AXIS DEVIATION AND BODY BUILD

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In 1913 Einthoven, Fahr, and DeWaart[1] published a method of estimating the direction and manifest magnitude, at a given instant in the cardiac cycle, of that component of the heart's electromotive force which is parallel to the plane defined by the standard limb leads. The literature is filled with experiments which were designed to demonstrate[2,3] and question[4,5] the validity of Einthoven's hypothesis.

There also have been a number of clinical and anatomic studies in which various body measurements have been correlated with size of normal hearts[6,7] as well as anatomic consideration of the heart in its relationship within the thoracic cage. In view of the interest in these correlations between somatic measurements and size of the heart, it is surprising how little data are available on correlations of these somatic measurements with the electrical axis. Bland and White[8] and Master and Oppenheimer,[9] in studying the clinical significance of complete inversion of Lead III, concluded that obesity with a high diaphragm was the cause in the majority of instances in normal individuals. No somatic measurements or morphologic variations were included in these papers. Comeau and White,[7] in studying body build and heart size, expressed the opinion that at that time the ponderal index (that is, an expression of height and weight) was the best known index of body build but was not entirely satisfactory in expressing body mass. This difficulty has been surmounted by Sheldon and associates[10] who have presented, by the system of somatotyping, a method based on anthropometry which is a more reliable index for expressing body build and, hence, body mass. By employing this systen it is possible to correlate heart size and electrical axis with body build as expressed in the most definitive manner known at this time.

It is the purpose of this paper, therefore, to (1) present correlations between electrical axes of 144 normal men and several of their anthropometric (somatic) measurements and indices; (2) to present a more reliable index as to the influence of body morphology on electrical axis as expressed by the Einthoven technique, and (3) to consider the possible clinical significance of these studies.

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METHOD

As a part of a larger and more inclusive study of coronary heart disease, routine electrocardiograms, including standard limb leads checked by unipolar limb leads, were taken on 144 normal men who did not show any clinical or laboratory evidence of heart disease. The electrocardiograms were taken in accordance with the method recommended by the American Heart Association. These individuals were also employed as a control group in an extensive study of coronary heart disease by one of us. The axis deviation in degrees in each individual was determined from the standard limb leads by direct measurement on an Einthoven triangle. Each subject was photographed and somatotyped by the method proposed and described by Sheldon and associates.[10] In addition, certain other body measurements were taken.* These are listed in Tables I and II.

TABLE I. COEFFICIENTS OF CORRELATION BETWEEN AXIS DEVIATION (ECG) AND ANTHROPOMETRIC MEASUREMENTS AND INDICES

Height	+ 0.05 ±0.08
Sternal ensiform	− 0.03 ±0.08
Chest depth	− 0.20 ±0.08*
Chest ratio D/W	− 0.21 ±0.08*
Chest width	− 0.25 ±0.07†
Weight	− 0.33 ±0.07†
Ponderal index	+ 0.36 ±0.08†

*Significant ($p > 0.05$).
†Highly significant ($p > 0.01$).

Sheldon's method of somatotyping physique is classified into a continuum of three components, namely, endomorphy (softness and roundness), mesomorphy (angularity and muscularity), and ectomorphy (linearity). Each of these three components is given a numerical rating[1-7]; accordingly, the numerical value of these ratings may be employed in calculating correlation coefficients. Thus a 3-7-1 somatotype would be an individual who possesses three degrees of endomorphy, seven degrees (maximal) of mesomorphy, and one degree (minimal) of ectomorphy.

TABLE II. COEFFICIENTS OF CORRELATION BETWEEN AXIS DEVIATION (ECG) AND SOMATOTYPE DOMINANCES

Endomorphy	− 0.37 ±0.07*
Mesomorphy	− 0.15 ±0.08
Ectomorphy	+ 0.34 ±0.07*

*Highly significant ($p > 0.01$).

RESULTS

The coefficients of correlation on the 144 individuals between axis deviation and various anthropometric measurements are presented in Tables I and II.

