A COMPARISON OF THE ELECTROCARDIOGRAMS OF CONDITIONED AND NON-CONDITIONED MIDDLE AGED MEN

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A COMPARISON OF THE ELECTROCARDIOGRAMS OF CONDITIONED AND NON-CONDITIONED MIDDLE AGED MEN

by

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C.G.

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

It has long been a common belief that exercise and conditioning have a positive effect on cardiovascular functioning in athletics. Many studies have been made to support this belief.[1] These studies have measured cardiovascular function by pulse rate, blood pressure, and most recently by the electrocardiograph. The preponderance of evidence has pointed to a positive relationship between exercise and improved cardiovascular function.

I. THE PROBLEM

Statement of the Problem

The principle question to be answered in this study was, do conditioned and non-conditioned middle aged men differ in certain electrocardiographic measurements which have been found to be different in athletes and non-athletes. Secondly, can these differences be shown to exist when the effects of body build are considered. The frontal and horizontal vectors were computed to analyze this second problem.

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[1] T. K. Cureton, The Physical Fitness of Championship Athletes (Urbana: The University of Illinois Press, 1951).

Need for the Study

Due to the relative newness of the field of vectorcardiography little work has been done using this technique by researchers in Physical Education. In the field of medicine, this technique is being used along with or it is replacing the older methods of electrocardiography.[2] Experts concur that spatial vector analysis gives a truer picture of heart location and fitness than does the conventional electrocardiograph.[3,4,5] Studies in vector analysis can probably add to evidence gathered by other methods.

This study also uses "matched pairs" of conditioned and non-conditioned middle aged men so as to eliminate the effects of age, weight, height, and chest configuration on the determination of the QRS and T vectors in the

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[2] Robert Grant and E. H. Estes, Spatial Vector Electrocardiography (Philadelphia: The Blaikson Co., 1951).

[3] E. Simonson, "The ECG Exercise Test: Effect of relative and absolute body weight and comment on normal standards," American Heart Journal, July 1956, pp. 83-105.

[4] Richard Howard and Menard Gertler, "Axis Deviation and Body Build," American Heart Journal, Vol. 44:1 (July 1952), 35-41.

[5] D. L. Urschell and D. C. Abbey, "Mean Spatial Vectorcardiography," American Heart Journal, Vol. 46 (October 1953), 496-506.

subjects.[6,7,8] These effects may have been the cause of the difference in the data obtained from athletes and non-athletes as the angle of the electrical axis of the heart determines to a great extent, the amplitude of ECG waves.

Limitations of the Study

The basis of selection of "conditioned middle aged man" is not absolute as only minimum standards could be asked for and these standards can not be precisely measured.

The number of subjects tested limits the interpretation of statistical results obtained from this study.

There is a limitation in reliability of spatial vector measurements due to electrical wave distortion by internal or external chest configuration.

It has remained a problem to show that the deviations found in athletes are due to the results of training or whether certain pathological implications should be inferred.[9] This limitation is present in this problem as no clinical evaluation of the data was made. An X-Ray analysis to determine the anatomical position of the heart would have been valuable in the measurement of axis deviations in this study.

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[6] E. Simonson, loc. cit.

[7] Richard Howard and Menard Gertler, loc.cit.

[8] D. L. Urschell and D. C. Abbey, loc..cit.

[9] T. K. Cureton, loc.cit.

II. DEFINITIONS OF TERMS USED

Definitions

The standardization committee of the American Heart Association has prepared definitions of terms related to electrocardiography.[10] The following terms, dealing with the electrocardiograph are used throughout the world. Also included are terms which are significant to this study.

Electrocardiogram. A time record of electrical events in the heart, from which information concerning the locus of origin of each beat and the spread of activity can be obtained.[11] (Standard record in Appendix p. 35.)

PR interval. The PR interval represents the time required for depolarization to reach the ventricle from the time of its origination in the sino auricular node.

QRS duration. This represents the time interval for the depolarization wave to travel through the ventricles.

QT interval. The period from the beginning of depolarization to the end of repolarization of the ventricle is known as the QT interval.

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[10] Louise H. Katz, Electrocardiography (Philadelphia: Lea and Febiger, 1949), p. 80.

[11] R. Grant and E. H. Estes, op. cit., p. 3.

P wave. The P wave is produced by the spread of excitation over the auricles.

R wave. The R wave occurs during the beginning of electrification of the main mass of walls of the ventricles.

S.wave. The electrification of the rest of the ventricular muscle.

T wave. The T wave represents repolarization of the sinus node and the action currents of the heart muscle.

Lead I. Standard lead taken from the left to the right arm.

Lead II. Standard lead taken from the right arm and the left leg.

Lead III. Standard lead taken from the left arm and the left leg.

Precordial leads. The precordial or chest leads are six in number and are located as prescribed by the American Heart Association.[12]

Mean Spatial QRS and T Vectors. The electrical forces produced in the QRS and T processes are directed from the

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[12] The Standardization of ECG Nomenclature. The report on standardization of precordial leads, Second Supplementary Report. Official reports of the American Heart Association, 1790 Broadway, New York.

endocardium to the epicardium at each region of the heart.[13] The QRS or T force for a given region of the ventricular heart can be represented by a vector which is directed perpendicularly to the surface of the heart in that position.

> A vector is any quantity such as a force which has a known magnitude of direction. The mathematical symbol for the vector is an arrow; the length of the arrow indicates magnitude, its inclination represents the direction of the force and the caret or arrowhead indicates the sense of the force.[14]

Conditioned and non-conditioned men. The basis of selection of conditioned middle aged men was their participation in an exercise program for at least three hours per week for three months prior to the testing. The non-conditioned men did not participate in exercise in any measurable degree.

Matched pairs. Each conditioned subject was matched with a non-conditioned subject for the factors of age and a chest width and sitting height ratio. The chest width and sitting height ratio was computed by dividing the sitting height (cm) by the chest width (cm).

