A COMPARISON OF ELECTROCARDIOGRAM MEASUREMENTS OF ATHLETES AND NON-ATHLETES MICHIGAN STATE UNIVERSITY

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY
Richard Lyle Skimin

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A COMPARISON OF ELECTROCARDIOGRAM MEASUREMENTS

OF ATHLETES AND NON-ATHLETES

MICHIGAN STATE UNIVERSITY

By

Richard Lyle Skimin

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

College of Education
Department of Physical Education

1961

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ABSTRACT

A COMPARISON OF ELECTROCARDIOGRAM MEASUREMENTS
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Statement of the Problem

The purpose of the study was to compare the electrocardiograms of athletes and non-athletes of similar body builds. A vector analysis was used to help determine if body build was a factor in any differences found.

Methodology

Twenty-nine athletes were chosen because of their physical condition and training during the winter and spring seasons. The athletes were participating in the following sports: basketball (5), track (14), hockey (5), wrestling (3), swimming (2). Twenty-nine healthy non-athletes were chosen from the students of the same university. The non-athletes were matched with the athletes according to a chest-width/sitting-height ratio.

Each subject had two ECG's taken using three standard leads and six precordial leads. The second records of all subjects were used in this study. The instrument used to record the electrocardiogram was the Sanborn model 60-200 recorder. Dividers were used for the measurement of amplitudes and time intervals.

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An analysis was done on both groups to determine if there were any significant differences between them. Correlation coefficients were computed between the sitting-height/chest-width ratio and the ECG measurements. The subjects were matched by sitting-height/chest-width ratio and the "t" test was used to determine if differences were significant. Correlations were computed between age and ECG measurements.

Conclusions

1. The highly significant lower pulse rate in the conditioned group tends to support the previous literature dealing with exercise and training. It may also show the benefits of athletic conditioning in this group.

2. The significantly slower conduction (PR Interval) and the significantly faster ventricular depolarization (QRS Interval) may be an indication of the increased cardiovascular efficiency.

3. The highly significant difference found in the amplitude of the T vector is an indication of a stronger repolarization of the ventricle.

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The writer wishes to express his sincere appreciation to Professor Henry J. Montoye for his interest and untiring efforts in guiding the preparation of this study.

R.L.S.

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

It has been shown in the past that the cardiovascular function of the heart is improved with exercise. The many tests that have led to this conclusion have included pulse rate, blood pressure, cardiac output ratio, and heart rate as determined by the electrocardiogram.[1] There have also been numerous studies on the comparison of the effects of training and exercise on the electrocardiogram of the athlete and the non-athlete.[2] It is hoped that this thesis will contribute further to the knowledge of the effect of exercise and training on the athlete.

I. THE PROBLEM

Statement of the Problem

It was the purpose of this study to compare the electrocardiograms of athletes and non-athletes. A vector analysis was used to help determine if body build was a factor in any differences found.

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

[2] *Ibid.*

Importance of the Study

The use of vectorcardiography has not yet been applied to the field of athletics. It is the contention of the author that this study will give further evidence as to the value of exercise and training in the field of Physical Education and Athletics. The process of vectorcardiography offers a truer and more objective picture of the heart and its location which is also important in one of the biggest problems in the field of Physical Education, the assessment of physical fitness. Some light may be shed upon methods of determining the physical fitness of an individual.

Limitations

The element of human error in the measurement of the ECG may cause inaccurate figures from which to work.

The small number of subjects used limits the interpretation of the data from this study.

The lack of precision of the vector measuring instrument within five degrees limits the accuracy of the results of this study.

II. DEFINITIONS OF TERMS USED

Definitions

Electrocardiogram. "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 activity is spread can be obtained."[3] (Standard ECG will be found in the Appendix.) The nomenclature used to describe the realm of electrocardiography has been standardized by a committee established by the American Heart Association.[4] These standard definitions will therefore be used in this thesis to avoid confusion of terms.

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

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.

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

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

PR Interval. This interval represents the auriculoventricular conduction time, or the time required for the excitation wave to travel from the sinus node through the auricular musclature to the auricular ventricular node, through this node, the His bundle, and down the upper reaches of the right and left branches.

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

[4]The Standardization of ECG Nomenclature, Standardization of Precordial Leads, Second Supplementary Report. Official reports of the American Heart Association, 1790 Broadway, New York.

QRS Duration. This represents the time interval for depolarization wave to travel through the ventricle.

Lead I. Standard lead taken from the left arm and 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. Six leads. Located on the frontal area of the ribs as prescribed by the American Heart Association.

Mean Spatial QRS and T Vectors. "The electrical forces produced by the QRS and the T processes are directed from the endocardium to the epicardium at each region of the heart. The QRS or T force for a given region of the ventricular heart can therefore be represented by a vector which is directed perpendicularly to the surface of the heart at that region."[5]

Vector. A vector is any quantity, such as a force, which has a known magnitude and direction. The mathematical symbol for a vector resembles an arrow: the length of the arrow represents the force, its inclination or direction indicates the direction in which the force is exerted, and the caret or arrowhead indicates the "sense" of the force which for an electrical force is the orientation of electrical positivity of the force.[6]

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[5] R. Grand and E. H. Estes, Spatial Vector Electrocardiography (Philadelphia, New York, and Toronot: The Blakiston Co., 1951), p. 5.

[6] Ibid.

Conditioned athletes in training. A subject who was participating in a varsity sport that required "top" cardiac efficiency. He was well into his sports season at the time the ECG was taken.

Non-athlete. A subject who had never played a varsity sport in high school or in college and has never had to do any physical training which required "top" cardiac efficiency.

Matched pairs. Subjects were matched by their sitting-height/chest-width radio.

CHAPTER II

REVIEW OF THE LITERATURE

The author has found a very good review of the literature on athletics and the electrocardiogram in The Physical Fitness of Champion Athletes by T. K. Cureton and associates.[1] Studies by Tuttle and Korns (1941)[2] and Krause and Nicolai (1910)[3] reported that the T wave of the ECG of trained athletes were higher at rest, but otherwise no differences were noticed. Messerlee (1928)[4] reported that training not only caused the T wave to become higher but lowered the ventricular peaks, greatly increased the duration of the QRS and slowed the pulse rate, all attributed to vagal influence.

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

[2] W. W. Tuttle and H. M. Korns, "Electrocardiographic Observations on Athletes before and after Season of Physical Training," American Heart Journal, 21:104-107, January, 1941.

[3] S. Krause and G. Nicolai, Das Electrokardiogramm des Gesunden and Kranken Menschen (Leipzig: 1910).

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

Hoogerwerf (1925)[5] found that the T wave in general, becomes higher with exercise, but with all-out work it will become much smaller, possibly one-half as high. The QRS complex in general tends to decrease to about one-half after exercise.

