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A COMPARISON OF ELECTROCARDIOGRAPHIC MEASUREMENTS OF ATHLETES AND NON-ATHLETES AT MICHIGAN STATE COLLEGE

Thesis for the Degree of M. A.

MICHIGAN STATE COLLEGE

Richard Leroy Foerch

1951

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Henry J. Montoye

Major professor

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A COMPARISON OF ELECTROCARDIOGRAPHIC MEASUREMENTS OF ATHLETES AND NON-ATHLETES AT MICHIGAN STATE COLLEGE

By

RICHARD LEROY FOERCH

A THESIS

Submitted to the School of Graduate Studies of Michigan
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CHAPTER I

INTRODUCTION

Electrocardiography was born with the introduction of the string galvanometer by Einthoven of Leyden in 1903. It had been known since 1856 that the contraction of the heart was accompanied by the production of differences in electric potential, for Kolliker and Muller[1] at this time had demonstrated the fact in an experimental laboratory, using the heart of a frog.

The electrocardiograph is one of the most valuable instruments available for the investigation of the various abnormal heart conditions. With its help, it is now possible to study diseases of the heart with a precision which was impossible hitherto. An electrocardiogram is now taken as a matter of routine, being almost as commonplace a procedure as the

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[1] A. Kolliker and H. Muller, Nachweiss der negativen Schwankung des Muskelstrome am Naturlich sich contrahierenden (Muskel, Verhandl. d. phys.-med. Gesellsch., zer Wurzb. 6:528, 1855), cited by J. B. Carter, Fundamentals of Electrocardiographic Interpretation (Baltimore: Charles C. Thomas, 1946), p. vii.

determination of the blood pressure. Important information is given by the electrocardiogram of the state of the conducting tissue of the heart. "The electrocardiogram is the time record of the electrical events in the heart from which information concerning the locus of origin of each beat and how the activity has spread can be obtained."[2] Not all regions of the heart are in a position where their effect upon the electrocardiogram is adequate to give this information. It follows, then, that damage to the heart may be present and yet the electrocardiogram be normal in configuration, and contra-wise, that relatively insignificant damage may be so situated as to lead to rather extensive alterations in the electrocardiogram. It is believed by many authorities that the electrocardiogram is affected by exercise and that it can be used to differentiate between good and poor cardiovascular conditions, within limits.

Statement of the Problem

The purpose of this study was to compare the electrocardiographic measurements of athletes and non-athletes at

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

Michigan State College. The following measurements were selected for comparison: amplitude of the P wave, QRS interval, amplitude of the T wave, PR interval, QT interval, and amplitude of the QRS.

Limitations

The measurements used in this study were confined to leads 1, 2 and 3. The following leads were taken on each subject, but not used in this study: AVR, AVL, AVF, VF, VL and VR. At no time in this study will the author attempt to give a medical interpretation of the findings. In choosing the subjects the author did not think in terms of body build, therefore the grouping is heterogeneous. The number of athletes from the various sports was limited because perfect physical condition was stressed. This paper will not attempt to delineate the historical aspects of the electrocardiogram, for the author feels that it could not be covered adequately in a project of this type.

Definitions of Terms Used

In the field of electrocardiography, it is very difficult to describe and explain the various amplitudes and intervals in the electrocardiogram; therefore, there is an electrocardiographic nomenclature which is universally used and approved by the standardization committee of the American Heart Association.

The following are a list of the terms to be used in this study (refer to diagram, Appendix, page 36):

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

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

3. Amplitude of the S wave. The S wave is produced during the electrification of the rest of the ventricular muscle.

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

5. Time of the PR interval. This interval represents the auriculo-ventricular conduction time, or the time required

for the excitation wave to travel from the sinus node through the auricular musculature to the auriculo-ventricular node, through this node, the His bundle, and down to the upper reaches of the right and left bundle branches. The interval is normally less than 0.20 seconds in duration.[3]

6. Time of the QRS interval. This represents the duration of intraventricular conduction. It is less than 0.10 seconds normally.

7. Time of the QT interval. This interval, according to Carter,[4] is the best measure available for the duration of electrical ventricular systole. It varies primarily with the heart rate; with a rate of 45 it is 0.45 second, with a rate of 75 it is 0.35, while a rate of 120 per minute gives a QT interval of about 0.25 second.

8. Lead I. Standard lead taken from the left arm and the right arm.

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

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[3] Carter, *op. cit.*, p. 43.

[4] *Loc. cit.*

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

11. Precordial lead. Placing of the electrode on the precordium and another at a standardized location on the arm or leg to complete the circuit.

CHAPTER II

REVIEW OF THE LITERATURE

In the past, most of the writing in electrocardiography has been too polemic to be of value to the unspecialized reader. On this account, while the author's own views on the subject are given main consideration, they are tempered with a recognition and presentation of other points of view.

A great deal has been written in electrocardiography in the past ten years, however very little of this has been related to physical education. Only a brief resume of the work completed will be related here.

Wolf[5] set up electrocardiogram standards for normal young men at the University of Illinois. His results were as follows:

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[5] Jacob Grove Wolf, ''Electrocardiogram Standards for Normal Young Men'' (unpublished Master's thesis, The University of Illinois at Urbana, 1948).

	Range $(M \pm \sigma)$[6]	Actual Range Found
Amplitude of P wave	0.5 - 1.8	0.3 - 31
Amplitude of QRS	2.8 - 20.8	1.0 - 24.1
Amplitude of T wave	1.1 - 6.1	0.0 - 9.4
P-QR interval	.15 - .20	.10 - .22
QRS time	.04 - .08	.03 - .09

Chamberlin and Hay[6] found the following measurements in a study of 136 normal individuals, whose ages ranged from 20 through 30:

Lead		P	Q	R	S	T
I	Average	0.6	0.4	9.0	1.6	3.1
	Range	0.1-1.5	0.0-2.6	2.5-18.6	0.0-7.5	1.1-6.5
II	Average	1.7	0.5	15.6	3.0	4.2
	Range	0.5-2.7	0.0-2.5	6.5-23.6	0.0-10.6	0.5-12.5
III	Average	0.7	0.5	9.3	1.5	-0.3
	Range	-3.5-2.5	0.0-3.6	1.5-20.5	0.0-8.5	-5.5-6.5

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[6] Chamberlin and Hay, "Electrocardiogram Standards," British Heart Journal, 1:105-115, 1939.