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[13] R. Grant and E. H. Estes, op. cit., p. 5.

[14] Ibid.

CHAPTER II

REVIEW OF THE LITERATURE

Much has been written in regard to the differences in electrocardiograms of the athlete and the non-athlete. An excellent review is presented by Cureton in *The Physical Fitness of Championship Athletes*.[1] Referring to this review of literature, Kraus and Nicolai (1910)[2] are reported to have found in the electrocardiograms of trained athletes a higher T wave in Leads I, II, and III. No other differences were noted. Messerlee (1928)[3] reported that training not only caused the T wave to become higher, but lowered the QRS peaks, greatly increased the duration of the QRS, and slowed the pulse rate, all attributed to vagal influence. Von Csinday (1930)[4] made a similar observation about the prolonged PQR interval in a large number of athletes.

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[1] T. K. Cureton and Associates, *The Physical Fitness of Championship Athletes* (Urbana: The University of Illinois Press, 1951), pp. 140-147.

[2] S. Kraus and G. Nicolai, *Das Electrokardiogramm des Gesunden und Kranken Menschen* (Leipzig: 1910).

[3] N. Messerlee, "Die veranderungen im Elektrokardiogramm bei Korperarbeit," *Ztschr, f. d. ges. Exp. Med.*, Vol. 60 (1928), p. 490.

[4] E. Von Csinday, "Sportsartlischen Untlerschungen, III meitlung," *Arbeitsphysiologie*, Vol. 3 (Oct.1950), 379-95.

An outstanding study by Hogerwerf (1929)[5] was conducted at the Olympic Games of 1928, in which 260 athletes were used as subjects. Results of the tests showed that the athletes had higher T waves than the normal individual, their S wave was eliminated and the R-SE segment was raised.

Broustell and Eggenberger (1936)[6] examined thirty-five men who had competed in boxing and rowing. They concluded that the ECG of the athletes show a fine regular tracing, without claiming that the R and T waves were affected by the vigor of the heart. They did, however, believe that there was a relation between the form of the tracing and the anatomical and functional state of the heart.

Reindell (1937)[7] in his study of sportsmen found that in addition to a marked lengthening of the PQR interval the length of systole varied with the ability to perform in certain sports. McFarland, Gaybiel, Leidercrantz, and

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[5] S. Hogerwerf, "Ergebnisse de sportsartlischen Untersuchungen bei den IX Olimpischen Spilene," Arbetsphysiologie, Vol. 2 (929), 118-138.

[6] P.Broustell and H. Eggenberger, "L'electrocardiogramme des Sportifs," Journal de Medicine de Bordeaux de Sud-Oust, Vol. 113 (1936), 126-127.

[7] H. Reindell, "Kymographische und Elektrokardiographische Befunde Am Sportherzen," Duetsches Archiv Für Klinische Medezin, Vol. 131 (1937), 484-517.

Tuttle (1938-1939)[8] discovered in their study of 173 civil airline pilots that:

1. Usually long PR intervals were found in three subjects.
2. Low QRS voltage appeared in cases of exceptionally healthy young men.
3. Elevation of the diaphragm may cause axis deviation.

McPhee and Wells[9] point out that the low pulse rate of athletes are due to strong vagus tone. They say that changes in the QT should not be ascribed to age or exercise, which are dut to changes in cycle length. However, the author does feel that any real improvement in the heart would show in fundamental changes in characteristics of the ECG not dependent on pulse rate.

Cureton[10] gives the results of ECG tests done at the physical fitness laboratory at the University of Illinois on the comparison of amplitudes and intervals of athletes and non-athletes. Higher T waves, lower P waves, and longer QRS intervals were found among the athletes in these studies.

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[8] R. A. McFarland, A. Graybiel, Eric Leidercrantz, and A. D. Tuttle, "An analysis of the psychological and physiological characteristics of Two Hundred Airline pilots," Jr. of Aviation Medicine, 9-10:160-210 (1938-1939).

[9] H. R. McPhee and P. V. Wells, "Spurious Fitness by the endurance test," Lancet, 65:226 (June 1945).

[10] T. K. Cureton and Associates, op. cit.,pp. 140-147.

From a study of Marathron Runners and Skiers done in Italy by Bucuresti,[11] the following results were obtained: decreased P wave, elevation of the ST, and slight axis deviation to the right in resting athletes. Increased QRS, larger P, and sharper T wave after exercise. This is explained as a correcting system due to training.

In another study Venerando and Boldrini[12] find trained athletes had less of a QT shortening than normal individuals and that the athlete had a lower K constant which always remained in normal range. Study of the ventricular gradient showed a diminuation after effort and a displacement to the right.

Doliopulus and Bagou[13] in a report on unipolar ECG in athletes show an above average T wave for the twenty-four athletes tested.

Literature on Vectorcardiography

Vectorcardiography is not a recent innovation in the field of electrocardiographic interpretation. When

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[11] Bucuresti, "Obseruatii asupra alegatorilor de Maraton si Sicori," Rev. Stiint. Med. Intern., Vol. 9 (1955), 493.

[12] A. Venerando and R. Boldrini, "Comportamento dell intervallo Q-Tcdel gradiente ventricolare negli athleti," Studi Medi Chir Sport, Vol. 8/4 (1954), 151-60.

[13] Doliopolus and Bagou, Cardiologia (Basel), 23:2, pp. 169-76.

Einthoven[14] developed the three standard leads he had the idea of using the frontal plane vectors as measurements of heart axis and as possible determination of deviation from normal heart position. Since that time the vector theory has been used by many authors to explain the theory of the electrocardiogram. It has only been recently that methods of determining spatial vectors have been discovered and their clinical significance is being determined.

Advantages of spatial vector electrocardiography are clearly set forth in books by Grant and Estes[15] and by Hurst and Woodson.[16] This type of interpretation has gained world wide acceptance as is evidenced from the recent medical literature in foreign periodicals.