Broustet and Eggenberger (1936)[6] from the examination of thirty-five men who participated regularly in boxing, rowing, Rugby, and cycling in competition, concluded that the ECG of an athlete presented a fine, full, regular tracing, without claiming that the amplitude of the R and T waves were directly affected by the vigor of the heart. They still believe that there is a relation between the form tracing and the functional state of the heart.

McFarland, Graybiel, Liljencrantz, and Tuttle (1938-1939)[7] did a study on 173 Civil air line pilots and concluded that:

1. No age difference was observed. The average duration of the QRS being no different in the older groups than in the younger.

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[5] S. Hoogerwerf, "Elektrokardiographische Untersuchungen der Amsterdamer Olympiade," Arbeitsphysiologie, Vol. 2 (1929), p. 61.

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

[7] R. A. McFarland, A. Graybiel, Eric Liljencrantz, and A. D. Tuttle, "An analysis of the psychological and physiological characteristics of Two Hundred Air Line Pilots," Jr. of Aviation Medicine, 9-10:160-210 (1938-1939).

2. Low voltage seemed to be common in exceptionally healthy persons who showed no significant deviations in body weight and basal metabolic rate from the group as a whole.

3. Elevation of the diaphragm may cause right or left axis displacement.

Doliopolus and Bagou,[8] in a study of 24 athletes, found higher T waves in the ECG.

Vectocardiography is not a new area, it is about as old as the ECG itself. Since Einthoven[9] revealed his theory with the three limb leads in 1911, the field of spatial vectors was given a boost. Einthoven introduced these standard leads with the belief that frontal plane projections of electrical forces of the heart could be measured from these leads. This theory is now quoted in almost all of the literature that is related to mean spatial vectors and vectorcardiography. The study of the vector is a step closer to precision and mathematical objectivity in clinical interpretations of the ECG.

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[8] T. Doliopolus and Bagou, "Unipolar ECG's in Athletes," Cardiologia (Basel), Vol. 22:3 (1953), pp. 169-176.

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

Grant and Estes[10] believe that the vector method of interpretation is advantageous in many ways over the "pattern" or empirical interpretations.

a. It greatly simplifies clinical analysis of the Electrocardiogram because it eliminates the need to memorize deflection patterns.

b. It is more accurate and objective than the empirical methods.

c. Changes in wave forms due to changes in position of the heart are easily separated from changes due to myocardial abnormalities.

d. The criteria for the normal and abnormal tracing become simple, rational, and relatively precise.

Simonson and Keyes[11] reported in the American Heart Journal changes in the mean QRS and T vectors in two types of exercise. They used Spatial QRS and T vector norms from 178 middle-aged men.[12] This is believed to be the first comparison of mean spatial QRS and T vectors for different relative body weights and exercise tests. Five out of seven items showed highly significant changes.

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[10] R. P. Grant and R. Estes, Spatial Vector Electrocardiography (Philadelphia, New York, and Toronto: The Blakiston Co., 1951), p. viii.

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

[12] E. Simonson and A. Keyes, "The Spatial QRS and T Vector in 178 Normal Middle-aged Men," Circulation, 9:05, 1954.

Howard and Gertler[13] correlated the electrical axis of 144 normal men and several of their anthopometric measurements and indices. Each subject was somatotyped by the method proposed by Sheldon and associates. The measurements that were taken included: chest width, chest depth, chest ratio, height, weight, and sterno ensiform. Correlations were not significant between axis deviations and height and sternal ensiform measurements. There were moderate significant negative correlations between axis deviation and chest depth and chest ratio. Highly significant negative correlation between axis deviation and chest width and weight existed, and the ponderal index showed a highly significant positive correlation with axis deviation. There was highly significant inverse correlation between axis deviation and endomorphy so a positive correlation with ectomorphy is what may be expected from the anthropometric data.

Simonson[14] also found that there was a right axis shift in the T wave after exercise in older men. Seven items showed a significant difference of the mean changes between

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

[14] E. Simonson, "Effect of Moderate Exercise on the ECG in Healthy Young and Middle Aged Men," Journal of Applied Physiology, 5:19 (April, 1953), 584-588.

the younger and older men. Urschel and Abbey,[15] from a selection of fifty men and fifty women in the adult age group, desired a normal range of distribution for QRS and T vectors. The subjects were set in age groups. The data clearly showed that there is a progression towards a more horizontal vector as the age of the subjects increases. Sex differentiation was very negligible as far as the mean QRS vector was concerned.

In relation to body build, it was found generally that the marked thin and the marked obese correlated with the anticipated directions. This was not precise enough for statistical evaluation. It was concluded that the higher the diaphragm, the more horizontal must be the axis of the heart.

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[15]D. Urschel and D. C. Abbey, "Influence of Age, Sex, Body Build and Chest Configuration on the QRS Vector in Normal Individuals," American Heart Journal, 46 (October, 1953), 496.

CHAPTER III

METHODS OF PROCEDURE

Instrumentation

A Sanborn ECG two channel direct writer (model 60-200) was used for recording. A calipers was necessary for more precise measurement of the waves from the baseline. All of the measurements were taken from the baseline. Vector amplitude and degrees were determined by methods described in an article by Jackson and Winsor.[1]

Selection of Subjects

The athletes were selected from the varsity teams at Michigan State University--twenty-nine men who were in seasonal training at the time of the study. These men were chosen because of their physical condition and training during the winter and spring seasons. The athletes participated in the following sports: Track (14), Basketball (5), Hockey (5), Wrestling (3), Swimming (2).

Twenty-nine non-athletes were chosen from the students at the same university. They were normal men as far as the examiner could determine. The non-athletes were matched

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

with the athletes according to a chest-width and sitting-height ratio. See Table VII in the Appendix.

Measurement Procedure

Two ECG's were taken of each subject. The second record was used for making all measurements for the analysis. The first test was an orientation and served the purpose of eliminating the novelty of the instrument in the minds of the subjects. The method of determining the frontal vectors is described in an article by Jackson and Winsor.[2]

Each individual who was tested was asked to walk slowly or to ride in an automobile when reporting for his examination. He was also asked to refrain from drinking any alcoholic and cold beverages at least two hours prior to the examination. Upon arrival, the examinee was asked to lie quietly on a cot for a period of fifteen minutes. The cot was within a few steps of the testing area so that a minimum of steps would be taken just previous to the examination.

Statistical Analysis

An analysis was done to find any significant differences between the groups. Correlation coefficients were computed between the sitting-height, chest-width ratio and the ECG measurements. The subjects were matched by the sitting-height/chest-width ratio and the "t" test was used to determine if differences were significant. Correlations were computed between age and ECG measurement.

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[2]Ibid.

CHAPTER IV

RESULTS AND ANALYSIS

Results

The following tables contain the results of the statistical analysis.