Another interesting study was made by Massey[7] on the prediction of all-out treadmill running from electrocardiographic measurements. Massey found that those individuals who participated vigorously in physical exercise had a smaller P wave, greater T wave amplitude, RST segment is elevated, PQR interval is increased, S wave may be eliminated and the QRS interval may be increased. On the whole, Massey found that athletes' tracings were clearer, larger, more regular, and the T wave is considered the electrocardiographic measurement making the greatest contribution to the prediction of endurance running ability.

In making a comparison of Olympic athletic candidates with normal standards for the electrocardiograph, Strydom[8] found that swimmers tend to have longer QRS intervals than track and field athletes and that the athletes have either a shorter rest period or a longer work period. The rest period

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[7] Ben Henry Massey, "Prediction of All-Out Treadmill Running From Electrocardiographic Measurements" (unpublished Master's Thesis, The University of Illinois at Urbana, 1947).

[8] N. B. Strydom, "A Comparison of Olympic Athletic Candidates With Normal Standards for the Electrocardiogram" (unpublished Master's Thesis, The University of Illinois at Urbana, 1948).

is considered to be from the end of the T wave to the end of the QRS complex, and the work period is the T wave duration.

Hoogerwerf[9] studied electrocardiographic measurements of athletes at the Olympic games at Amsterdam in 1928. He studied a total of 260 men and women and was able to get a representative sample from each sport. Of the many athletes examined in this study, the only ones who had definite U waves were those who won their particular event. The author found, upon summarizing the results:

> The examinations at Amsterdam demonstrated that strong bradycardies with slow irritant transmission (Reizleitung) in the auricles were endured without any trouble. Even extrasystoles occurred extremely seldom, probably because at the same time, the irritability in the other parts of the heart was equally reduced.[10]

As a final summary, Hoogerwerf found that the athletes undergo the influence of a strong vagus tonus, the P waves were generally small and the T waves were generally large, and that in 10 percent of the electrocardiograms the QT interval is more or less increased such as it occurs also in thrombosis of the coronary artery.

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[9] S. Hoogerwerf, "Elektrokardiographische Untersuchunger der Amsterdamer Olympiadekampfer," Arbeitsphysiologie, 2:61 (1929).

[10] Ibid., p. 73.

Wolf[11] found in his study on the effects of posture and muscular exercise on the electrocardiogram, that the electrocardiograph can record quite accurately the effects of exercise, and these results may be used to differentiate between good and poor cardiovascular conditions within limits.

> Statistically significant differences at the 5% level occurred between good and poor groups in the amplitude of the P wave and T wave after "all-out" treadmill running at 7 m.p.h., 8.6% grade. Significant differences at the 5% level in the same condition groups also occur in changes from lying to sitting and lying to standing in the P, R, and T wave amplitudes. These changes were an increase in P and S wave amplitude and a decrease in R and T wave amplitude. Changes in posture may suggest a valid method of differentiating between poor and good cardiovascular condition.[12]

Robb,[13] in a study of 533 athletes and 250 medical students, computed K and attempted to show its relationship to sportsmen with a high degree of circulatory efficiency. With

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[11] J. Grove Wolf, "The Effects of Posture and Muscular Exercise on the Electrocardiogram" (a paper read before the Research Section, 56th National Convention of the American Association For Health, Physical Education and Recreation, Detroit, Michigan, April 17, 1951).

[12] _Loc. cit._

[13] Jane S. Robb, "QT and K Values in Athletes," _Journal of Insurance Medicine_, 29:33, December, January, February, 1950-51.

Bazett's formula, $K = QT \div \sqrt{cycle}$, Robb found the following data: (1) K as well as QT is related to cycle length. (2) Those having high K values have slightly larger hearts than those with low K values. (3) The best relationship of K duration is to diastolic blood pressure. (4) K derived from Bazett's formula, $K = QT \div \sqrt{cycle}$, is found to vary with cycle rather than to be evenly distributed above and below straight line having a value of 0.37 (for normal men).

Cureton[14] reports that low P waves, high T and R waves, and short P-R intervals are associated with endurance by actual treadmill running tests. No P-R intervals greater than 0.22 seconds were found in 76 champion athletes. The R and T waves of highly-trained athletes were higher except in distance runners on restricted diets.

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[14] T. K. Cureton, "The Hearts of Athletes," Illinois Medical Journal, Volume 99, Number 3, March, 1951.

CHAPTER III

METHOD OF PROCEDURE

Instrument

The instrument used was the new PC-2 Cardiotron. This is a direct-writing electrocardiograph which produces permanent records instantaneously on an abrasion-resistant, thermosensitive paper. It incorporates such features as automatic instantaneous compensation during the switching of leads without pushing knobs or buttons, a fifteen-lead selector switch, absolute elimination of power line, automatic time marking, and an automatic protection circuit for the stylus.

The paper is ruled in one-millimeter squares. The required speed of the paper movement is twenty-five millimeters per second. Each vertical line of the graph represents the passing of 0.04 seconds. The speed of the paper is controlled by a synchronous motor, whose speed is constant. The sensitivity for standard electrocardiographic records is set so that an injected voltage of one millivolt (0.001 volt) will produce a stylus deflection of one centimeter.

This instrument has been approved by the American Medical Association and is manufactured by the Electro-Physical Laboratories, Incorporated, Rye, New York.

Selection of Subjects

The athletes in this experiment were chosen because of their outstanding athletic ability. The author's main purpose was to obtain the electrocardiograms of "top-notch" athletes who were in the peak of condition in their respective sport. By putting the primary emphasis on "top-notch" condition, it was impossible to procure an even number of athletes from the various sports. The distribution of the athletes was as follows: three boxers, two wrestlers, one swimmer, two tennis players, eight track and field, and four gymnasts.

The non-athletes were selected because they have had no athletic experience in high school or college. All of the non-athletes in this experiment were normal young men as far as could be determined by the experimenter. None of the men in the non-athlete group were enrolled in an adapted sports class.