In recent literature we find many researchers delving into problems which can seriously influence our research studies on the electrocardiograms of athletes and non-athletes. These studies are done on the results of exercise and conditioning, and they show the offset of the factors of chest configuration, age, weight, and height on the electrocardiograph. This may possibly show that some of the

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[14] W. Einthoven, G. Fahr, and A. DeWaart, "Uber de reichtung und die manifeste grosse der potential schwankungon im meneschelen Herzen und uber der einfluss der Herzlage auf der formdes Elektrokardiogramms," Arch, f.d. ges Physiol, 150:308 (1913).

[15] R. Grant and E. H. Estes, op. cit.

[16] J. W. Hurst and G. C. Woodson, Atlas of Spatial Vector Electrocardiograph (New York: The Blaikston Co.,1952).

differences found between the ECG's of athletes and non-athletes or conditioned and non-conditioned men to be due to body size and chest configuration rather than to conditioning.

Simonson[17] reports in his study of "Effect of Moderate Exercise on the ECG of Healthy Young and Middle Aged Men" that the most important functional differences between the groups are greater ST depression and a right axis shift of the T wave after exercise in older men, which are interpreted as relative signs of coronary insufficiency of the left ventricle. He discusses the significance of the results for physical fitness of older men and for ECG exercise tests.

In a study of "Axis Deviation and Body Build," Howard and Gertler[18] report that:

1. Coefficients of correlation between measureable variations of physique and axis deviations have been established.

2. In the subjects studied, axis deviation is influenced more by horizontal configuration than by lineraiity. There is an association between the degree of compactness of the individual and the tendency to left axis deviation. In

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[17] E. Simonson, "Effect of Moderate Exercise on the ECG in Healthy Young and Middle Aged Men," <u>Jour. of Appl. Physiology</u>, 5:10 (April, 1953), 584-88.

[18] R. Howard and M. M. Gertler, "Axis Deviation and Body Build," <u>American Heart Journal</u>, 44:1 (July 1952), 35-41.

the absence of endomorphy, there is an association between the tendency to right axis deviation and the degree of ectomorphy.

3. Sheldon's index of body types offers a satisfactory measurement for correlating axis deviation and structural variations.

In a study of "Mean Spatial Vectorcardiography,"[19] the influence of age, sex, body build, and chest configuration on the QRS vector in the normal individual was explored by Urschell and Abbey. The following conclusions ensued:

1. When considered by decades of age, there was a perfect mathematical progression from a relatively vertical heart in early years to a relatively horizontal one in later years.

2. This appears to be due to two main factors, the relative increase in the mass of the left ventricle and the increasing life of the diaphragm.

3. Correlation of QRS vector direction and body build was not statistically significant. The tall and thin individual usually had a vertical heart and the obese individual a horizontal one.

4. Internal configuration of the chest correlates well with QRS direction: the position of the left diaphragm being of special importance.

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[19] D.L. Urschell and D. C. Abbey, "Mean Spatial Vectorcardiography," <u>American Heart Journal</u>, 43:3 (Oct.1953),496-506.

5. A height-width radio of the chest (devised by the authors) appears to have adequate validity as an index of chest configuration.

Significant results were found by Simonson and Keyes[20] in an "ECG Exercise Text." Changes in the Scaler ECG and the mean spatial QRS and T vectors in two types of exercise were studied. The importance of relative body weight is pointed out and some normal standards are given.

Summary

Studies done on the comparisons of the ECG's of athletes have shown, higher T waves and lower QRS and P waves among athletes. A slower pulse rate was found among athletes which in turn influences the length of the PR, QRS, and QT intervals all of which have been found longer in the athlete. Right axis deviation has been found in resting athletes.

The computation of vectors to determine electrical axis of the heart has done much to improve ECG interpretation. Age, body build, and chest configuration have all been shown to affect vector angle. A vector analysis of ECG's is useful as the vector angle is a prime factor in the amplitude of both QRS and T waves.

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[20] E. Simonson and A. Keyes, "The ECG Exercise Test," American Heart Journal, 51:1 (July 1956), 83-105.

CHAPTER III

METHODS OF PROCEDURE

Source of Data

The conditioned middle aged men were chosen from the Faculty Physical Education class at Michigan State University and from a group of businessmen who received their conditioning at the Lansing Y.M.C.A. These subjects were selected to meet the standards listed in the definitions. The non-conditioned middle aged group were selected from the Michigan State University Men's Club and were all staff members of Michigan State University.

Method of Testing

Each individual was asked to walk slowly or to ride in an automobile when reporting for his examination. He was also asked to refrain from smoking, eating, or drinking alcoholic beverages two hours prior to the examination. Upon arrival the examinee was asked to lie quietly on a cot for a period of twenty minutes. The ECG was then taken using the three standard leads and the six pre-cordial leads. This procedure was repeated again for each subject within four weeks and the second set of results were used in the comparison.

Measurement of Records

Dividers were used for the measurement of amplitudes and time intervals. Time measurements are recorded in hundredths of a second and amplitude measurements in millimeters. Three typical cycles were measured and their average for each item tested was recorded. A cycle was measured from T wave to T wave.

Horizontal vector determination was made according to Langner.[1]

Frontal vector angle and length were determined according to Jackson and Winsor.[2]

The instrument used to record the electrocardiogram was the Sanborn Model 60-200. It is a two channel recorder, each channel being a single push pull type stage which increases sensitivity of the system to a stylus deflection of one centimeter per millivolt input. Separate lead selector switches for each channel provide a choice of ten lead derivations. Power for the preamplifier is taken from a Sanborn power supply Model 60-1000.

Statistical Analysis

An analysis was done on both groups to determine if there was any significant difference between them. Correlation

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[1] P. H. Langner, "A Geometric Model for Determining the Direction of Mean Spatial Vectors," American Heart Journal, 44:3 (Sept. 1952), 378-82.