TABLE I

STATISTICAL ANALYSIS OF THE DIFFERENCES BETWEEN UNMATCHED GROUPS

Measurement	Conditioned Subjects Mean	Non-Conditioned Subjects Mean	Student "t"
Age	20.88	19.70	2.37*
Weight	156.50	157.90	.28
Sitting Height	90.29	90.65	.45
Chest Width	30.78	30.47	.54
Chest Depth	19.97	19.56	1.05
Ratio (Sitting height ÷ chest width)	2.95	2.98	.64
PR Interval	4.26	3.91	2.06*
QRS Interval	1.58	1.81	2.30*
QT Interval	7.75	7.38	1.29
T Amplitude--Lead I	3.46	2.20	2.90*
T Amplitude--Lead III	1.21	1.66	.86
QRS Amplitude--Lead I	4.06	3.44	.72
QRS Amplitude--Lead III	9.31	7.67	1.26
T Vector Degrees	43.10	52.89	1.46
QRS Vector Degrees	71.13	67.60	.09
T Vector Amplitude	5.05	4.14	2.52*
QRS Vector Amplitude	14.08	12.32	1.20
Heart Rate	56.89	70.75	5.41*

*Significant at a probability of 0.01.

TABLE II

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT BETWEEN AGE AND STATISTICALLY SIGNIFICANT ELECTROCARDIOGRAM MEASUREMENTS

ECG Measurement	r*
T Amplitude Lead I	.162
PR Interval	.01
T Vector Amplitude	.06
QRS Interval	-.019

*None of the r's were statistically significant.

TABLE III

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN SITTING HEIGHT AND CHEST WIDTH RATIO AND THE ELECTROCARDIOGRAM MEASUREMENTS

ECG Measurement	r
T Amplitude Lead I	.11
T Vector Degrees	.27*
QRS Interval	-.23
PR Interval	-.05

*Significant at a probability of .01.

TABLE IV

STATISTICAL ANALYSIS OF THE DIFFERENCE BETWEEN MATCHED PAIRS OF SUBJECTS

ECG Measurement	Mean Difference	Student "t"
PR Interval	.35	2.06
QRS Interval	.23	2.30*
QT Interval	.37	1.42
T Amplitude Lead I	1.26	3.09*
T Amplitude Lead III	.45	1.15
QRS Amplitude Lead I	.62	.64
QRS Amplitude Lead III	1.64	1.43
T Vector Degrees	9.79	1.34
T Vector Amplitude	.91	2.63*
QRS Vector Degrees	3.53	.42
QRS Vector Amplitude	1.76	1.32
Heart Rate	13.69	5.92*

*Significant at a probability of 0.01.

TABLE V

STATISTICAL ANALYSIS OF THE DIFFERENCES BETWEEN THE FIRST AND THE SECOND RECORDS OF THE ATHLETES

Measurement	Coefficient of Reliability
PR Interval	.89
QRS Interval	.89
QT Interval	.96
T Amplitude Lead I	.90
T Amplitude Lead III	.99
QRS Amplitude Lead I	.93
QRS Amplitude Lead III	.94

TABLE VI

STATISTICAL ANALYSIS OF THE DIFFERENCES BETWEEN THE FIRST AND THE SECOND RECORDS OF THE NON-ATHLETES

Measurement	Coefficient of Reliability
PR Interval	.90
QRS Interval	.82
QT Interval	.84
T Amplitude Lead I	.99
T Amplitude Lead III	.99
QRS Amplitude Lead I	.99
QRS Amplitude Lead III	.99

Analysis

In this study the fitness of the athletes may be readily seen by the low pulse rate. Karpovich reports that "the effect of training on the heart rate may be well observed during physical reconditioning of convalescents. With the regaining of physical fitness, their pulse rates, in response to a standard exercise, gradually decrease."[1]

Montoye shows that there is a significant correlation between pulse rate and success in cross-country running.[2] Cureton reports a significantly lower pulse rate in well-conditioned champion athletes, with the normal pulse rates ranging from thirty-eight to one hundred and ten, and the average about sixty-four beats. Champion Track and Field athletes have slower pulse rates than swimmers and divers or the controls.[3]

As can be seen in Table I, the athletes have a significantly lower heart rate than the non-athletes. The mean difference being 14.4 beats per minute. We may, therefore,

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[1]Peter V. Karpovich, Physiology of Muscular Fitness (Philadelphia and London: W. B. Saunders Company, July, 1949), p. 15.

[2]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 Mid-West Association of the A.A.H.P.E.R., Milwaukee, Wisconsin, April 17, 1958.

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

justify the separation of conditioned and non-conditioned subjects. As both groups were members of the same student body at Michigan State University, with very similar environment, it appears that the great difference in their heart rate is a result of one group's training or conditioning through daily physical exercise.

Reindell found a longer PR interval in Sportsmen.[4] Jouve and Sivan, in observing records of professional athletes found the same phenomenon in approximately 60 per cent of the cases.[5] Meyer observed a much prolonged PR interval in one athlete.[6] Von Scinady witnessed analogous evidence of prolonged PR interval on a large number of athletes and found several examples of it.[7] Hoogerwerf explains, "A PR interval of .24 seconds is not at all unusual in athletes

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[4]H. Reindell, "Kymographische und Elektrokardiographische Befund am Sportherzen," Deutches Archiv fur Klinische Medizin, 131:485-514, 1937.

[5]A. X. Jouve and O. Sivan, "L'examen electrocardiographique du sportif; Ses Conditions," Marseille-Medical, 1:70-80 (January 30, 1940).

[6]P. Meyer, Archives des Maladies du Coeur et des Vaisseaus, 27:772, 1924. Cited by Thomas K. Cureton, Physical Fitness of Champion Athletes. (Urbana: The University of Illinois Press, 1951), pp. 140-147.

[7]E. Von Scinady, "Sportzartzlische Untersuchungen, III. Mitteilung: Vergleichende elektokardiographische Untersuchungen an Sporttreibenden bei besonderer Berucksichtingung der EKG-Zweitwerte," Arbeitphysiologie, 3:579-595 (October, 1930).

which the author believes is due to strong vagus tone. Increased vagus tone exerts its influence be decreasing the rate of transmission of the contractile wave and also by slowing down the rate of propagation in the bundle of His."[8] As may be seen in Table I, this study supports the evidence found in literature showing a prolonged PR interval.

As may be observed from Table I, there is a significantly higher T amplitude in lead I. Krause and Nicolai,[9] Hoogerwerf,[10] and Messerlee,[11] all reported higher T wave in exercise groups. T. K. Cureton[12] also reports that athletes seem to have a higher T wave.

It was the purpose of this study to determine whether higher T waves are present in athletes and if so, was it possibly due to body build or chest configuration. The vector technique of analysis used showed a significantly greater amplitude in the T vector of athletes.

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[8]S. Hoogerwerf, Ergebnisse der sportarzlichen Untersuchungen, bei den IX Olympischen Spielen, pp. 118-138, Berlin, 1929: "Elektrokardiographische Untersuchungen der Amsterdamer Olympiade," Arbeitphysiology, 2:61, 1929.