Measurement Procedure

All measurements were taken in accordance with the recommendations of Wolff.[15] The instrument used for measurement was a pair of dividers as recommended by Dr. T. A. Hockman, a noted cardiologist in Lansing, Michigan. Amplitudes are vertical displacement measures and are recorded in millimeters. Interval measurements are recorded in hundredths of seconds determined by counting the small squares, interpolating where necessary. They are measured horizontally along the iso-electric line. Only three cycles (a cycle is considered from one T wave to the next T wave) were measured in each lead. In all leads the average amplitude and the average interval were recorded. The iso-electric line is used as the basic point for measurement, and all measurements are measured perpendicular to it. Each individual tested was asked to walk slowly or ride in an automobile when reporting for his examination. He was also asked to refrain from eating, smoking, or drinking an alcoholic beverage two hours prior to the

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[15] Louis Wolff, Electrocardiography Fundamentals and Clinical Application, Philadelphia and London: W. B. Saunders Company, 1950, p. 25.

examination. Upon arrival, the examinee was asked to lie quietly on a cot for a period of fifteen minutes.

Statistical Methods

The statistical analysis of the group results included the use of the student's "t" to determine the significance of the differences between these two groups. Also computed in this study was the F-test, which was used to determine whether or not homoscedasticity existed with regard to the various measurements in the two groups of subjects. Each amplitude and interval measurement was recorded, and a comparison of the athletes' and non-athletes' measurements were computed statistically to show the significance, if any.

The mean, range and standard deviation for the athletes and non-athletes has been set down in table form. This is elucidated in Chapter IV.

CHAPTER IV

RESULTS

The results are presented in table form on pages 18, 19, 20, 21, 22, and 23.

In using the student's "t," the author found that a number of the measurements displayed a significance at either the 0.01 or the 0.05 level. The T-wave in lead one showed significance at the 0.01 level. The T wave represents the repolarization of the sinus node and is called the work period of the heart cycle. Hoogerwerf[16] found that athletes with a very high T wave showed symptoms of excellent heart activity. Massey[17] also found large T waves in those who participated vigorously in physical exercise.

In lead III the QRS time was significantly increased in the non-athletes. It was also increased in lead one and two but only at a small degree. The QRS time is the duration of intraventricular conduction. If this is increased sufficiently,

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[16] Hoogerwerf, op. cit., p. 75.

[17] Massey, op. cit.

TABLE I

A COMPARISON OF THE ATHLETES AND NON-ATHLETES IN THE MEAN, RANGE AND STANDARD DEVIATION (N = 20 in both groups)

	Athletes			Non-Athletes		
	M	σ	Limits	M	σ	Limits
Height	69.35	2.77	66.5 - 75.0	69.90	2.97	65.0 - 75.0
Weight	151.75	11.92	125.0 - 179.0	157.0	20.27	128.0 - 200.0
Age	20.41	4.98	18.25 - 26.67	20.57	3.68	183.3 - 34.50
Pulse	54.55	8.26	40.0 - 70.0	69.65	36.97	51.0 - 95.0
Amplitude of P_1	.645	.244	.5 - 1.0	.590	.29	.2 - 1.0
Amplitude of QRS_1	5.93	2.10	1.3 - 10.5	5.06	2.27	1.9 - 9.0
Amplitude of T_1	3.21	.738	2.0 - 5.0	2.57	.57	1.5 - 5.5
Time of QRS_1	.062	.02	.04 - .09	.076	.03	.04 - .11
Time of PR_1	.126	.028	.12 - .20	.129	.03	.08 - .16
Time of QT_1	.409	.028	.36 - .44	.364	.03	.32 - .40
Amplitude of P_2	.96	.424	.1 - 2.0	1.10	.45	.2 - 2.0
Amplitude of QRS_2	13.07	3.05	7.5 - 20.5	11.82	2.63	7.0 - 19.0

TABLE I (Continued)

	Athletes			Non-Athletes		
	M	σ	Limits	M	σ	Limits
Amplitude of T_2	4.28	1.26	.38 - .47	3.35	1.23	1.5 - 6.1
Time of QRS_2	.073	.024	.04 - .11	.088	.03	.04 - .12
Time of PR_2	.169	.028	.12 - .20	.147	.03	.12 - .18
Time of QT_2	.421	.028	.38 - .47	.375	.03	.32 - .40
Amplitude of P_3	.625	.469	.1 - 2.0	.795	.37	.1 - 1.5
Amplitude of QRS_3	8.54	3.025	2.5 - 14.0	8.06	3.97	.5 - 16.0
Amplitude of T_3	1.665	1.21	.1 - 6.0	1.275	.58	.1 - 2.5
Time of QRS_3	.071	.028	.04 - .12	.105	.02	.08 - .13
Time of PR_3	.172	.02	.12 - .20	.138	.022	.10 - .19
Time of QT_3	.41	.055	.33 - .56	.37	.03	.32 - .40

TABLE II

SIGNIFICANCE LEVELS[1] FOR THE COMPARISON OF THE VARIOUS ELECTROCARDIOGRAPHIC MEASUREMENTS OF ATHLETES AND NON-ATHLETES

	t	% Level of Significance	F	% Level of Significance
Height	-0.59[2]	more than 0.05	1.14	more than 0.05
Weight	-1.69	more than 0.05	2.89	between 0.05 and 0.01
Age	-0.11	more than 0.05	1.84	more than 0.05
Pulse	-4.60	less than 0.01	2.01	more than 0.05
Amplitude of P_1[3]	0.62	more than 0.05	1.42	more than 0.05
Amplitude of QRS_1	1.22	more than 0.05	1.16	more than 0.05
Amplitude of T_1	3.0	less than 0.01	1.71	more than 0.05
Time of QRS_1	-1.62	more than 0.05	2.50	between 0.05 and 0.01
Time of PR_1	2.76	less than 0.01	1.25	more than 0.05
Time of QT_1	4.61	less than 0.01	1.25	more than 0.05
Amplitude of P_2	-0.98	more than 0.05	1.17	more than 0.05
Amplitude of QRS_2	1.35	more than 0.05	1.33	more than 0.05
Amplitude of T_2	1.85	more than 0.05	1.04	more than 0.05

TABLE II (Continued)

	t	% Level of Significance	F	% Level of Significance
Time of QRS_2	-1.62	more than 0.05	1.66	more than 0.05
Time of PR_2	2.26	between 0.05 and 0.01	1.25	more than 0.05
Time of QT_2	4.72	less than 0.01	1.66	more than 0.05
Amplitude of P_3	-1.24	more than 0.05	1.63	more than 0.05
Amplitude of QRS_3	.42	more than 0.05	1.72	more than 0.05
Amplitude of T_3	1.23	more than 0.05	4.25	less than 0.01
Time of QRS_3	-4.28	less than 0.01	2.0	more than 0.05
Time of PR_3	4.95	less than 0.01	1.25	more than 0.05
Time of QT_3	2.75	less than 0.01	2.70	between 0.05 and 0.01

[1] In the student's "t," 2.711 was significant at the 0.01 level and 2.025 was significant at the 0.05 level. For the F ratio, 3.0 was significant at the 0.01 level and 2.15 was significant at the 0.05 level.