[2] Charles E. Jackson and Travis Winsor, "Aids for Determining Magnitude and Direction of Electric Axes of the ECG," Circulation, Vol. 1, No. 4 (April 1950), Part II.

coefficients were then computed for the body build ratio and ECG measurements. The groups were then matched by the body build ratio and analyzed for any significant difference in the matched pairs. Correlation coefficients were computed for age and the ECG measurements. The groups were then matched by their ages and were analyzed for any significant difference in the matched pairs. All analyses done on differences were computed using the "t" test.

Reliability coefficients were computed for ECG measurements using the first and second record of twenty subjects. "T" tests were run on these results to determine if the differences found were significant.

CHAPTER IV

RESULTS AND ANALYSIS

Results

The following tables are the results of the statistical analysis of the data of the conditioned and non-conditioned groups.

TABLE I

STATISTICAL ANALYSIS OF THE DIFFERENCES BETWEEN UNMATCHED GROUPS

Measurement	Conditioned Subjects Mean	Non-Conditioned Subjects Mean	Student "t"
Age	43.29	45.76	1.5080
Sitting Height	91.70	91.16	.0004
Chest Width	33.36	32.93	.8000
Weight	176.75	179.96	.6700
Heart Rate	67.21	74.50	2.9400**
PR Interval	4.41	4.33	.0300
QRS Interval	2.41	2.46	1.1340
QT Interval	9.34	8.76	.3450
QRS Amplitude-- Lead I	4.39	4.95	.0700
QRS Amplitude-- Lead II	5.78	3.06	2.8120**
T Amplitude-- Lead I	1.94	2.61	.2596
T Amplitude Lead III	.63	1.06	.2847
Ratio (sitting ht.-chest width)	2.850	2.780	.4635

**Significant at a probability of 0.01.

TABLE II

PEARSON PRODUCT MOMENT CORRELATIONS BETWEEN SITTING HT.-CHEST WIDTH RATIO AND THE ELECTROCARDIOGRAPH MEASUREMENT

ECG Measurement	r*
QRS Amplitude Lead I	.267
QRS Amplitude Lead III	-.158
T Amplitude Lead I	.043
T Amplitude Lead III	-.190
QRS Vector Degrees	.068
QRS Vector Amplitude	-.037
T Vector Degrees	.096
T Vector Amplitude	.103

*None of the r's were statistically significant.

TABLE III

STATISTICAL ANALYSIS OF THE DIFFERENCE BETWEEN MATCHED PAIRS OF SUBJECTS

Measurement	Mean Difference	Student "t"
QRS Amplitude Lead I	.56	.7000
QRS Amplitude Lead III	2.72	2.9890**
T Amplitude Lead I	.67	.2791
T Amplitude Lead III	.43	.1535
QRS Vector Degrees	23.93	2.4111**
QRS Vector Amplitude	1.20	1.1214
T Vector Degrees	1.91	.2663
T Vector Amplitude	.56	.2240

**Significant at a probability of 0.01.

TABLE IV

STATISTICAL ANALYSIS OF THE DIFFERENCES BETWEEN MATCHED PAIRS OF SUBJECTS IN FRONTAL AND HORIZONTAL ELECTROCARDIOGRAPH VECTORS

Measurement	Conditioned Subjects Mean	Non-Conditioned Subjects Mean	Student "t"
Frontal QRS Vector Degrees	61.03	37.11	2.6518**
Frontal QRS Vector Amplitude	10.05	8.85	1.4258
Frontal T Vector Degrees	35.39	33.48	.1989
Frontal T Vector Amplitude	3.13	3.69	.7810
Horizontal QRS Vector Degrees	27.21	24.21	1.0598
Horizontal QRS Vector Amplitude	32.39	29.96	.9274

**Significant at a probability of 0.01.

TABLE V

PEARSON PRODUCT MOMENT CORRELATION OF ELECTROCARDIOGRAPH MEASUREMENTS WITH AGE

Measurement	r
QRS Amplitude Lead I	.17
QRS Amplitude Lead III	.24**
T Amplitude Lead I	-.27**
T Amplitude Lead III	-.55**
QRS Vector Degrees	.56**
QRS Vector Amplitude	.38**
T Vector Degrees	.55**
T Vector Amplitude	.55**

**Significant at a probability of 0.01.

TABLE VI

STATISTICAL ANALYSIS OF THE DIFFERENCE BETWEEN PAIRS MATCHED BY AGE

Measurement	Mean Difference	Student "t"
QRS Amplitude Lead I	.56	.8250
QRS Ampltitude Lead III	2.72	2.3652**
T Amplitude Lead I	.67	.2310
T Amplitude Lead III	.43	.1442
QRS Vector Degrees	23.92	2.5020**
QRS Vector Degrees	1.20	1.2121
T Vector Degrees	1.92	.2640
T Vector Amplitude	.56	.1766

**Significant at a probability of 0.01.

TABLE VII

STATISTICAL ANALYSIS OF THE DIFFERENCES IN THE FIRST AND SECOND RECORDS OF TWENTY SUBJECTS

Measurement	First Record Mean	Second Record Mean	Student "t"	Coefficient of Relibility
PR Interval	.385	.388	.33	.87**
QRS Interval	1.98	1.93	1.25	.99**
QT Interval	9.85	9.87	1.00	.99**
T Amplitude--Lead I	2.48	2.55	.12	.99**
T Amplitude--Lead III	1.22	1.21	.18	.99**
QRS Amplitude Lead I	3.79	3.75	.24	.99**
QRS Amplitude Lead III	6.97	6.97	.00	.99**
Heart Rate	70.00	70.50	.24	.96**

*Significant at a probability of 0.01.

Analysis

The statistical analysis has shown that in this study there is a significantly faster heart rate in the non-conditioned group. This factor has been considered a measure of conditioning in the field of athletics and endurance sports. Montoye finds that there is a significant correlation between pulse rate and success in cross-country running.[1] Cureton points out a significantly lower heart rate in well-conditioned champion athletes.[2] It is assumed in the present analysis that the significantly lower heart rate in the conditioned group justifies the labeling of that group as conditioned . As both groups consisted of men with sedentary occupations, the difference seems to indicate that conditioning may be a contributing factor in this difference.