[9]S. Krause and G. Nicolai, Das Elektrokardiogramm des Gesunden und Kranken Menschen (Leipzig: 1910).

[10]Hoogerwerf, S., loc. cit.

[11]N. Messerlee, "Die Verunderungen im Elektrokardiogramm bei korroperabeit," Zstchr. F. d. ges Exp. Med., 60 (1928), 490.

[12]T. K. Cureton, The Physical Fitness of Champion Athletes (Urbana: The University of Illinois Press, 1951), p. 156.

A height/width ratio correlation with the T vector degrees shows that there is a relationship between body build and axis deviation; this is shown in Table III. Howard and Gertler,[13] in their study of "Axis Deviation and Body Build," reported that coefficients of correlation between measurable variations of physique and axis deviation have been established. In the subjects studied they found an association between the degree of compactness of the individual and the tendency to a left axis deviation. Table IV, which compares matched pairs of subjects of athletes and non-athletes, shows significant differences in the same measurements as those found in Table I.

Tables V and VI, which are a statistical analysis of the difference in the first and second records of the athletes and non-athletes, show a reliability coefficient ranging from .82 to .99. Table I shows a significant difference in the age of the two groups. This may be explained in that the conditioned athletes tended to be the juniors and seniors while the non-conditioned group were mainly freshmen and sophomores.

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

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The problem in this study was: "Do the Electrocardiograms of conditioned athletes differ significantly from those of non-conditioned students?" A vector analysis as well as matching by sitting height-width ratio was used to help determine whether the differences were due to conditioning rather than body build.

Significant differences have been found in electrocardiograms of athletes as compared to those of non-athletes. T. K. Cureton,[1] Tuttle and Korns,[2] Krause and Nicolai,[3] and Hoogerwerf,[4] have reported significant differences. In previous studies that compared the ECG of athletes to non-athletes, factors of chest size and configuration were not considered.

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

[2]W. W. Tuttle and H. M. Korns, "Electrocardiographic Observations on Athletes before and after Season of Physical Training," American Heart Journal, 21:104-107 (January, 1941).

[3]S. Krause and G. Nicolai, Das Electrokardiogramm des Gesunden and Kranken Menschen (Leipzig: 1910).

[4]S. Hoogerwerf, "Elektrokardiographische Untersuchangen der Amsterdamer Olympiade," Arbetsphysiologie, 2 (1929), 61.

There have been studies in the field of electrocardiography which have shown the influence of age and body build on electrocardiograms of normal individuals.[5] Age and body build have been found to be significant on the frontal vector measurements. The frontal vectors in turn influence the amplitude measurement. A study by Howard and Gertler[6] correlated the electrical axis of 144 normal men and several of their anthropometric measurements and indices. There were moderate significant negative correlations between axis deviation and chest depth and chest ratio.

Each subject was given two electrocardiograms. Three limb leads and six precordial leads were used for each test. A calipers was used to determine more precise measurements of the electrocardiograms from the base line. Vector amplitude and degrees were determined by methods found in the literature on vectorcardiography.[7]

All subjects used were students at the Michigan State University. The conditioned subjects were the varsity

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

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

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

athletes training for an in season sport which required vigorous conditioning. The Pearson-Product Moment Correlation and the Student's "t" were used to determine the statistical analysis.

Conclusions

The following are the conclusions reached by the authors of this study:

1. The highly significant lower pulse rate in the conditioned group tends to support the previous literature dealing with exercise and training. It may also show the benefits of athletic conditioning in this group. The results agree with previous studies by Montoye[8] and Cureton.[9]
2. The significantly slower conduction (PR interval) and the significantly faster depolarization (QRS interval) may be an indication of increased cardiovascular efficiency.
3. The highly significant difference found in the amplitude of the T wave and T vector is an indication of a stronger depolarization of the ventricle.

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[8] Montoye, op. cit.

[9] Cureton, op. cit., pp. 104-147.

The difference helps to substantiate the findings of studies by Krause and Nicolai,[10] Messerlee,[11] Hoogerwerf,[12] and Cureton.[13]

Recommendations

1. This study should be repeated using a larger number of subjects.
2. Further studies may be done between active non-athlete groups of students.
3. Further studies may be done between athletes of different sports.
4. The use of X-rays to determine a true anatomical position of the heart would aid the precision of measurement.
5. A longitudinal study of a group of non-athletes undertaking an exercise program using the electrocardiogram and vector measurements to determine if any changes have taken place.

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[10] Krause and Nicolai, op. cit.

[11] Messerlee, op. cit.

[12] Hoogerwerf, op. cit.

[13] Cureton, op. cit.

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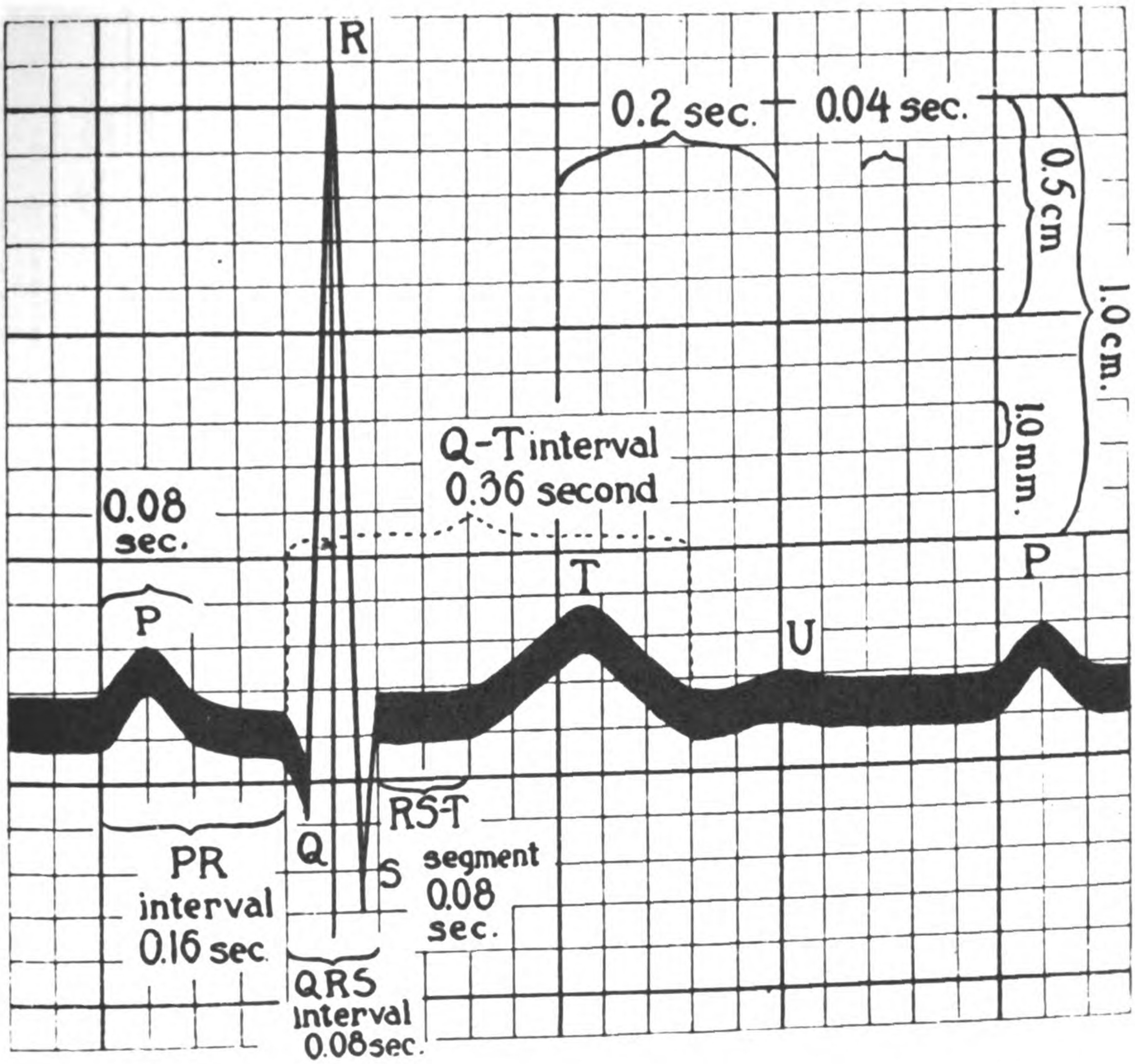
APPENDIX