[2] The minus sign means that the non-athlete was greater than the athlete.

[3] The large letter refers to the particular amplitude or interval, and the small number following refers to the particular lead.

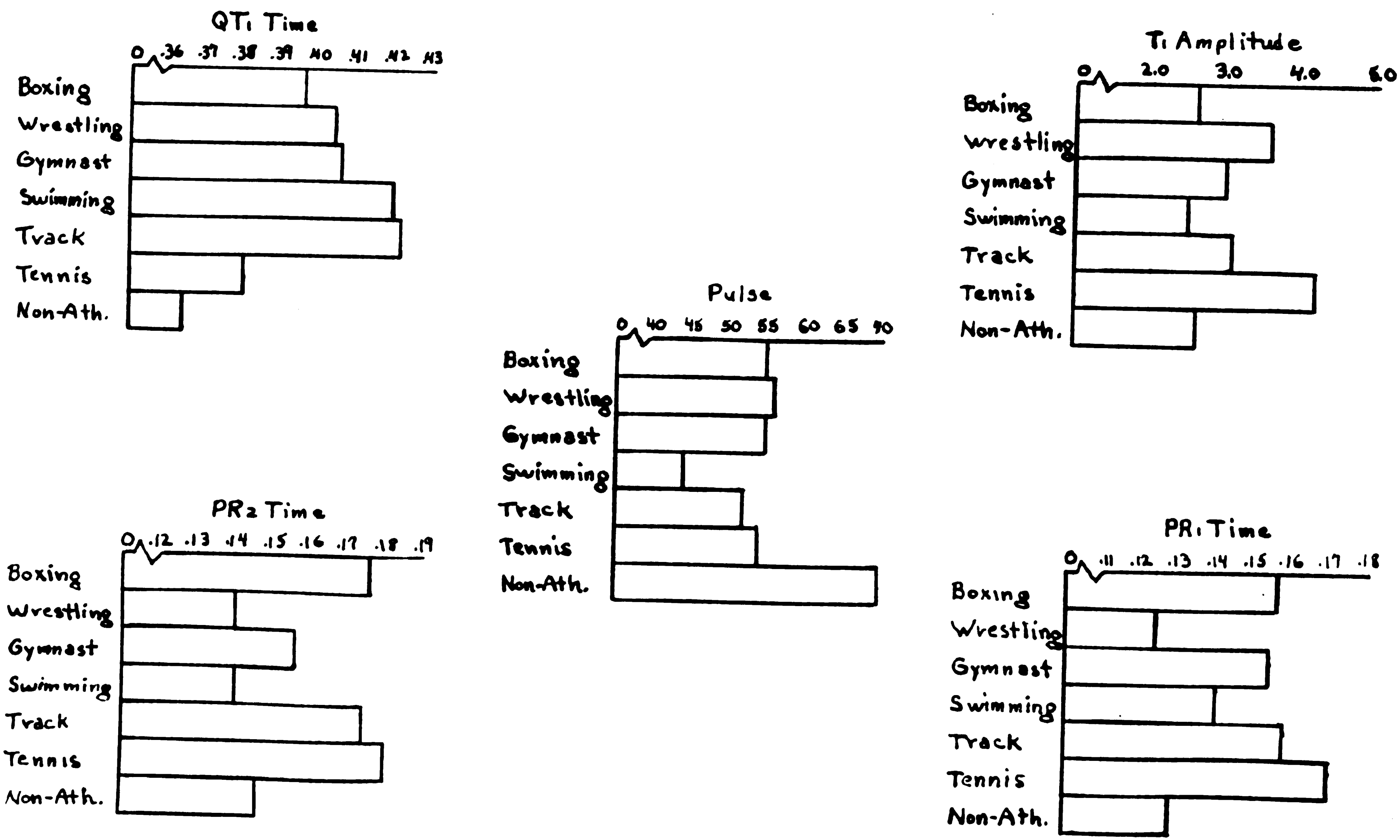

FIGURE 1

A COMPARISON OF ELECTROCARDIOGRAPHIC MEASUREMENTS
OF NON-ATHLETES WITH THE VARIOUS SPORTS

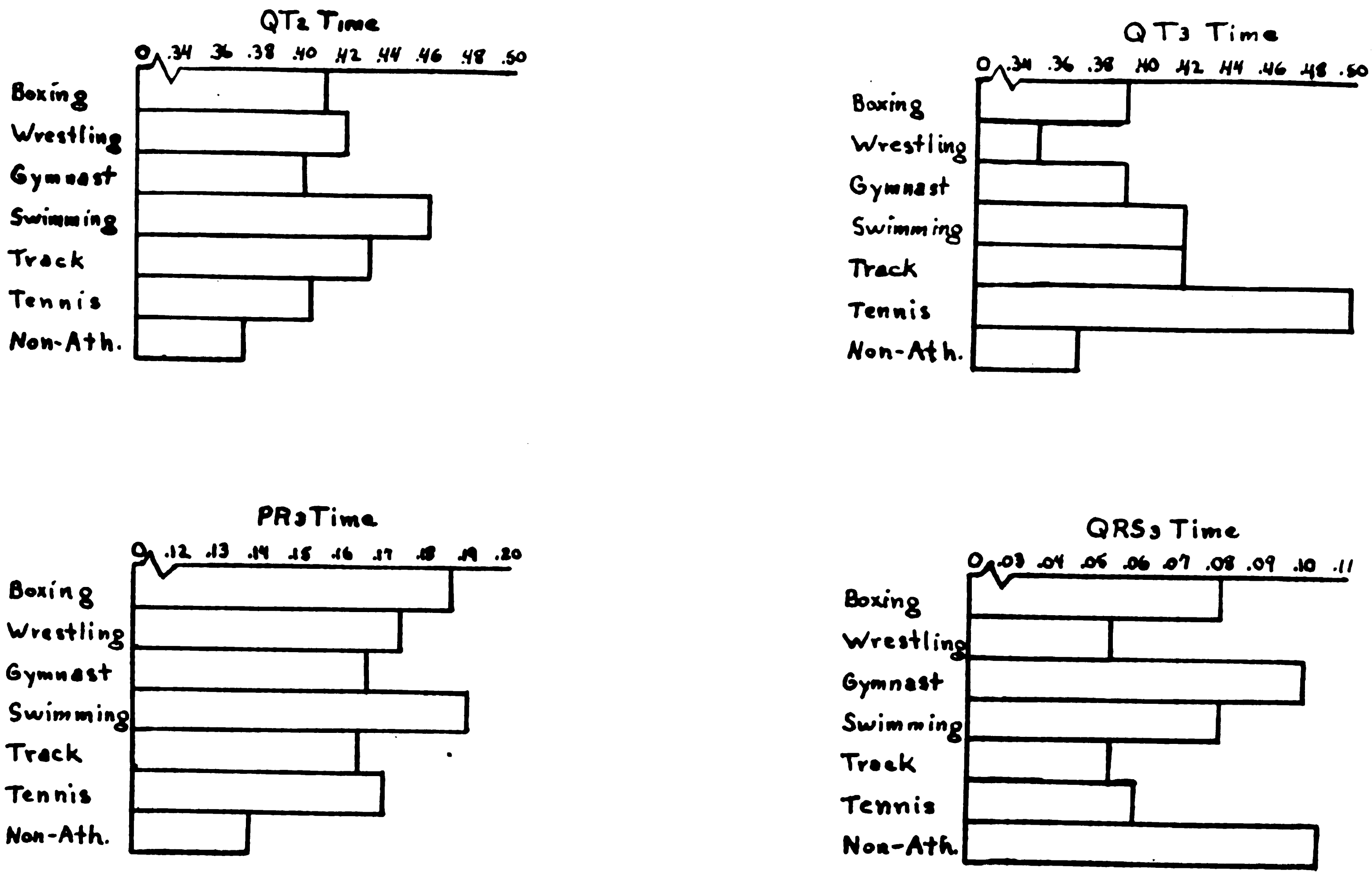

FIGURE 2

A COMPARISON OF ELECTROCARDIOGRAPHIC MEASUREMENTS OF NON-ATHLETES WITH THE VARIOUS SPORTS an intraventricular block may occur. However, none of the non-athletes possessed an extremely long QRS time.

The average pulse of the athlete was 54.55 where the non-athletes pulse was 69.65. This appears very significant at the 0.01 level. The pulse is an expansile impulse of the arteries which occurs at regular intervals. If the heart must beat faster for a given amount of work, the heart is working harder. If the heart will beat slowly and regularly the heart output will be less and therefore it should last for a longer period of time.

The PR interval showed a significance at the 0.05 level in lead two and a significance at the 0.01 level in leads one and three. The PR interval represents the auriculo-ventricular conduction time. A long PR interval is frequently found in an auriculo-ventricular block, but this is when the PR interval is greater than 0.20. Since the athletes have a longer PR interval and we assume that they aren't suffering from an auriculo-ventricular block, the long PR interval could be caused by a large heart or a heart with a slow pulse rate.

In all three leads the athletes had a longer QT interval, which was significant at 0.01 level. The QT interval is the duration of electrical ventricular systole and varies with the heart rate. Hoogerwerf found, "that in 10% of the electrocardiograms the QRS-T interval is more or less increased such as occurs also in thrombosis of the coronary artery."[18] The author found that the QT interval is related to the pulse and varies with the rate as described on page 5 of this paper.[19] These findings are substantiated by Figures 1 and 2 on pages 22 and 23, respectively.

Similarity in the Three Leads

The various amplitudes and time intervals were in agreement in the three leads. The following shows their resemblance:

1. The **P** wave amplitude was greatest in lead II for both athletes and non-athletes.

2. The QRS amplitude was greatest in lead II for both athletes and non-athletes.

