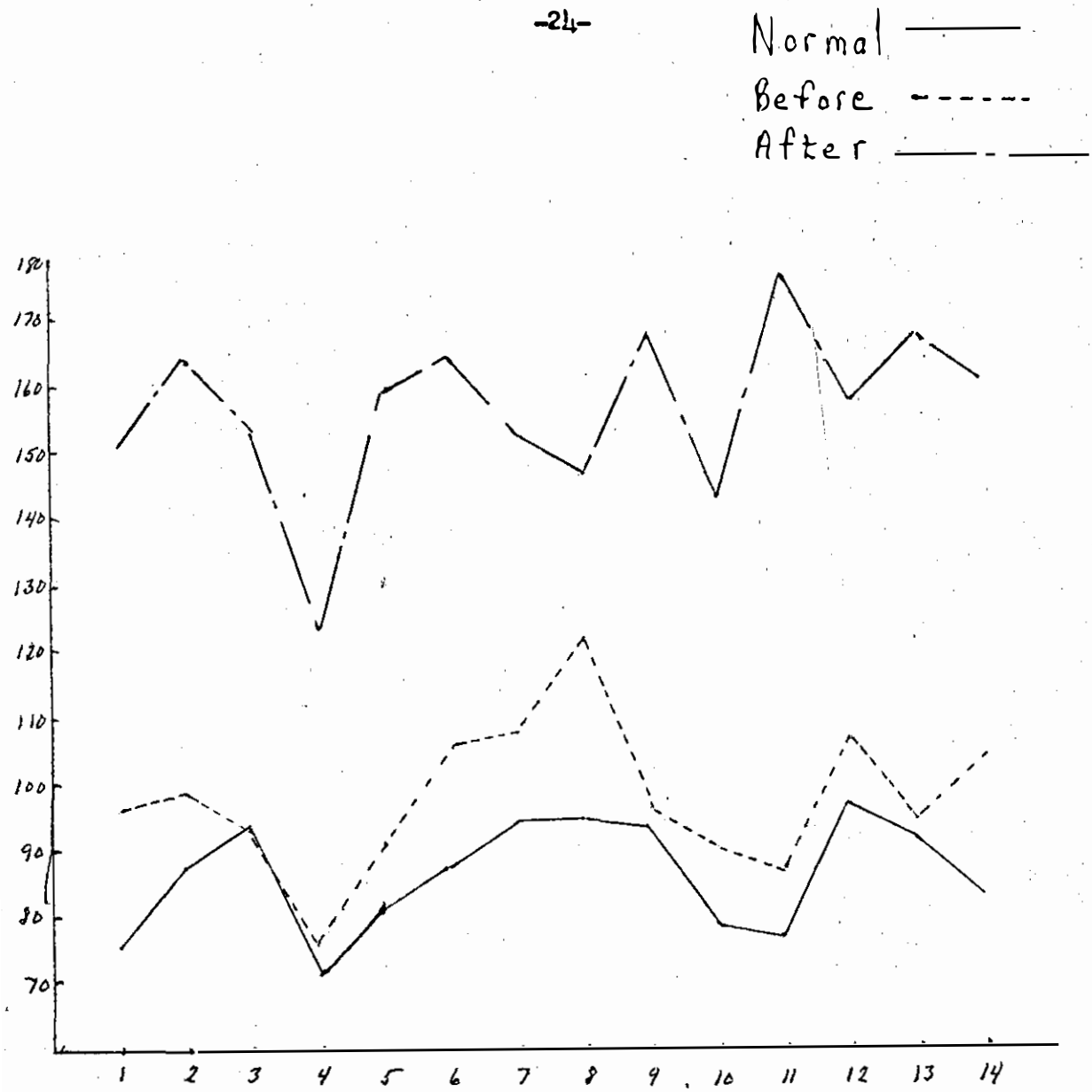

Figure 6.
Pulse Rate Under
Meet Conditions

Before meet routines, there was a noticeable increase in the pulse rate over normal in every subject but 3, 4, 9, and 13.

After meet routines, there was a noticeable increase over normal in the pulse rate of every subject.

The average pulse rate was twenty counts higher after a meet routine than after a practice routine.

The majority of the subjects in this study showed a rise in systolic pressure after exercise. Their diastolic pressure showed a decline after exercise. The author's views, in the review of literature, were in disagreement as to what diastolic pressure change would take place after exercise but they agreed that systolic pressure and pulse rate increased after exercise.

CHAPTER IV

SUMMARY AND RECOMMENDATIONS

The effect of gymnastic routines on blood pressure and pulse rate was determined by taking a series of eighteen blood pressure and pulse rate measurements on fourteen high school varsity gymnasts. Six measurements were taken to determine normal standing blood pressure readings, four were taken both before and after meet routines, and two were taken before and after practice routines. The mean of all blood pressure and pulse rate readings was computed for the purpose of this study. There was a rise in systolic pressure of 22 mm. Hg after meet routines and 15 mm. Hg after practice routines. Diastolic pressure showed a decrease of 63 mm. Hg after meet routines and 38 mm. Hg after practice routines. The pulse rate showed an increase of 59 after meet routines and 44 after practice routines.

Further studies of this nature should be completed on one piece of apparatus at a time with one performer so that a series of measurements could be made at different time intervals following a routine. In this manner the effect of each piece of apparatus on blood pressure and pulse rate might be more clearly understood.

If possible a more accurate measuring device should be used. It should be one that could be realiably used immediately

after the finish of a routine.

A study could be made to determine if better cardiovascular fitness would result in better gymnastic performances. Female gymnasts could be measured after apparatus use to determine if there were any changes in blood pressure and pulse rate readings due to sex differences.

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