TABLE VII

COMPARISON OF THE CHEST-SITTING HEIGHT RATIOS OF MATCHED PAIRS OF ATHLETES AND NON-ATHLETES

Pair No.	Athletes	Chest-Sitting Height	Ratios	Non-Athletes
1	Kennedy, H.	2.857	2.921	Vandenburo
2	Kenedy, C.	3.142	3.077	Miller
3	Reynolds	3.192	2.934	Macek
4	McLaughlin	3.360	2.892	Sill
5	Lean	3.249	2.711	Nielson
6	Hruby	2.845	3.033	Abraham
7	Ferrari	2.910	3.003	Phillips
8	Whebler	3.000	3.106	Lindberg
9	Crowell	2.857	2.818	Bridge
10	Horan	3.063	2.885	Olson
11	Hoffman	2.802	2.966	Swerdfeger
12	Polano	2.761	2.969	Rupp
13	Rand	2.651	3.067	McDonald
14	Lindholm	3.241	3.262	Newhouse
15	McCue	3.087	3.032	Shadwick
16	Smith	2.949	2.892	Fiacable
17	Hamilton	2.765	3.069	Chlpka
18	Quiggle	2.779	3.064	Pressel
19	Jennings	2.819	2.731	Clayton
20	Kellogg	3.000	2.862	Stewart
21	Dafoe	3.087	2.917	Fife
22	Grable	2.825	2.889	Johnson
23	Lake	2.967	3.034	Sherman
24	Arslanian	2.792	3.333	Stoltz
25	Green	2.924	2.900	Chelmedos
26	Hotchkiss	3.050	3.254	Smith
27	Manissto	2.676	3.211	Stenberg
28	Carr	3.100	3.227	Lamsa
29	Turak	2.671	2.932	Bimms
	Mean*	2.945	2.984	
	SD*	0.2	0.22	

*No significant difference shown.


R
0.2 sec.
0.04 sec.
0.5 cm
1.0 cm.
1.0 mm.
Q-T interval
0.36 second
0.08
sec.
P
T
U
P
RS-T
segment
0.08
sec.
PR
interval
0.16 sec.
Q
S
QRS
interval
0.08 sec.

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TABULATION SHEET

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TOPIC ELECTROCARDIOGRAM of ATHLETES