3. The T wave amplitude was greatest in lead II for both athletes and non-athletes.

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[18] Hoogerwerf, op. cit.

[19] Cf. ante., p. 5.

4. The QRS time was greatest in lead III for the non-athletes.

5. The QRS time was greatest in lead II for the athletes.

6. The PR time was greatest in lead II for the non-athletes.

7. The PR time was greatest in lead III for the athletes.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this investigation was to compare the electrocardiographic measurements of athletes and non-athletes. Also, as a subordinate investigation, a comparison was made between the various sports and non-athletes. With such a small number of participants in the various sports, it is difficult to get a clear picture of how they would ordinarily rank. It is clear, however, that the athletes rank differently than the non-athletes in a number of the measurements.

In obtaining the athletes, the author tried to find those athletes who were nationally known and were in good physical condition at the time of the investigation. Among these were: Charles Davey, four times N.C.A.A. boxing champion, Burt McLachan, Big Ten swimming champion, Jed Black, N.C.A.A. boxing champion, Jessie Thomas, Michigan State football star, and nationally known track and field champion, Warren Druetzler, nationally known distance runner, now touring in Japan with an

American track team delegation, and Bob Hoke and Eddie Casalichio, N.A.A.U. wrestling champions. Other of the athletes who are not mentioned here are 19 and 20 year old college men who were runner-ups for many national titles.

The non-athletes were picked from the service course classes at Michigan State and had no previous athletic experience in high school or college.

After the data were obtained, they were analyzed with conventional statistical techniques.

Conclusions

On the basis of the evidence presented in this study, the following conclusions are set forth:

1. Athletes have a longer QT interval than the non-athletes, which may be caused by their slower heart rate.

2. Athletes have a longer PR interval than the non-athletes. This may be caused by an enlarged heart.

3. Athletes have a slower heart rate than the non-athletes. This may be caused by exercise of a beneficial nature.

4. Non-athletes have a longer QRS interval than the athletes. This may be related to the elasticity of the heart.

If the QRS interval is short, the walls of the ventricle will contract quickly.