Previous studies done on athletes and non-athletes have found various electrocardiographic measures to be significantly different. Higher T waves, lower P waves, and longer QRS, PR, and QT intervals have been found among athletes. The QRS amplitude in Lead III and the direction of the frontal QRS vedtor were the only measurements besides heart rate to be found statistically significant at a probability of .01 in this study. The differences found can be seen in Tables I, III, IV, and VI. The fact that only these two measures are significant may be due to lack of extremes in the groups tested. In the case of athletes versus non-athletes, the degree of conditioning is much greater than in this study.

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[1] Henry J Montoye, William Mack, and John Cook, The Prediction Performance in the N.C.A.A. Cross-Country Run from the Brachial Sphygmogram. Presented at the 44th Annual Convention of the Midwest Association of the A.A.H. P.E.R., Milwaukee, Wisconsin, April 17, 1958.

[2] T. K Cureton, Physical Fitness of Champion Athletes (Urbana: The University of Illinois Press, 1951), pp. 140-147.

The athletes (conditioned group) in the athlete versus non-athlete type of study are usually chosen for their excellent cardio-vascular fitness and they are matched with non-athletes chosen for their non-participation and lack of conditioning. Thus, one can not expect to find as many differences in this study. It is felt, however, that the differences found indicate important trends.

The QRS vector measurement which actually pictures the electrical axis of the heart in a frontal plane during the spread of the electrical impulse through the ventricles, shows a very decided shifting to the left in the non-conditioned subjects. Urschell and Abbey have shown this axis deviation to be correlated with age.[3] The statistical analysis of this study shows a significant correlation coefficient of .56 between axis deviation and age. The reasons for this movement of the heart towards a more horizontal position are not completely known. It is believed, however, to be partially due to a lessening of tension in the diaphragm and the deposition of fat in the tissues surrounding the heart. Further results may substantiate the greater axis shift among the non-conditioned individuals and this may prove to be the most important contribution which electrocardiography can make to the field of physical education.

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[3] D. L. Urschell and D. C. Abbey, "Mean Spatial Vectorcardiography," <u>American Heart Journal</u>, 43:3 (October, 1953), 496-506.

It could possibly show that exercise in middle age men, aids in retarding the ageing process of the heart.

The correlations of chest configuration and the ECG measurements as shown in Table IV are in no way significant. Subjects used in this study show no correlation between their sitting height and chest width ratio and ECG measurements.

Urschell and Abbey have found a significant correlation in their study between body build and the direction of QRS vector.[4] Correlations which they found, however, can be applied only to extreme ectomorphs or endomorphs using Sheldons classification. The above authors believe that in these extreme cases the position of the heart is dictated by the surrounding tissue and chest configuration. The majority of men in this study were mesomorphic. No extreme ectomorphs or endomorphs were found. The use of conditioned men, dictates that the majority of body builds within the group will be mesomorphic.

The reliability coefficients computed for the ECG measurements using the first and second records of twenty subjects yielded coefficients with a range between .86 and .99. This high reliability means that the taking of two records in a cross-sectional study with this age group is not necessary.

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[4] D. L. Urschell and D. C. Abbey, op. cit., pp. 496-506.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem in this study was: "Do the electrocardiograms of conditioned middle aged men differ significantly from those of non-conditioned middle men?" The author was also faced with the problem of finding whether any differences found may be due to the conditioning factor rather than to body build or age.

Hogerwerf and Cureton have found significant differences in the electrocardiograms of athletes as compared to non-athletes.[1,2] The normal measurement technique used by these researchers does not take into account chest size or configuration. More recent studies in the field of electrocardiography have shown the influence of age, and body build on the electrocardiograms of normal individuals.[3] This influence is found to be significant on the frontal vectors which in turn have influence on amplitude measurement.

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[1] S. Hogerworf, "Ergenbisse de sportzlischen unterschungen bei de IX Olimpischen Spielen," Arbeitphysiologie, Vol. 2 (1929), pp. 118-138.

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

[3] D. L. Urschell and D. C. Abbey, "Mean Spatial Vectorcardiography," American Heart Journal, 46:3 (October, 1953), 496-506.

Each subject in the study had an electrocardiogram taken using the three limb leads and the six precordial leads. Measurements of amplitudes and intervals were made with calipers and the frontal and horizontal vectors were determined by methods found in the medical literature.[4,5]

The subjects used were either staff members at Michigan State University or volunteers from the Lansing Y.M.C.A. The conditioned subjects were those who participated three times or more weekly in an exercise program.

The statistical analysis involved the use of Pearson-Product moment correlations and the Student's "t" technique.

Conclusions

The following are the conclusions reached by the author of this study.

1. The significantly lower pulse rate in the conditioned group may show a beneficial effect of exercise in this group.

2. A highly significant axis deviation in the non-conditioned group, which has been considered as a sign of ageing was not present in the conditioned group.

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[4] P. H. Langner, "A Geometric Model for Determining the Direction of Mean Spatial Vectors," American Heart Journal, 44:3 (September, 1952), 378-82.

[5] Charles E. Jackson and Travis Winson, "Aids for Determining Magnitude and Direction of Electric Axes of the ECT," Circulation, 1:4 (April 1950), Part II.

Significant correlation between age and ECG measurements were found in this study.

3. The group of subjects used show no correlation between chest configuration and their electrocardiographic measurements. This may possibly be due to lack of extremes in body build among the groups.

Recommendations

The following recommendations for further study are made by the author.

1. The study should be repeated using more extreme cases. The extremes should be in the form of conditioning and body build.

2. Further studies may be done using different occupational groups. This type of study may compare the ECG's groups such as manual and white collar workers.