*These were accomplished by Dr. Stanley M. Garn of Harvard University.

TABLE III.

NO.	AXIS DEVIATION	SOMATOTYPE	WT.	HT.	PONDERAL INDEX $\left(\frac{\text{HT.}}{\sqrt[3]{\text{WT.}}}\right)$
1	−40	5 –2 –3	181	172	11.9
2	−30	$4-4-2^2$	175	173	12.1
3	−30	2 –4 –5	171	177	12.6
4	−30	$2-3-5^2$	172	182	12.9
5	−28	$4-5^2-1$	194	178	12.1
6	−22	$3-4^2-3$	195	184	12.5
7	−15	5^2-4-2	195	177	12.0
8	−15	$5-4^2-2$	190	184	12.6
9	−10	$4-4^2-2$	177	174	12.2
10	− 3	$6-6^2-1$	235	178	10.9
11	− 3	4 –3 –4	170	177	12.5
12	0	$6-4^2-1$	205	175	11.7
13	0	$6-3-2^2$	179	174	12.1
14	+ 5	$6-3^2-1$	163	162	11.6
15	+ 7	4^2-5-1	216	179	11.7
16	+ 8	3 –6 –1	188	170	11.7
17	+10	$5-4-2^2$	190	182	12.4
18	+10	$4-5^2-1$	194	175	11.9
19	+12	5 –4 –2	190	184	12.6
20	+12	4 –5 –2	185	172	11.9
21	+12	4 –4 –3	155	171	12.6
22	+13	4 –5 –3	208	192	12.7
23	+15	5 –6 –1	196	171	11.6
24	+19	6 –4 –1	231	190	12.2
25	+19	5 –4 –2	215	187	12.2
26	+20	6 –4 –1	189	178	12.1
27	+20	5 –5 –1	250	192	11.9
28	+20	4 –5 –2	161	165	11.9
29	+21	6 –5 –1	238	178	11.2
30	+21	5 –4 –1	171	172	12.2
31	+24	5 –3 –2	185	178	12.2
32	+25	5 –4 –2	178	183	12.8
33	+25	4^2-5-2	178	169	11.8
34	+26	5 –2 –3	175	177	12.4
35	+28	6^2-3-2	204	178	11.9
36	+29	6 –4 –1	176	170	12.0
37	+29	6 –3 –1	179	167	11.7
38	+30	$6-4^2-1$	230	186	11.9
39	+30	5 –5 –1	200	168	11.3
40	+39	5 –4 –2	170	174	12.3
41	+30	5 –4 –1	185	176	12.2
42	+30	5 –6 –1	206	179	11.9
43	+30	5 –5 –2	187	175	12.1
44	+30	3^2-6-1	191	175	12.0
45	+30	$3-4^2-3$	164	179	12.9
46	+30	3 –4 –3	181	182	12.6
47	+30	$2^2-3^2-2^2$	168	172	12.4
48	+30	2 –3 –5	134	165	12.7
49	+30	$3-5^2-2$	154	169	12.3
50	+33	2 –3 –6	165	186	13.3
51	+35	$5-4^2-2$	186	181	12.5
52	+35	4 –5 –1	180	169	11.8
53	+37	5 –5 –1	200	168	11.3
54	+39	4 –2 –4	142	173	13.0
55	+41	5^2-3-1	213	178	11.7
56	+41	$4-5^2-1$	187	186	12.8
57	+41	$4-3^2-4$	167	194	13.9
58	+42	5^2-5-1	163	165	11.9
59	+43	7 –3 –2	177	168	11.7