5. Athletes have a greater T wave amplitude than the non-athletes.

6. Leads II and III appear to show the greatest amplitudes as well as intervals.

Recommendations

The following recommendations are made for additional studies in electrocardiographic measurements of athletes and non-athletes:

1. Record and measure leads AVR, AVL, AVF, V_1, V_4, V_6.

2. Compare body type and electrocardiograms with athletes and non-athletes.

3. Use a magnifying glass along with the dividers for measuring the various amplitudes and intervals.

4. A very good study could be made between the various sports, using a much larger selection than was used in this study.

5. Study an athlete in the peak of condition and then again when he is in his "lay-off" period.

6. It would be well to repeat this study using a larger group.

7. Study the direction of the impulse to see if it is related to the athletes or the non-athletes.

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Strydom, N. B., "A Comparison of Olympic Athletic Candidates With Normal Standards for the Electrocardiograph." Unpublished Master's Thesis, The University of Illinois, Urbana, 1947.

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APPENDICES

MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH AND RECREATION FOR MEN

GRADUATE STUDIES AND RESEARCH

ELECTROCARDIOGRAM MEASUREMENTS OF ATHLETES

TABULATION SHEET

TOPIC E.C.G's of Athletes at M. S. C.

DATE OF TABULATION July 2, 1951

TABULATED BY Richard L. Foerch

		Sport	Height	Weight	Age	Pulse	Amplitude of P_1	Amplitude of QRS_1	Amplitude of T_1	Time of QRS_1	Time of PR_1 (sec)	Time of QT_1 (sec)	Amplitude of P_2	Amplitude of QRS_2	Amplitude of T_2	Time of QRS_2 (sec)	Time of PR_2 (sec)	Time of QT_2 (sec)	Amplitude of P_3	Amplitude of QRS_3	Amplitude of T_3	Time of QRS_3 (sec)	Time of PR_3 (sec)	Time of QT_3 (sec)
1	Lane	Boxing	66.0	153	20.6	64	1.0	5.0	3.0	.04	.16	.36	1.0	14.5	3.5	.04	.17	.40	.3	11.0	.5	.04	.16	.40
2	Casalichio	Wrestling	66.5	148	20.17	65	1.0	7.0	3.3	.04	.17	.37	1.0	14.4	5.2	.08	.15	.40	.5	8.0	2.0	.07	.19	.37
3	McLachan	Swimming	75.0	179	20.0	44	.5	1.3	2.5	.09	.14	.42	.1	7.5	4.0	.10	.14	.46	-1.0	7.5	2.0	.08	.19	.42
4	Kau	Tennis	67.0	145	26.67	56	.2	5.5	5.0	.08	.16	.36	6.0	16.5	7.0	.08	.20	.38	.4	12.0	3.0	.08	.18	.56
5	Black	Boxing	67.0	155	22.08	63	.5	5.0	2.0	.08	.16	.40	1.5	14.5	3.5	.10	.20	.40	1.5	11.0	1.5	.08	.20	.36
6	Thomas	Track	70.0	165	23.08	62	.5	10.5	4.0	.04	.20	.40	.5	18.0	5.0	.04	.20	.40	.1	9.6	1.0	.04	.18	.40
7	Feldmeier	Gymnast	68.0	137	23.0	54	.5	6.0	3.0	.08	.20	.40	1.0	9.0	3.0	.04	.20	.40	.5	9.0	1.2	.12	.18	.40
8	Cook	Track	73.0	142	21.0	49	1.0	5.0	3.0	.08	.14	.44	1.0	14.0	6.0	.08	.19	.44	.8	14.0	6.0	.04	.18	.41
9	Druetzler	Track	73.0	152	22.0	55	.5	4.0	2.0	.04	.16	.40	2.0	14.0	25	.04	.16	.46	2.0	10.5	1.0	.04	.18	.46
10	Hoke	Wrestling	71.0	163	18.88	49	.5	9.0	4.0	.04	.08	.44	1.0	10.5	3.0	.04	.13	.44	.5	2.5	-.5	.04	.16	.33
11	Corbelli, Joe	Track	68.0	160	22.58	60	.5	6.0	3.0	.04	.16	.42	1.0	14.5	3.3	.05	.17	.40	.1	7.5	.1	.04	.14	.38
12	Corbelli, John	Track	71.0	165	19.67	70	.5	4.5	3.5	.07	.16	.40	1.5	13.5	6.0	.08	.20	.40	1.0	11.0	2.5	.10	.14	.37
13	Paul	Gymnast	66.0	125	18.25	56	.5	4.5	3.0	.04	.16	.36	.5	11.0	5.0	.08	.15	.39	.1	7.0	2.0	.12	.20	.41
14	Makielski	Track	72.0	160	24.0	53	1.0	7.0	4.0	.04	.12	.43	1.1	12.3	6.0	.06	.16	.45	.5	6.8	2.0	.06	.15	.43
15	Davey	Boxing	68.5	146	25.92	43	.5	7.0	3.7	.07	.15	.43	1.1	13.0	3.5	.12	.16	.43	1.0	7.0	.8	.12	.20	.43
16	Scutt	Track	74.0	160	20.67	40	1.0	5.8	2.8	.08	.14	.44	.5	13.2	4.0	.08	.12	.47	-.5	8.0	1.5	.08	.15	.45
17	Mills	Tennis	68.0	140	20.0	55	1.0	4.0	2.5	.08	.18	.40	1.2	10.5	5.0	.10	.16	.43	.5	5.0	1.7	.04	.16	.44
18	Barr	Track	68.0	140	19.83	40	.5	5.0	2.8	.06	.18	.45	1.2	10.0	4.2	.07	.20	.47	.5	4.5	1.5	.04	.19	.44
19	Walker	Gymnast	66.0	150	19.75	60	.5	6.5	4.0	.08	.12	.41	.5	10.0	3.5	.07	.12	.41	-.2	5.0	-1.5	.08	.12	.35
20	Mullineax	Gymnast	69.0	150	19.0	53	.7	10.0	2.0	.07	.18	.44	.5	20.5	2.5	.11	.20	.40	-.5	14.0	1.0	.10	.18	.42
21	Σx		1387.0	3035	408.31	1091	12.9	118.6	64.1	1.24	3.12	8.17	19.2	261.4	85.7	1.46	3.38	8.43	12.5	170.8	33.3	1.41	3.43	8.23
22	M_x		69.35	151.75	20.41	5455	.645	5.93	3.21	.062	.156	.409	.96	13.07	4.285	.073	.169	.421	.625	8.540	1.665	.071	.172	.41
23	Σx^2		96342.50	463410	8829.19	60877	9.53	790.58	217.01	.0841	.5018	3.3533	22.06	3602.14	399.07	.1188	.5866	3.5691	12.21	1641.74	84.73	.1165	.5981	3.432
24	M_x^2		4817.12	23170.50	441.459	3043.85	.476	39.58	10.85	.0042	.0251	.1676	1.1030	180.107	19.953	.00594	.0293	.1784	.6105	82.087	4.2365	.0058	.0299	.1716
25	M^2		4809.42	23028.06	416.568	2975.70	.416	35.165	10.304	.0038	.0243	.1668	.9216	170.825	18.361	.00533	.0285	.1776	.3906	72.9316	2.7722	.0050	.0295	.1689
26	σ^2		7.70	142.24	24.89	68.15	.060	4.42	.546	.0004	.0008	.0008	.18	9.282	1.592	.0006	.0008	.0008	.2199	9.1554	1.4643	.0008	.0004	.003
27																								
28	F		1.14	2.89	1.84	2.01	1.42	1.16	1.71	2.50	1.25	1.25	1.17	1.33	1.04	1.66	1.25	1.66	1.63	1.72	4.25	2.0	1.25	2.70
29	"t"		-0.59	-1.69	-0.112	-4.60	0.625	1.22	3.0	-1.62	2.76	4.61	-0.978	1.35	1.85	-1.62	2.26	4.72	-1.24	0.419	1.23	-4.28	4.95	2.75
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MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH AND RECREATION FOR MEN

