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The Effect of Body Stature and Exercise Conditioning of the Mean Electrical Axis, P-R Interval, QRS Duration, and Rate of the Heart

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The Effect of Body Stature and Exercise Conditioning of the Mean Electrical Axis, P-R Interval, QRS Duration, and Rate of the Heart

By John R. Imig [1]

Abstract. The mean electrical axis of the heart is not affected by body stature. The angle and magnitude of this axis seem to be altered with exercise conditioning. Electrocardiographic P-R intervals and QRS durations do not seem to be affected by either body stature or conditioning.

In recent years numerous studies have indicated that body build and conditioning affect certain aspects of heart function as evidenced by changes in cardiac electrical potentials (Guyton, 1958). Graphic tracing of electrical potential developed in the beating heart and detected on the body surface enable mean electrical axes of the heart to be determined. According to Guyton (1966) if one ventricle hypertrophies for any particular reason while the other remains normal, there will be an axis deviation toward the hypertrophied ventricle. This study used electrocardiographic tracings to investigate the effects of body build and of exercise conditioning on the electrical axis, contraction durations, and intervals of the heart.

The first part of the work attempted to confirm the assertion of Simonson and Dahl (1953) that short subjects show electrocardiographic evidence of left axis deviations and that tall, thin individuals tend to have right axis deviations.

Studies of well-conditioned athletes have shown that the weight and volume of the cardiac muscle is markedly greater than that of non-conditioned individuals (Jokl, 1964). In some cases left ventricular hypertrophy was reported to have been largely responsible for this increased cardiac mass. The purpose of the second part of the work was to investigate these claims as they pertain to relatively young conditioned and non-conditioned subjects. Magnitude and direction of mean electrical axes as well as important waves, intervals, and durations were especially significant to this study.

Methods

All the electrocardiograms were taken in the sitting position by means of a "Cardiotron" electrograph.[2]

The first study involved 12 subjects, nine normal young male adults and three normal young females. Five were classified as

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[2] Cardiotron, Model PC-2, Electrophysical Laboratories, Inc., Boston.

short (under 5'8") and seven were in the tall category (above 5'10") Mean electrical axes, P-R intervals, QRS durations and pulse rates were determined.

The second study involved 20 subjects, three normal young female adults and 17 normal young male adults. They were grouped into three categories, "non-conditioned", "conditioned", and a group that was measured before and after they participated in daily rigorous exercise programs for at least three weeks. None of the non-conditioned individuals had participated in regular vigorous exercise programs for at least three months prior to the tests. The conditioned group had exercised daily on varsity athletic teams for at least 25 days immediately before their electrocardiographic measurements, and were considered to be in good condition by their coaches. The third group, fulfilled both requirements for their first and second EKG's respectively. There were 16 subjects in the non-conditioned category, nine in the conditioned group, and five in the "before and after" classification. Mean electrical axes, P-R intervals, and QRS durations were calculated for all subjects in this study.

In both the first and second studies the data were evaluated with Student's t test as proposed by Lord (1947) and simplified by Hogben (1964). With all the data the Null hypothesis was rejected at the 5% level.

Results

Vector analysis graphs in the first study (listed in appendix) yielded magnitudes and directions of mean electrical axes. The mean vector direction of the tall group was 76.4°, representing a 29.6% right axis deviation from the normal 59°. The short subjects showed a rather normal axis angle of 60.2°. The differences in the mean values of the two groups, however, was not statistically significant.

The magnitude of the tall category's electrical axis was 1.34 millivolts, 0.25 milivolts higher than the 1.09 millivolt value for the short subjects. Again the differences were not statistically significant. Mean electrical axis data are listed in Table I.

Pulse rates, P-R intervals and QRS durations revealed negligible differences between the two categories. Table II lists these data for both groups.

Vector plots of the second study revealed that the nine conditioned subjects had a 1.41 mv. mean electrical axis magnitude, 0.35 mv. higher than the 1.07 mv. value for the 16 non-conditioned individuals. Differences of these averages were statistically significant to the 2% level. The axis directions of the conditioned subjects averaged 68.2°, while the non-conditioned individuals axis direction was 58.6°. The direction results were not statisti-

Table I. Effect of body stature on the mean electrical axis of the heart.

TALL			SHORT		
Subject	Magnitude (mv.)	θ	Subject	Magnitude (mv.)	θ
B.L.	1.32	88°	B.B.	0.95	78°
H.B.	1.60	86°	Im.J.	1.10	57°
L.M.	0.86	97°	Ir.J.	1.50	82°
M.De.	1.75	78°	M.Do.	0.55	9°
O.J.	1.38	78°	R.L.	1.38	78°
S.E.	1.14	38°			
S.J.	1.18	70°			
mean	1.34	76.4°		1.09	60.8°

L value (magnitude) – 0.125
% significance (magnitude) – > 5%
L value (θ) -0.212
% significance (θ) – > 5%

Table II. Effect of body stature on pulse rate P-R interval, and QRS duration.