TABULATED BY Richard Skimin

		AGE	WEIGHT	SITTING HEIGHT	CHEST WIDTH	CHEST DEPTH	HEIGHT / WIDTH RATIO	PR INTERVAL	QRS INTERVAL	QT INTERVAL	T AMPLITUDE I	T AMPLITUDE III	QRS AMPLITUDE I	QRS AMPLITUDE III	T VECTOR°	T VECTOR mm	QRS VECTOR°	QRS VECTOR mm	HEART RATE
1	RAND	20.08	187	92	34.7	22.4	2.651	4.6	2.3	9.1	4.3	-2.0	7.7	4.2	40	4.5	49	12.2	48
2	TURAK	20.50	176	93.5	35	21.5	2.671	4.3	1.4	9.0	4.0	1.7	2.7	4.9	45	5.7	71	7.6	57
3	MANNISTO	19.16	154	91	34	21.3	2.676	4.6	1.5	8.0	2.1	2.3	4.2	13.6	64	4.5	78	18.9	70
4	POLANC	22.08	161	87	31.5	20.0	2.761	5.0	1.6	8.0	5.3	1.6	2.5	7.3	43	6.8	75	9.9	58
5	HAMILTON	21.50	162	93.2	33.7	20.3	2.765	4.6	1.7	8.8	2.0	1.2	2.0	10.0	49	3.1	81	12.9	48
6	QUIGGLE	20.50	191	92	33.1	21	2.779	4.3	2.0	8.8	3.7	-1.7	7.1	5.0	5	3.5	55	12.1	52
7	ARSLANIAN	19.83	184	90.2	32.3	22.5	2.792	3.3	2.0	7.5	2.7	1.7	7.0	7.7	52	4.0	58	15.0	64
8	HOFFMAN	21.75	169	88	31.4	19.4	2.802	3.5	2.0	8.2	4.3	1.0	10.5	4.2	40	5.9	58.5	19.6	57
9	JENNINGS	21.75	204	97	34.4	21	2.819	6.8	1.6	8.2	3.4	1.7	-1.2	8.5	47	5.1	95	9.2	60
10	GRABLE	20.33	154	89	31.5	20.2	2.825	4.0	1.5	8.1	-3.1	3.3	6.8	8.6	142	3.8	138	9.5	53
11	HRUBY	23.00	165	88.2	31	22	2.845	4.5	1.4	4.8	3.8	6.0	2.6	6.5	36	4.9	74	9.0	52
12	CROWELL	19.50	154	90	31.5	18.5	2.857	4.0	1.0	8.4	5.4	1.5	3.0	16.9	42	7.4	83	21.5	62
13	KENNEDY, H.	23.83	155	90	31.5	21.5	2.857	3.4	1.3	7.5	4.4	-1.4	2.6	4.3	11	4.5	67	7.2	57
14	FERRARI	19.83	128	85	29.2	19.5	2.910	3.0	1.7	8.0	5.3	1.6	2.5	7.3	43	6.8	75	7.9	58
15	GREEN	19.33	182	96.5	33	17.5	2.924	4.6	1.3	8.1	3.6	1.3	4.1	1.2	45	5.7	41	5.3	74
16	SMITH	19.67	131	87	29.5	19	2.944	4.0	1.2	7.6	3.0	1.2	4.8	7.3	44	4.2	65	12.1	77
17	LAKE	20.83	154	92	31	20	2.967	4.5	1.2	9.0	3.0	3.0	9.3	2.4	57	6.5	60	4.8	54
18	KELLOG	18.83	135	87	29	17	3.000	4.7	1.3	8.4	3.4	1.0	5.0	7.5	41	4.6	66.5	14.5	54
19	WHEELER	21.92	168	93	31	21	3.000	4.6	2.2	4.1	3.6	1.3	2.8	.8	42	4.7	44	4.2	50
20	HOTCHKISS	20.00	171	90	29.5	20.5	3.050	4.0	1.6	8.3	2.7	1.7	7.8	9.3	52	4.0	62	17.0	52
21	HORAN	20.42	148	91	29.7	20	3.263	4.2	1.5	3.7	4.6	1.8	7.0	15.2	46	7.2	72	22.5	53
22	DAFOE	23.92	136	88	28.5	20.5	3.087	4.2	2.4	8.1	2.1	2.0	1.0	20.1	60	4.0	88	23.8	56
23	McCLUE	19.83	134	88	28.5	19	3.087	3.2	1.3	8.0	3.0	1.0	7.5	18.3	44	4.2	74	25.5	58
24	CARR	20.41	144	93	30	18.2	3.100	4.7	1.0	8.0	3.0	-2.0	2.1	15.7	11	3.1	84	18.6	67
25	KENNEDY, C.	22.92	141	88	28	20	3.142	4.2	1.6	9.1	4.3	-1.1	8.2	12.3	18	4.1	67	20.1	58
26	REYNOLDS	19.75	137	91	28.5	20	3.192	4.0	2.2	4.1	5.0	1.0	6.0	3.1	37	6.4	49	9.2	56
27	LINDHOLM	20.16	158	94	29	20	3.241	5.3	1.5	8.3	5.0	1.5	5.5	14.0	43	6.8	74	20.0	47
28	LEAN	22.41	145	90	27.7	18	3.249	3.6	1.3	8.4	4.7	3.2	4.2	16.0	53	7.5	79	21.0	44
29	McLAUGHLIN	21.67	111	84	25	17.5	3.360	3.8	1.5	9.0	5.2	-1.4	4.1	8.2	.5	5.3	71	12.4	52
30																			
31	ΣX	605.71	4541	2618.6	892.7	579.3	85.42	123.7	45.9	22.49	100.5	35.2	117.8	270.1	1250	146.6	2063	405.3	1650
32	ΣX^2	1270565	723701	236719.02	27640.27	11631.43	252.59	542.41	76.41	1809.27	446.62	127.56	794.00	3285.83	71730	787.72	15630.5	6824.05	95684
33	M	20.88	156.5	90.29	30.78	19.97	2.945	4.26	1.58	7.75	3.46	1.21	4.01	9.31	43.10	5.05	71.13	13.97	56.89
34	SD	1.47	21.5	3.23	2.39	1.51	.2	4.14	3.6	1.53	1.61	1.73	2.47	5.16	24.8	1.29	18.19	6.34	7.93
35																			

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TOPIC Electrocardiogram of Non-Athletes

TABULATED BY Richard Skimin

	Age	Weight	Sitting Height	Chest Width	Chest Depth	Height Width Ratio	PR Interval	QRS Interval	QT Interval	T amplitude I	T amplitude III	QRS Amplitude I	QRS Amplitude III	T Vector	T Vector mm	QRS Vector°	QRS Vector mm	Heart Rate			
1 Nielson	20.16	167	93.0	34.3	19.0	2.711	3.7	1.8	8.0	2.6	3.3	0.0	12.7	66	6.0	90	15.0	66			1
2 Clayton	19.50	192	91.5	33.5	21.0	2.731	3.8	2.0	7.6	3.0	1.0	12.2	7.4	44	4.2	57	19.2	75			2
3 Bridge	20.56	163	93.0	33.0	18.5	2.818	3.0	1.8	7.2	2.1	3.0	3.0	9.5	67	5.0	76.5	13.0	72			3
4 Steward	19.84	134	85.0	29.7	19.0	2.862	3.2	2.7	8.3	3.5	1.5	-2.7	9.6	47	5.1	104	10.4	78			4
5 Olson	19.50	162	90.0	31.2	19.5	2.885	4.2	1.7	8.7	2.7	2.0	3.6	7.4	56	4.5	71	10.7	66			5
6 Johnson	20.25	164	96.0	31.5	18.7	2.889	3.7	2.6	7.1	2.9	0.8	3.9	10.5	44	4.2	74.5	14.9	64			6
7 Fiacable	20.16	180	94.0	32.5	19.3	2.892	3.6	2.1	6.9	0.5	1.0	4.2	9.2	71	1.5	79	13.3	69			7
8 Sill	20.67	141	83.0	28.7	18.0	2.892	4.0	1.7	8.3	3.5	1.4	0.7	12.3	47	5.1	88	14.1	60			8
9 Chelemedos	18.67	162	90.5	31.2	19.7	2.900	3.8	1.5	7.3	2.5	0.3	2.0	3.9	39	3.2	71	6.1	71			9
10 Fife	18.41	145	87.5	30.0	17.7	2.917	4.0	2.0	6.7	3.7	1.0	5.5	-1.5	42	4.7	14.5	5.7	76			10
11 Vandenburg	18.50	179	92.0	31.5	20.0	2.921	3.2	2.4	6.9	3.1	1.3	4.2	10.9	49	4.6	75	15.5	77			11
12 Bimms	19.50	191	86.0	34.7	21.0	2.932	4.5	1.8	7.0	0.9	-2.4	3.5	-6.0	-67	2.5	-54	6.0	74			12
13 Macek	27.75	153	89.5	30.5	20.4	2.934	3.3	2.0	7.4	2.1	1.8	4.0	12.0	56	4.5	76	16.7	64			13
14 Swerdfeger	19.25	149	87.5	29.5	20.7	2.966	3.8	1.4	7.0	2.1	3.2	7.2	10.6	67	5.0	67	18.2	78			14
15 Rupp	20.50	168	95.0	32.0	19.0	2.969	3.9	2.0	7.3	1.5	0.3	2.0	5.5	44	2.1	75	7.7	60			15
16 Phillips	19.00	154	91.0	30.3	20.0	3.003	5.0	1.7	7.3	2.0	1.0	5.6	2.1	49	3.1	44	8.4	90			16
17 Shadwick	18.67	177	95.5	31.5	22.0	3.032	5.5	2.0	7.3	-4.0	4.8	-7.4	8.2	129	5.9	143	8.7	57			17
18 Abraham	18.75	165	91.0	30.0	20.5	3.033	3.8	2.0	6.5	0.3	.5	4.8	6.6	49	1.5	65	12.1	66			18
19 Sherman	20.00	150	88.0	29.0	20.0	3.034	3.7	1.7	7.5	3.6	1.4	5.0	10.3	51	2.6	71	15.4	64			19
20 Pressel	20.08	147	91.0	29.7	20.0	3.064	4.0	1.5	8.2	1.5	0.7	6.8	2.0	60	1.0	42	9.5	57			20
21 McDonald	18.75	150	90.5	29.5	18.5	3.067	4.6	1.5	6.8	3.6	1.0	6.0	4.6	42	4.7	55	10.5	75			21
22 Chlpka	19.83	153	89.0	29.0	20.0	3.069	5.0	1.3	5.1	4.0	2.0	7.0	7.4	49	6.1	64	16.0	60			22
23 Miller	21.16	160	96.0	31.2	24.3	3.077	3.2	2.2	6.4	0.5	1.5	2.1	7.3	76	2.1	78.5	10.0	73			23
24 Lindberg	17.50	159	91.0	29.3	17.2	3.166	3.5	1.4	7.5	2.2	9.2	2.2	8.3	67	5.0	74.5	11.6	94			24
25 Stenberg	18.92	145	91.5	28.5	18.0	3.211	4.0	1.7	9.0	3.7	2.7	0.0	17.0	54	6.0	76	18.1	69			25
26 Lamsa	19.41	150	91.0	28.2	20.4	3.227	3.7	1.2	6.5	2.0	1.7	1.5	12.0	55	3.5	84	14.8	102			26
27 Smith	19.67	121	88.0	27.0	19.2	3.254	3.8	1.5	7.2	4.7	1.4	7.6	1.7	44	6.3	38	10.2	65			27
28 Newhouse	19.33	149	92.0	28.2	17.7	3.262	4.2	1.3	6.3	2.7	2.0	2.4	11.7	56	4.5	81	15.6	102			28
29 Stoltz	22.00	156	95.0	28.5	18.0	3.333	3.9	2.0	7.8	3.8	2.0	3.1	6.5	71	3.1	73	10.9	67			29
30																					30
31 ΣX	576.29	4580	2629.0	883.7	567.9	86.542	113.6	52.7	214.1	64.40	48.2	100.0	222.7	1546	120.0	2048.5	357.5	2052			31
32 ΣX²	11548.27	730324	238601.0	27030.33	11158.63	258.188	454.14	99.53	1599.93	220.54	118.6	697.44	2347.91	105852	554.02	162224.3	4823.17	148872			32
33 M	19.87	157.9	90.65	30.47	19.56	2.984	3.91	1.81	7.38	2.22	1.66	3.44	7.67	52.87	4.14	67.60	12.32	70.25			33
34 SD	1.77	158.4	3.2	1.91	1.48	.22	.671	.4	.109	.64	1.15	3.5	4.71	28.3	1.49	24.6	3.82	11.3			34
35																					35