GRADUATE STUDIES AND RESEARCH

ELECTROCARDIOGRAM MEASUREMENTS OF NON-ATHLETES

TABULATION SHEET

DATE OF TABULATION July 2, 1951

TABULATED BY Richard L. Foerch

TOPIC E.C.G.'s of Non-Athletes at M.S.C.

		Height	Weight	Age	Pulse	Amplitude of P_1 (mm)	Amplitude of QRS_1 (mm)	Amplitude of T_1 (mm)	Time of QRS_1 (sec.)	Time of PR_1 (sec.)	Time of QT_1 (sec.)	Amplitude of P_2 (mm)	Amplitude of QRS_2 (mm)	Amplitude of T_2 (mm)	Time of QRS_2 (sec.)	Time of PR_2 (sec.)	Time of QT_2 (sec.)	Amplitude of P_3	Amplitude of QRS_3	Amplitude of T_3	Time of QRS_3 (sec.)	Time of PR_3	Time of QT_3
1	Sterling	74.0	150	24.25	67	.5	4.0	2.5	.04	.12	.38	1.5	19.0	5.2	.04	.16	.40	1.0	14.5	3.5	.12	.14	.40
2	Smith	65.5	154	21.58	67	.5	7.5	5.5	.08	.10	.36	1.0	12.0	6.1	.10	.13	.36	.5	9.0	1.2	.12	.12	.36
3	Post	72.0	175	18.67	78	1.0	8.0	2.0	.04	.12	.35	.3	11.5	3.0	.08	.13	.34	-.5	4.0	1.0	.10	.10	.36
4	Folkert	68.0	180	34.50	59	.5	6.5	2.0	.08	.16	.36	1.0	13.0	3.0	.10	.16	.39	.5	6.5	1.0	.13	.16	.38
5	Sheets	72.0	160	20.92	60	1.0	4.0	2.0	.11	.16	.36	1.0	7.0	2.5	.10	.20	.38	-.5	3.0	.1	.12	.13	.34
6	Eggebrecht	67.5	131	19.42	65	1.0	6.5	2.0	.10	.16	.40	.2	9.0	3.2	.12	.12	.40	-.5	5.0	1.0	.12	.12	.40
7	Allen	72.5	175	18.92	87	1.0	2.8	2.0	.08	.14	.33	1.0	11.5	3.2	.08	.12	.36	.1	8.5	2.0	.08	.12	.36
8	Blesch	69.0	151	18.50	68	1.0	4.5	3.0	.08	.13	.36	1.5	13.5	5.0	.08	.16	.37	1.0	11.0	2.0	.11	.12	.36
9	Skidmore	66.0	137	19.42	56	.2	1.7	1.9	.04	.13	.36	1.0	11.5	2.5	.10	.16	.39	.5	10.5	2.0	.12	.14	.36
10	Neils	69.0	132	18.33	86	.2	3.0	1.5	.04	.12	.32	1.0	11.0	2.7	.12	.14	.32	1.0	6.7	1.2	.04	.16	.32
11	Strauss	66.5	132	18.58	61	.2	4.5	3.0	.08	.08	.38	1.0	8.5	3.0	.08	.13	.39	1.0	5.0	.5	.11	.14	.39
12	Sordyl	70.5	149	22.17	60	1.0	5.0	2.2	.06	.16	.40	.5	13.0	4.0	.07	.14	.40	-.5	9.0	1.5	.10	.16	.40
13	Dorais	74.0	183	19.00	87	.5	2.0	2.5	.10	.12	.39	1.5	11.5	2.5	.08	.16	.39	1.5	12.0	1.0	.08	.14	.39
14	Lindenfeld	67.0	185	18.83	62	.5	9.0	2.3	.08	.14	.37	.5	8.0	2.0	.09	.16	.36	.3	.5	-.5	.10	.15	.36
15	Passage	72.5	200	20.42	74	.5	8.0	3.0	.08	.12	.38	1.5	11.0	3.7	.08	.16	.40	1.0	5.0	1.0	.10	.16	.36