TALL				SHORT			
Subject	P-R (sec.)	QRS (sec.)	Pulse (beats/ min.)	Subject	P-R (sec.)	QRS (sec.)	Pulse (beats/ min.)
B.L.	0.12	0.05	100	B.B.	0.16	0.08	112
H.B.	0.20	0.04	62	Im.J.	0.16	0.08	55
L.M.	0.16	0.04	82	Ir.J.	0.11	0.05	82
M.De.	0.12	0.05	70	M.Do	0.18	0.05	72
O.J.	0.14	0.05	65	R.L.	0.17	0.05	72
S.E.	0.16	0.07	60				
S.Jo.	0.18	0.05	66	MEAN	0.16	0.044	78
MEAN	0.15	0.05	72				

L value (P-R) – 0.072
% significance (P-R) – >5%
L value (Qrs) – > 5%
% significance (QRS) – > 5%
L value (Pulse) – 0.062
% significance (Pulse) – > 5%

Table III. Effect of conditioning on the mean electrical axis of the heart.

CONDITIONED			NON-CONDITIONED		
Subject	Magnitude (mv.)	θ	Subject	Magnitude (mv.)	θ
G.J.	0.90	57°	B.L.	1.32	88°
H.B.	1.56	86°	B.B.	0.95	78°
Im.J.	1.10	57°	F.J.	0.80	36°
M.De.	1.75	78°	G.J.	0.83	16°
R.L.	1.38	78°	H.E.	0.80	44°
S.E.	1.14	38°	H.B.	1.60	83°
S.Jo.	1.18	70°	Ir.J.	1.50	82°
T.P.	2.00	66°	K.P.	1.16	30°
Z.W.	1.64	83°	L.M.	0.86	97°
			M.D.	0.55	9°
			O.J.	1.38	78°
			S.J.	0.70	45°
			S.Jo.	0.78	58°
			T.P.	1.90	58°
			W.T.	1.55	98°
			Z.W.	1.48	86°
mean	1.41	68.2°	mean	1.07	58.6°

L value (magnitude) – 0.181
% significance (magnitude) – 5%
L value (θ) – 0.077
% significance (0) – > 5%

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cally significant, however. Table III shows mean electrical axis data for this study.

The average P-R intervals and QRS durations were almost identical for the two groups. The pulse rate of the conditioned group was 66, 16.5% less than the 79 pulse rate for the non-conditioned individuals. This pulse rate data showed a statistical significance of less than 1% probability of error. This data is listed in Table IV.

Table IV. Effects of conditioning on P-R intervals QRS durations, and pulse rate.

CONDITIONED				NON-CONDITIONED			
Subject	P-R (sec.)	QRS (sec.)	Pulse (beats/ min.)	Subject	P-R (sec.)	QRS (sec.)	Pulse (beats/ min.)
G.J.	0.19	0.05	64	B.L.	0.12	0.05	100
H.B.	0.20	0.04	60	B.B.	0.16	0.07	112
Im.J.	0.16	0.08	55	F.J.	0.16	0.04	80
M.De.	0.12	0.05	70	G.J.	0.17	0.04	84
R.L.	0.17	0.05	72	H.E.	0.15	0.04	74
S.E.	0.16	0.07	60	H.B.	0.20	0.04	62
S.Jo.	0.18	0.05	62	Ir.J.	0.11	0.05	82
T.P.	0.16	0.09	70	K.P.	0.15	0.05	74
Z.W.	0.14	0.05	80	L.M.	0.16	0.04	82
				M.Do.	0.18	0.05	72
				O.J.	0.14	0.05	65
				S.J.	0.19	0.05	82
				S.Jo.	0.18	0.05	66
				T.P.	0.17	0.09	82
				W.T.	0.16	0.06	66
				Z.W.	0.14	0.05	84
mean	0.16	0.059	66		0.16	0.051	79

L value (P-R) — ∞
% significance — (P-R) — > 5%
L value (QRS) — 0.06
% significance — (QRS) — > 5%
L value (Pulse) — 0.232
% significance (Pulse) — 1%

The EKGs of the five subjects who were tested before and after they were "conditioned" showed an average mean electrical axis of 1.36 mv., $\theta = 60.2°$ before, and 1.46 mv., $\theta = 72.4°$, after conditioning. That is, the average magnitude of the vector increased by 10.6% with conditioning, while the axis deviated 20.1% to the right with conditioning. The difference in the angles and magnitudes to the right. Four of the five subjects showed right axis deviation was statistically significant of 5% for the five subjects. Table V shows the vector data for this group.