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TOPIC ECG of Athletes and Non-Athletes

TABULATED BY Richard Skimin

	Non Athletes	Athletes	P Interval Non Athlete	P Interval Athlete	P Interval Difference	QRS Interval Non Athlete	QRS Interval Athlete	QRS Interval Difference	QT Interval Non Athlete	QT Interval Athlete	QT Interval Difference	T Amplitude I Non Athlete	T Amplitude I Athlete	T Amplitude I Difference	T Amplitude II Non-Athlete	T Amplitude II Athlete	T Amplitude II Difference	
1	11	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-11	[illegible]	[illegible]	-1.7	3.3	[illegible]	5.3	1
2	23	25	[illegible]	[illegible]	[illegible]	[illegible]	1.7	6.6	7.6	9.6	-14	3.6	4.6	-1.6	1.6	1.7	-0.1	2
3	13	26	[illegible]	[illegible]	1.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.3	[illegible]	3
4	3	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	1.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.8	1.9	1.6	-0.1	4
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1	-.5	6
7	16	[illegible]	[illegible]	3.3	[illegible]	[illegible]	[illegible]	[illegible]	6.9	7.5	-6.6	6.5	[illegible]	[illegible]	1.6	1.7	-0.1	7
8	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.3	[illegible]	[illegible]	1.6	[illegible]	8
9	[illegible]	12	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7	-1.4	9
10	5	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.4	[illegible]	[illegible]	6.8	1.6	[illegible]	[illegible]	10
11	14	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11
12	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12
13	[illegible]	1	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.8	-1.4	[illegible]	13
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6	[illegible]	14
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	15
16	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	16
17	[illegible]	[illegible]	[illegible]						[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	17
18	[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18
19	[illegible]	7	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19
20	4	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21
22	6	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22
23	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23
24	[illegible]	7		[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
25	[illegible]	[illegible]		[illegible]	[illegible]					[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	25
26	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26
27	[illegible]	[illegible]			[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29
30																		30
31	[illegible]			[illegible]			[illegible]			[illegible]			[illegible]				14.1	31
32	[illegible]			[illegible]			[illegible]						[illegible]				120.92	32
33	[illegible]			[illegible]			[illegible]			[illegible]			[illegible]				.47	33
34	[illegible]									[illegible]			[illegible]				.45	34
35																		35