3. Further studies involving mean spatial vector analysis should be undertaken.

4. The use of X-rays in determining the true anatomical position of the heart would be helpful in future studies.

5. The use of photography in determining a more exact measure of chest configuration can be used.

6. A longitudinal study of an exercise program, using electrocardiographic measurements should be done.

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APPENDICES

MICHIGAN STATE UNIVERSITY
DEPARTMENT OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

DATE OF TABULATION March 26, 1958

TOPIC E.C.G. study (middle aged men) Non Conditioned middle aged men

TABULATED BY Colman Grann

	AGE	SITTING HEIGHT	CHEST WIDTH	Weight lbs.	HEART RATE - MIN	P.R. Interval MM	Q.R.S. Interval MM	QT Interval M.M.	QRS Amplitude lead I	QRS amplitude lead III	T Amplitude lead I	T Amplitude lead III	QRS frontal vector degrees	QRS frontal vector MM	T Frontal vector degrees	T Frontal vector MM	Chest width-sitting height ratio					
1	45.83	86.0	36.0	186	70.0	3.5	2.5	8.1	9.0	4.1	3.1	-1.0	48.0	13.9	11.5	3.2	2.388					1
2	43.00	97.0	37.5	365	90.0	4.5	2.9	9.0	9.5	-3.0	1.9	-0.4	12.0	9.7	41.0	2.6	2.455					2
3	45.33	87.0	35.5	190	100.0	3.9	3.0	8.5	-4.5	0.2	2.0	2.0	-154.0	5.0	50.0	4.0	2.477					3
4	40.66	89.0	34.5	192	84.0	4.2	2.0	8.2	3.5	5.8	2.0	1.0	67.0	9.6	71.0	3.1	2.579					4
5	42.66	91.0	35.0	205	75.0	3.2	2.2	9.0	5.0	3.8	3.0	0.9	55.0	2.1	74.0	4.6	2.600					5
6	53.00	95.0	32.5	154	38.0	4.0	2.4	9.8	2.2	3.6	1.2	0.6	62.0	5.2	46.0	1.8	2.615					6
7	54.66	92.0	34.6	215	72.0	5.4	2.7	10.0	5.8	-0.2	3.0	0.0	46.0	6.2	37.0	3.2	2.623					7
8	37.00	94.0	34.5	170	64.0	3.5	2.2	9.5	6.2	2.2	3.0	1.9	44.0	3.2	55.0	3.2	2.666					8
9	59.33	91.0	34.0	166	56.0	3.9	2.6	10.2	5.0	3.3	1.3	1.1	55	8.5	56.0	2.3	2.676					9
10	34.50	97.0	33.0	148	60.0	4.3	2.1	10.5	4.1	[illegible]	3.0	0.9	32.0	9.4	44.0	4.2	2.797					10
11	53.00	92.0	34.0	[illegible]	58.0	5.0	2.1	[illegible]	[illegible]	7.1	3.0	1.7	[illegible]	6.2	57.0	3.2	[illegible]					11
12	41.33	91.0	34.0	126	64.0	5.5	3.0	4.5	4.8	1.0	3.2	0.1	31.0	6.4	33.0	3.7	[illegible]					12
13	40.72	10.5	32.7	171	72.0	[illegible]	[illegible]	4.7	7.1	4.2	1.1	-0.8	45.0	13.5	-11.0	1.5	2.741					13
14	43.66	94.0	32.0	186	72.0	4.1	1.9	4.1	6.1	5.5	2.7	0.7	53.0	9.1	45.0	3.1	2.751					14
15	51.00	91.0	32.0	147	75.0	4.1	2.1	2.7	4.1	3.2	2.1	1.0	55.0	7.0	41.0	3.1	2.716					15
16	50.1	94.0	30.0	165	72.0	[illegible]	3.0	3.7	5.4	[illegible]	2.0	[illegible]	71.0	[illegible]	45.0	2.1	[illegible]					16
17	45.00	97.0	32.0	[illegible]	76.0	3.0	[illegible]	[illegible]	2.4	[illegible]	1.9	[illegible]	[illegible]	11.1	34.0	4.2	[illegible]					17
18	35.33	[illegible]	31.4	[illegible]	65.0	4.3	3.2	1.5	3.1	[illegible]	[illegible]	[illegible]	[illegible]	10.1	4.0	[illegible]	2.334					18
19	51.42	95.0	33.0	[illegible]	[illegible]	4.5	3.0	1.4	7.5	[illegible]	2.0	2.8	[illegible]	10.1	66	4.2	[illegible]					19
20	31.1	[illegible]	32.0	153	60.0	4.5	2.0	1.5	[illegible]	4.5	1.1	3.0	74.0	[illegible]	[illegible]	[illegible]	[illegible]					20
21	41.66	[illegible]	34.1	174	[illegible]	[illegible]	2.7	1.1	7.1	[illegible]	3.1	[illegible]	[illegible]	17.5	47.0	4.1	[illegible]					21
22	54.83	94.0	36.0	171	[illegible]	2.8	2.5	7.1	5.4	-2.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2	[illegible]					22
23	37.33	[illegible]	[illegible]	159	[illegible]	[illegible]	[illegible]	7.6	6.1	[illegible]	[illegible]	[illegible]	45.0	9.7	[illegible]	[illegible]	[illegible]					23
24	41.33	11.0	[illegible]	153	55.0	[illegible]	[illegible]	11.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71.0	4.0	[illegible]					24
25	5408	95.0	[illegible]	[illegible]	[illegible]	[illegible]	2.4	1.2	4.0	[illegible]	2.0	[illegible]	23.5	4.4	[illegible]	3.5	3.064					25
26	37.50	91.0	34.0	[illegible]	[illegible]	4.1	[illegible]	[illegible]	5.6	[illegible]	3.4	[illegible]	11.0	16.7	[illegible]	3.1	[illegible]					26
27	[illegible]	[illegible]	[illegible]	[illegible]	65.0	4.1	2.0	9.1	[illegible]	-4.0	4.0	[illegible]	-15.0	3.7	45.0	5.7	[illegible]					27
28	[illegible]	10	33	175	54.0	[illegible]	2.7	[illegible]	2.5	4.0	3.0	1.3	[illegible]	12.7	41.0	[illegible]	2.121					28
29																						29
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MICHIGAN STATE UNIVERSITY
DEPARTMENT OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