TABLE III.—CONTINUED

NO.	AXIS DEVIATION	SOMATOTYPE	WT.	HT.	PONDERAL INDEX $\left(\frac{\text{HT.}}{\sqrt[3]{\text{WT.}}}\right)$
60	+43	3-2-5	170	181	12.8
61	+43	2-4-4	148	174	12.2
62	+43	5-3-2	186	175	12.1
63	+43	3-6-2	204	185	12.4
64	+44	4-5-2	174	168	11.8
65	+45	6-3-2	200	177	11.9
66	+46	4^2-3-3	180	181	12.2
67	+46	2^2-3-5	143	170	12.8
68	+47	6-3^2-1	195	172	11.5
69	+47	2-3^2-5	134	168	12.9
70	+48	5^2-4^2-2	177	172	12.0
71	+48	5-2^2-4	151	169	12.5
72	+48	3-4-4	152	172	12.7
73	+49	4-3-3^2	178	177	12.4
74	+50	4-4-2^2	170	173	12.2
75	+50	4-3-3	178	176	12.3
76	+50	3-5-3	175	179	12.6
77	+52	5-2-3	191	188	12.8
78	+52	5-3-2	162	171	12.3
79	+53	5-3-2	154	169	12.4
80	+54	4-3^2-4	163	170	12.2
81	+54	3-3^2-4	165	179	12.8
82	+54	2-3-5	156	179	13.1
83	+55	5^2-4-2	191	177	12.1
84	+55	5-4-1	174	171	12.0
85	+55	3-5-2	176	185	12.3
86	+55	2-5^2-3^2	174	176	12.4
87	+56	3^2-3-5	164	176	12.6
88	+56	2-3-5	133	166	12.8
89	+57	6-3^2-1	158	164	11.8
90	+57	6-3^2-1	188	176	11.9
91	+57	3-4-4	183	178	12.8
92	+58	4-3-3	175	179	12.6
93	+58	4-3-4	165	180	12.9
94	+59	4-5-2	182	181	12.8
95	+59	3-4^2-3	157	175	12.8
96	+59	2-3-6	164	182	13.1
97	+59	1-3-6	170	195	13.8
98	+60	4-4^2-2	184	178	12.3
99	+60	4-3^2-4	157	173	12.6
100	+60	3^2-4-3^2	172	178	12.6
101	+60	3-4-4	172	180	12.7
102	+60	2^2-4-5	150	173	12.8
103	+62	6-3^2-2^2	190	175	12.0
104	+62	2^2-3-6	177	183	12.8
105	+62	2-3-5	136	165	12.6
106	+63	7-3-1	225	177	11.4
107	+64	5-4^2-1	191	169	11.5
108	+64	5-4-2	170	176	12.5
109	+64	4^2-3-3	153	164	12.1
110	+64	4-3-4	193	185	12.6
111	+64	4-4-4^2	155	174	12.7
112	+68	6^2-4-1	210	178	11.7
113	+68	5-4-1	194	173	11.7
114	+68	4-6-2	220	182	11.8
115	+68	3-5^2-1	186	176	12.1
116	+68	4-4-2	155	166	12.1
117	+68	2-3-6	157	184	13.4
118	+69	6-3-2	180	174	12.1

TABLE III.—CONTINUED

NO.	AXIS DEVIATION	SOMATOTYPE	WT.	HT.	PONDERAL INDEX $\left(\frac{\text{HT.}}{\sqrt[3]{\text{WT.}}}\right)$
119	+70	6^2-3-1	190	172	11.8
120	+70	2^2-2^2-6	138	171	13.0
121	+71	2-6-1	177	171	12.0
122	+71	3-4-3	189	183	12.5
123	+72	4-3-4	176	180	12.7
124	+73	2-3-6	144	173	13.0
125	+75	3-3-5	158	179	13.0
126	+76	2-3^2-5	156	177	12.9
127	+77	2^2-2-6	136	181	13.8
128	+78	4-5-2	164	173	12.4
129	+80	3^2-5-2	177	178	12.4
130	+82	5-6-1	177	172	12.0
131	+82	2-4-5	171	180	12.8
132	+82	1-4-5	179	190	13.3
133	+83	1-3-6	147	176	13.1
134	+85	3-2-5	144	169	12.7
135	+90	4-6-1	174	172	12.1
136	+90	2-5-4	161	172	12.4
137	+90	3^2-3^2-4	169	177	12.6
138	+90	3-2-5	188	194	13.3
139	+90	3-2-6	160	187	13.5
140	+90	2-1^2-6	121	176	14.0
141	+90	1^2-2-6^2	135	185	14.2
142	+94	2-3-6	154	179	13.2
143	+109	4-4-4	153	174	12.8
144	+110	5-4^2-2	203	188	12.5