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

TABULATION SHEET

DATE OF TABULATION 6-3-58

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

GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

DATE OF TABULATION 6-3-58

TOPIC E.C.G. of Athletes + Non-Athletes

TABULATED BY Richard Skiman

	Non-Athlete	Athlete	QRS Axis I Non-Athlete	QRS Axis I Athlete	QRS Axis I Difference	QRS Axis III Non-Athlete	QRS Axis III Athlete	QRS Axis III Difference	T Vector° Non-Athlete	T Vector° Athlete	T Vector° Difference	T Vector mv Non-Athlete	T Vector mv Athlete	T Vector mv Difference	QRS Vector Non-Athlete	QRS Vector Athlete	QRS Vector Difference
1	11	13	0.0	7.7	-7.7	12.7	4.2	8.5	66	4	62	6.0	4.5	1.5	90	49	41
2	23	25	12.2	2.7	9.5	7.4	4.9	2.5	44	45	-1	4.2	5.7	-1.5	51	71	-20
3	13	26	3.0	4.2	-1.2	9.5	13.6	-4.1	67	64	3	5.0	4.5	.5	76.5	78	-1.5
4	8	29	-2.7	2.5	-5.2	9.6	7.3	2.3	47	43	4	5.1	6.8	-1.7	104	75	29
5	31	28	3.6	2.0	1.6	7.4	10.0	-2.6	56	49	7	4.5	3.1	1.4	71	81	-10
6	18	11	3.9	7.1	-3.2	10.5	5.0	5.5	44	5	39	4.2	3.5	.7	74.5	55	19.5
7	16	14	4.2	7.0	-2.8	9.2	7.7	1.5	71	52	19	1.5	4.0	-2.5	73	58	15
8	24	19	0.7	10.5	-9.8	12.3	9.2	3.1	47	40	7	5.1	5.9	-.8	88	58.5	29.5
9	3	12	2.0	-1.2	3.2	3.9	8.5	-4.6	39	47	-8	3.2	5.1	-1.9	71	95	-24
10	5	21	5.5	-6.8	12.3	-1.5	8.6	-10.1	42	142	-100	4.7	3.8	.9	14.5	138	-123.5
11	14	8	4.2	2.6	1.6	10.9	6.5	4.4	49	36	13	4.6	4.9	-.3	75	74	1.0
12	15	4	3.5	3.0	0.5	-6.0	16.9	-22.9	-67	42	-109	2.5	7.4	-4.9	-54	83	-137
13	21	1	4.0	2.6	1.4	12.3	4.3	8.0	56	11	45	4.5	4.5	0.0	76	67	9
14	28	27	7.2	1.5	5.7	10.6	12.0	-1.4	67	60	7	5.0	4.0	1.0	67	84	-17
15	17	23	2.0	4.1	-2.1	5.5	1.2	4.3	44	45	-1	2.1	5.7	-3.6	75	41	34
16	7	16	5.6	4.8	0.8	2.1	7.3	-5.2	49	44	5	3.1	4.2	-1.1	44	65	-21
17	22	5	-7.4	2.3	-9.7	8.2	2.4	5.8	139	57	82	5.3	6.5	-1.2	143	60	83
18	20	6	4.8	5.0	-0.2	6.6	7.5	-.9	49	41	8	1.5	4.6	-3.1	65	66.5	-1.5
19	2	9	5.0	2.8	2.2	10.3	0.8	9.5	51	42	9	5.6	4.7	.9	71	44	27
20	4	18	6.8	7.8	-1.0	2.0	9.3	7.3	60	52	8	1.6	4.6	-3.0	42	62	-20
21	10	22	6.0	7.0	-1.0	4.6	15.2	-10.6	42	76	-4	4.7	7.2	-2.5	55	72	-17
22	6	10	7.0	1.0	6.0	9.4	20.1	-10.7	49	60	-11	6.1	4.0	2.1	64	88	24
23	19	17	2.1	7.5	-5.4	7.5	18.3	-10.8	76	44	32	[illegible]	4.2	-2.1	78.5	74	4.5
24	29	7	2.2	2.1	0.1	8.5	15.7	-7.2	67	11	56	5.0	3.1	1.9	79.5	84	-4.5
25	9	15	0.0	8.2	-8.2	12.0	12.3	4.7	54	18	36	6.0	4.7	1.3	86	67	23
26	27	20	1.5	6.0	-4.5	12.0	3.1	8.9	55	39	16	3.5	6.4	-2.9	84	49	35
27	26	3	7.6	5.5	2.1	1.7	14.0	12.3	44	43	1	6.3	6.8	-.5	38	74	-36
28	26	24	2.4	4.2	-1.8	11.7	16.0	-4.3	56	53	3	4.5	7.5	-3.0	81	79	2
29	12	2	3.1	4.1	-1.0	6.8	8.2	-1.4	71	15	56	3.1	5.3	-2.2	23	21	2
30																	
31			ΣX		-17.7			-47.4			254			-25.6			-102.5
32			ΣX²		760.62			1786.60			45392			124.40			52146
33			M of Diff.		-.62			-1.64			8.78			-.92			-3.53
34			Difference in means		.62			1.64			9.79			.92			3.53
35																	

MICHIGAN STATE UNIVERSITY
DEPARTMENT OF HEALTH PHYSICAL EDUCATION, AND RECREATION

GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

DATE OF TABULATION 6-3-58

TOPIC E.C.G. of ATHLETES + NON-ATHLETES

TABULATED BY Richard Skinia

	Non-Athletes	Athletes		QRS Vectormm Non-Athlete	QRS Athlete	QRS Difference	Heart Rate Non-Athlete	Heart Rate Athlete	Heart Rate Difference	
1	11	13		15.0	12.2	2.8	66	48	18	1
2	23	25		19.2	7.6	11.6	75	57	18	2
3	13	26		13.0	18.9	-5.9	72	70	2	3
4	8	29		10.4	9.9	0.5	78	58	20	4
5	31	28		10.7	12.9	-2.2	66	48	18	5
6	18	11		14.9	13.1	2.8	64	52	12	6
7	16	14		13.3	15.0	-1.7	69	64	5	7
8	24	19		14.1	19.5	-5.4	60	57	3	8
9	3	12		6.1	9.2	-3.1	71	60	11	9
10	5	21		5.7	9.5	-3.8	76	53	23	10
11	14	8		15.5	9.0	6.5	77	52	25	11
12	15	4		6.0	21.5	-15.5	74	62	12	12
13	21	1		16.7	7.2	9.5	72	57	15	13
14	28	27		18.2	14.8	3.4	78	58	20	14
15	17	23		7.7	5.3	2.4	60	74	-14	15
16	7	16		8.3	12.1	-3.8	90	77	13	16
17	22	5		8.7	4.8	3.9	57	54	3	17
18	20	6		12.1	12.5	-.4	66	54	12	18
19	2	9		15.3	4.2	11.1	64	50	14	19
20	4	18		9.5	17.0	-7.5	59	52	7	20
21	10	22		10.5	22.5	-12.0	75	53	22	21
22	6	10		16.0	23.8	-7.8	60	56	4	22
23	19	17		10.0	25.5	-15.5	73	58	15	23
24	29	7		11.0	18.6	-7.6	59	67	-8	24
25	9	15		18.7	20.1	-1.4	63	58	5	25
26	27	20		14.8	9.2	5.6	102	50	52	26
27	25	3		10.2	20.0	-9.8	65	47	18	27
28	26	24		15.6	21.0	-5.4	102	44	58	28
29	12	2		10.3	12.4	-2.1	67	52	15	29
30										30
31			ΣX			-50.8			418	31
32			ΣX^2			1524.88			11815	32
33			M of Diff.			-1.75			14.4	33
34			Difference in Means			1.75			14.4	34
35										35

G-1070

INSTRUCTIONS FOR SUBJECTS

You are an important part of a research study and your full cooperation and compliance with these few simple instructions are essential to make this study valid and sound. Please adhere to these few rules prior to reporting for your ECG:

Do not engage in any vigorous activity on the day of your testing until after the ECG is recorded. Refrain from alcohol and tobacco at least two hours before the test. If you do not drive a car, then walk slowly to the lab or allow me to pick you up from a designated area. Avoid drinking cold fluids at least one hour prior to recording ECG.

All testing will be done in quonset lab #79. If for some reason you cannot keep your appointment phone Ed 2-1511, extension 2945 (or) 2929. Evenings--Dick Skimin, Ed 2-0158
Cole Genn, Ed 7-0804