TOPIC E.C.G. study (middle aged men)

Conditioned middle Aged Men

DATE OF TABULATION March 25, 1962

TABULATED BY Colman Green

	AGE	SITTING HT. C.M.	CHEST WIDTH CM.	Wheight lbs	Heart Rate/min	P.R. Interval MM.	Q.R.S. Interval MM.	Q.T. Interval MM.	Q.R.S Amplitude Lead I	Q.R.S. Amplitude Lead III	T. Amplitude Lead I	T Amplitude Lead III	Q.R.S Frontal vector degrees	Q.R.S. Frontal vector MM.	T Frontal vector degrees	T Frontal vector MM.	Chest width sitting height ratio				
1	37.83	90.5	36.0	198	62.0	3.7	2.5	10.8	4.5	5.7	3.4	1.5	64.0	10.2	47.0	5.1	2.513				1
2	37.12	88.8	35.2	160	60.0	4.0	3.0	9.0	3.5	6.5	2.1	1.0	70.0	10.1	49.0	3.1	2.522				2
3	46.50	91.0	33.5	182	56.0	4.0	2.0	10.2	6.0	-2.0	2.9	-2.0	44.0	8.3	11.0	3.1	2.563				3
4	37.15	95.0	37.0	177	68.0	4.9	2.1	9.7	-4.5	9.0	-2.5	3.9	71.0	13.7	128.0	4.0	2.567				4
5	49.0	89.0	36.5	179	75.5	3.9	2.0	9.0	4.0	3.8	3.2	0.8	54.0	7.8	40.0	4.2	2.578				5
6	51.50	90.5	35.0	177	75.0	4.0	3.0	9.0	8.9	-16.0	3.0	-1.0	-44.0	12.5	11.0	3.1	2.582				6
7	47.0	89.0	34.0	204	75.0	4.0	2.9	8.9	7.0	-1.4	[illegible]	0.3	11.0	7.4	36.0	3.3	2.617				7
8	44.05	86.0	32.5	136	90.0	4.3	2.2	9.1	3.0	5.9	1.5	1.9	65.0	9.5	63.0	3.6	2.646				8
9	36.75	90.0	34.0	172	43.0	3.5	3.0	10.5	1.0	2.5	1.0	2.5	40.0	9.9	17.0	3.2	2.656				9
10	46.5	85.0	32.0	176	67.0	5.0	2.9	9.0	6.9	-1.7	2.0	-2.0	34.0	11.6	-36.0	[illegible]	2.656				10
11	42.83	86.0	31.5	155	65.0	4.9	2.5	9.4	5.1	5.5	3.3	1.2	61.0	10.5	45.0	[illegible]	2.730				11
12	36.66	91.5	33.5	169	62.5	4.2	3.0	11.2	6.0	6.5	4.3	1.2	62.0	[illegible]	41.0	[illegible]	2.731				12
13	37.83	93.0	34.0	188	75.0	4.2	2.7	9.8	4.6	9.9	2.1	1.0	74.0	4.5	[illegible]	1.5	2.735				13
14	42.75	92.0	33.5	184	74.0	3.9	2.4	9.0	1.0	3.0	1.5	0.5	76.0	4.6	11.0	2.0	2.746				14
15	47.16	88.0	32.0	145	68.0	4.7	2.5	9.1	1.0	3.0	1.9	-1.0	76.0	4.5	0.0	3.1	2.750				15
16	41.75	91.0	33.0	185	71.0	4.0	2.0	9.5	2.9	11.5	1.9	-0.9	75.0	15.2	41.0	3.3	2.757				16
17	54.58	90.5	32.5	185	64.0	5.0	2.2	10.1	3.3	-1.5	[illegible]	-0.1	45.0	4.4	[illegible]	2.1	2.774				17
18	36.25	93.0	33.0	131	77.0	4.0	2.2	10.2	2.8	7.0	2.0	0.6	74.0	15.5	41.0	3.1	2.818				18
19	44.66	96.0	34.0	[illegible]	52.0	5.0	2.5	9.2	4.7	10.0	3.2	1.2	71.0	15.0	[illegible]	3.6	2.823				19
20	42.17	95.0	33.5	175	72.5	5.0	2.0	9.0	6.5	3.9	4.5	1.0	52.0	15.6	45.0	[illegible]	2.830				20
21	50.33	92.0	32.0	160	54.0	4.8	2.1	5.8	0.1	3.0	1.5	1.0	57.0	4.3	55.0	0.6	2.875				21
22	39.75	98.0	34.0	210	70.0	4.0	3.6	9.2	2.0	10.0	2.5	-0.5	66.0	11.0	-30.0	3.1	2.882				22
23	44.83	98.5	34.0	210	67.0	5.0	2.0	9.0	3.3	4.0	2.1	-1.1	63.0	7.3	4.0	3.1	2.897				23
24	44.50	91.0	31.0	162	72.0	5.1	2.2	9.1	8.0	-6.5	2.9	-1.0	42.0	9.5	71.0	2.1	2.903				24
25	37.33	99.0	34.0	194	75.0	6.0	1.2	10.0	2.5	7.1	0.5	4.5	75.0	9.9	71.0	1.5	2.911				25
26	37.00	92.0	31.5	1-6	45.5	4.0	2.5	10.0	3.2	13.5	1.0	0.4	77.0	16.5	35.0	4.5	2.930				26
27	50.00	87.0	28.5	124	75.0	4.0	2.0	9.0	4.0	2.0	2.0	2.5	41.0	6.1	67.0	4.0	3.052				27
28	42.00	99.0	32.0	183	64.0	3.1	2.1	9.2	5.0	7.7	2.0	2.0	66.0	12.8	60.0	3.3	3.093				28
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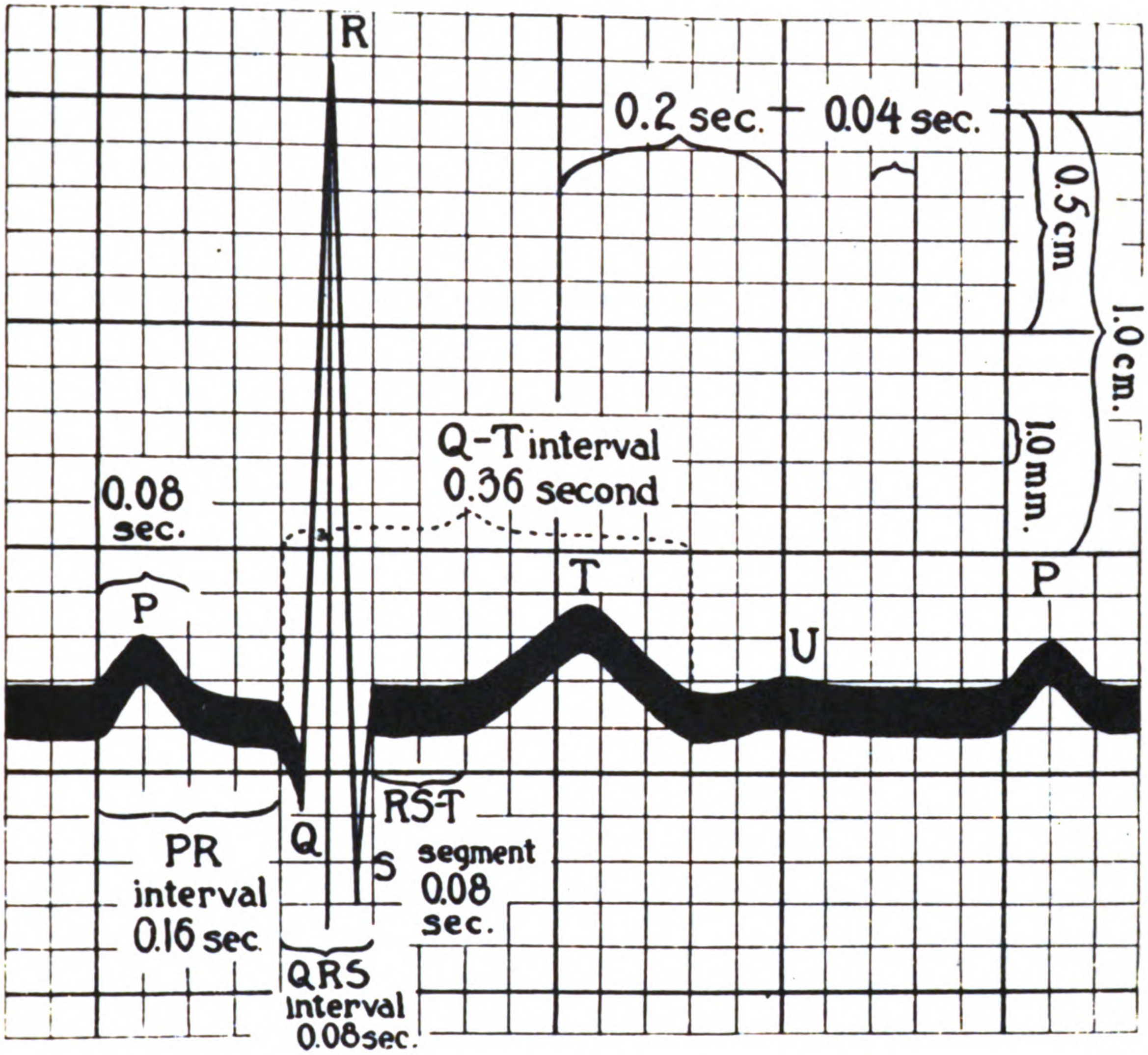
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ECG MEASUREMENTS OF THE FIRST RECORDS OF TWENTY NON-CONDITIONED SUBJECTS