These correlations indicate (1) no significant correlation between axis deviation and (a) height or (b) sternal ensiform measurements; (2) moderately significant negative correlations ($p > 0.05$) between axis deviation and (a) chest depth and (b) chest ratio; (3) highly significant negative correlations between axis deviation and (a) chest width and (b) weight, and a highly significant positive correlation with ponderal index.

In Table II the highly significant negative correlation between axis deviation and endomorphy (obesity) and the highly significant positive correlation between axis deviation and ectomorphy (linearity) are what may be expected from the anthropometric data. Accordingly, it may be stated that with increasing obesity (not muscularity) the electrocardiographic axis tends to shift more toward the "left," while the more linear (thin) the individual is, the more the electrocardiographic axis tends to shift towards the "right" in the normal individual.

DISCUSSION

The coefficients of correlation presented in Tables I and II bear out the general concept that physical causes affecting heart position influence the electrocardiogram in regard to axis deviation as manifested by the QRS complex. It is interesting to note that the axis deviation is influenced more by the physical attributes in the horizontal plane than in the vertical plane. This is further corroborated by the insignificant correlations between axis deviation and height, and sternal ensiform measurements, which represent vertical measurements. The only other measurable variable in this study which revealed no significant correlation is the mesomorphic component. This is further substantiated by the other significant correlations since no correlation would be expected in the individual who is predominantly muscular, other than the contribution of muscularity to the horizontal plane.

Chest depth and chest ratio (depth/width) show a significant negative coefficient of correlation ($p > 0.05$). These observations may be interpreted as meaning that the greater the chest depth in an individual, the greater the tendency toward left axis deviation; the resulting effect is probably due to the effect of the shape of the thoracic cage on the cardiac position.

The highly significant negative coefficients of correlation ($p > 0.01$) include weight, endomorphy (obesity), and chest width, and are interpreted by us as meaning that the greater the obesity (weight, endomorphy, and increased chest ratio) the greater the tendency toward left axis deviation. The reverse is also true, in that the greater the diminution of these measurements (weight, endomorphy, and chest ratio) the greater the tendency toward right axis deviation. This statement is supported by the highly significant positive correlation between axis deviation and (1) ectomorphy and (2) ponderal index (that is, the less compact an individual, the greater the tendency to right axis deviation).

The only procedure of vectorial relationships included in this study is the axis deviation or the two-dimensional configuration which is, in essence, the frontal plane projection. However, since the heart is considered to be a volume conductor, it is reasonable to suggest that by incorporating a third dimension or spatial configuration, it may be possible to report even higher and more significant correlations between body build and the heart position as determined by vectorial methods, which probably define more accurately the electrical potentials arising from the heart within the thoracic cage.[11]

With the technique of somatotyping, a more reliable index in body build is given for predicting axis deviation in a certain physique. Where somatotyping is not available, it is suggested that the ponderal index be employed in addition to the usual method of description of tall, short, medium, etc., or other criteria that cannot give a reliable index as to the physique. It is believed that by incorporating such data with the clinical description more accurate interpretations of the electrocardiographic pattern would be possible.

SUMMARY

1. Coefficients of correlation between measurable variables of physique and axis deviation are reported.

2. In the subjects studied, axis deviation is influenced more by horizontal configuration than by linearity. In general it may be stated that there is an association between the degree of "compactness" of the individual and the tendency to left axis deviation. In the absence of endomorphy (and perhaps mesomorphy), there is an association between the tendency to right axis deviation and the degree of ectomorphy of the subject.

3. Sheldon's index of body build is presented and offers a more satisfactory measurement in correlating axis deviation with structural variations.

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