16	Stewart	70.0	154	19.33	51	.5	7.0	5.0	.08	.12	.39	1.0	13.0	6.0	.04	.12	.40	1.0	7.5	1.5	.10	.10	.40
17	Fraser	70.0	157	22.17	70	.5	7.5	3.0	.10	.12	.36	1.5	10.5	4.0	.12	.14	.40	1.0	4.0	1.0	.13	.14	.39
18	Johnson	72.0	140	20.00	95	.5	2.0	2.0	.10	.12	.32	1.5	16.0	1.5	.11	.16	.34	1.0	16.0	1.0	.12	.14	.34
19	Rausch	75.0	167	18.42	62	.2	2.0	1.5	.08	.12	.36	2.0	13.0	3.5	.09	.12	.38	1.5	13.0	2.0	.12	.12	.40
20	Girven	65.0	128	18.42	78	.5	5.5	2.5	.08	.14	.35	1.5	13.0	4.1	.09	.18	.34	1.0	10.5	1.5	.08	.19	.34
21	Σ_y	1398.0	3140	411.85	1393	11.8	101.2	51.4	1.53	2.58	7.28	22.0	236.5	70.7	1.77	2.95	7.51	15.9	161.2	25.5	2.10	2.75	7.41
22	M_y	69.90	157.0	20.57	69.65	.590	5.06	2.57	.076	.129	.364	1.10	11.82	3.53	.088	.147	.375	.795	8.06	1.275	.105	.138	.37
23	Σ_y^2	97896.50	501198	8733.20	99757	8.66	615.20	152.24	.126	.341	2.660	28.38	2935.75	279.77	.166	.4443	2.832	15.35	1614.64	39.39	.229	.3875	2.757
24	M_y^2	4894.83	25059.9	436.66	4987.85	.433	30.76	6.92	.006	.017	.133	1.42	146.78	13.99	.008	.022	.141	.767	80.73	1.969	.0114	.0194	.138
25	M^2	4886.01	24649.0	423.12	4851.12	.348	25.60	6.60	.005	.016	.132	1.21	139.83	12.46	.007	.021	.140	.632	64.96	1.625	.0110	.0189	.137
26	σ^2	8.82	410.9	13.54	136.73	.085	5.16	.32	.001	.001	.001	.21	6.95	1.53	.001	.001	.001	.135	15.77	.344	.0004	.0005	.001
27																							
28	F	1.14	2.89	1.84	2.01	1.42	1.16	1.71	2.50	1.25	1.25	1.17	1.33	1.04	1.66	1.25	1.66	1.63	1.72	4.25	2.0	1.25	2.70
29	"t"	-0.59	-1.69	-0.112	-4.60	0.625	1.22	3.0	-1.62	2.76	4.61	-0.978	1.35	1.85	-1.62	2.26	4.72	-1.24	.419	1.23	-4.28	4.95	2.75
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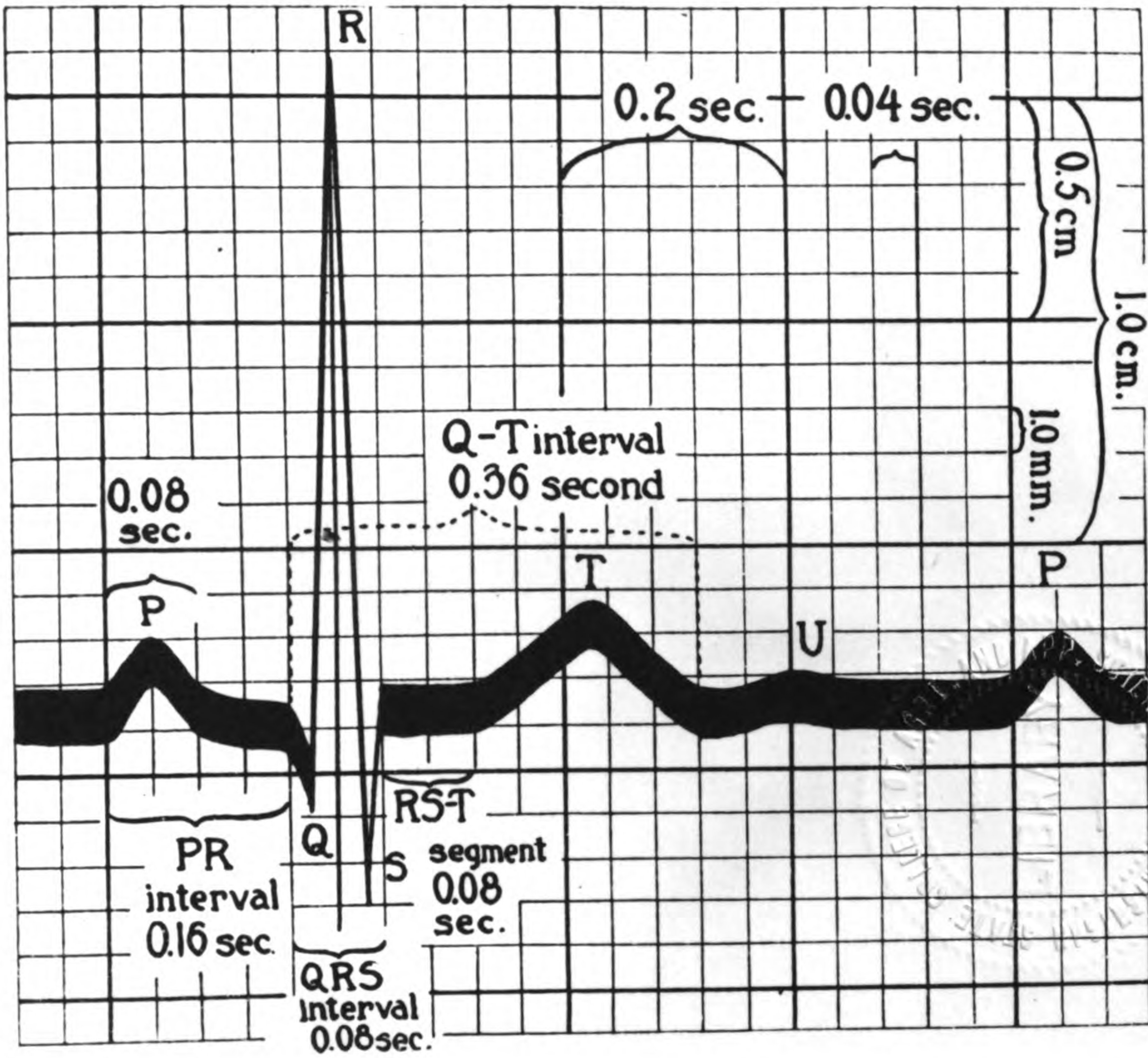
DRAWING OF ACTUAL ELECTROCARDIOGRAM
ENLARGED ABOUT FIVE TIMES[1]



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[1] L. H. Sigler, The Electrocardiogram, Greene and Stratton, New York, 1944.

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De 10 '52

~~Jan 23 '53~~

Jl 21 '54

Jan 6 '55

Feb 1? '57

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26 Aug 59

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