Subject	PR Interval	QRS Interval	QT Interval	T, Amplitude Lead I	T, Amplitude Lead III	QRS Amplitude Lead I	QRS Amplitude Lead III	Heart Rate
1	3.6	2.5	8.0	3.1	-1.0	9.0	4.1	90
2	4.4	2.8	9.1	1.9	-0.3	9.4	-3.0	92
3	3.7	2.9	8.5	2.0	2.0	-4.4	0.1	102
4	4.3	2.1	8.3	2.0	1.0	3.4	5.9	82
5	3.1	2.3	9.1	3.1	0.8	5.1	3.8	76
6	4.0	2.4	9.7	1.1	0.5	2.3	36	72
7	5.3	2.6	10.1	3.1	0.0	5.8	-0.2	70
8	3.6	2.9	9.6	2.1	1.7	6.2	2.1	63
9	3.3	2.5	10.1	1.1	1.2	5.0	3.4	59
10	4.7	2.2	10.4	3.0	0.9	2.1	0.2	62
11	5.0	2.1	9.0	2.0	1.7	3.7	4.2	70
12	5.5	3.0	4.5	3.1	0.2	4.8	0.9	69
13	3.6	2.2	4.8	1.6	-0.8	8.9	4.3	76
14	4.9	1.8	4.0	2.7	0.9	6.7	5.4	83
15	4.7	2.0	8.9	2.2	1.1	4.1	3.2	74
16	4.5	3.0	9.0	2.1	0.7	2.3	8.4	72
17	5.1	1.8	9.8	1.8	2.5	3.3	7.0	77
18	4.1	3.2	9.4	2.6	0.9	4.0	6.2	70
19	4.4	2.0	9.4	2.0	2.8	7.6	2.8	74
20	4.6	2.0	9.5	1.9	3.1	2.6	6.5	62