Pulse rates of the five subjects decreased with conditioning from an average of 76 to 68, a 7.9% decrease. This was statistically significant to 1%. QRS duartions and P-R intervals were almost identical before and after conditioning. These data are listed in Table VI.

Table V. The effects of conditioning on mean electrical axes of five subjects.

BEFORE CONDITIONING			AFTER CONDITIONING		
Subject	Magnitude (mv.)	θ	Subject	Magnitude (mv.)	θ
G.J.	0.83	16°	G.J.	0.90	57°
H.B.	1.60	83°	H.B.	1.56	86°
S.Jo.	1.90	58°	S.Jo.	2.00	66°
T.P.	1.48	86°	T.P.	1.64	83°
Z.W.	0.78	58°	Z.W.	1.18	70°
mean	1.32	60.2°		1.46	72.4°

L value (magnitude) – 0.318
% significance (magnitude) – 5%
L value (0) – 0.330
% significance (0) – 5%

Table VI. Effect of conditioning on P-R intervals, QRS duration, and pulse rate of heart.

BEFORE CONDITIONING				AFTER CONDITIONING			
Subject	P-R (sec.)	QRS (sec.)	Pulse (beats/ min.)	Subject	P-R (sec.)	QRS (sec.)	Pulse (beats/ min.)
G.J.	0.17	0.04	84	G.J.	0.19	0.05	64
H.B.	0.20	0.04	62	H.B.	0.20	0.04	60
S.Jo.	0.18	0.05	66	S.Jo.	0.18	0.05	62
T.P.	0.17	0.09	82	T.P.	0.16	0.09	70
Z.W.	0.14	0.05	84	Z.W.	0.14	0.05	80
mean	0.17	0.054	76		0.17	0.056	68

L value (P-R) –
% significance (P-R) – > 5%
L value (QRS) – 0.04
% significance (QRS) – > 5%
L value (Pulse) – 0.476
% significance (Pulse) – 1%

Discussion

The finding of Dahl and Simonson (1953) that tall subjects had right axis deviation of their mean electrical axes seemed to be confirmed by the average values found in the first study, but statistical analysis of the data lessened its credibility. Only one of the seven tall subjects failed to show at least some right axis deviation, and perhaps the small number of subjects was responsible for the poor statistical reliability. The study did not substantiate Dahl and Simonson's (1953) claim that short persons often show left axis deviations. Although the 60.8° mean axis angle for the short group was 15.6° to the left of the tall group's average, the value is quite close to what is considered normal. Statistical significance of the difference in the average vector magnitudes of the two groups again was too poor to allow conclusions to be made. The fact that the tall individuals had an average vector magnitude 0.25 mv. higher than that of the short subjects warrants further study to gain more reliable data. QRS durations, P-R intervals, and pulse rates did not seem to be affected by body stature.

The assertion of Jokl (1964) that well-conditioned subjects have increased cardiac mass seemed to be confirmed by the electrocardiographic data of the second study. The mean vector magnitude of the conditioned category was 0.34 mv. greater than that of the non-conditioned subjects, which indicated a greater cardiac mass in conditioned persons. A larger number of subjects participated in this second study and statistical analysis showed the magnitude data to be quite reliable.

The hypothesis that left ventricle hypertrophy is often predominately responsible for the net increase in cardiac mass of conditioned individuals (Jokl, 1964) was not confirmed by this study. The conditioned individuals, in fact, showed a right axis deviation, while the non-conditioned individuals average was normal. A 12.2° axis shift to the right also occurred in the "before-after" subjects following their conditioning period. This occurrence might be explained by loss of weight often concurrent with vigorous exercise. That is, with a loss of weight the abdominal contents would push up on the diaphragm with less force, allowing the apex of the heart to hang at a more perpendicular angle.

The "before-after" group, serving as its own control group, yielded the most reliable data statistically. A marked increase in vector magnitude after exercise conditioning further substantiated the increase of cardiac mass hypothesis. A larger number of "before-after" subjects would have greatly contributed to the reliability of this study.

As expected pulse rates were significantly lower in the conditioned category than in the non-conditioned, while the "before-after" individuals exhibited a decreased cardiac rate with conditioning. A decreased pulse rate is usually considered concurrent with increased cardiac capacity (Jokl, 1964). P-R intervals and QRS durations showed no trends or significant variations in this study.

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