A TRIAL AND FORMULATION OF REGRESSION
EQUATIONS OF RV_5 ON SEVERAL CONSTITUTIONAL
VARIABLES INCLUDING AGE
—RELATIONSHIP BETWEEN ELECTROCARDIOGRAM
AND BODY-BUILD—

ETSU HASHIDA, KUNIO RIN, TAKAHISA INOUE,*
CHOOICHIRO ASANO, SHUNITSU HATANAKA,
YOSHIFUMI TOYAMA, AND AKIO YODEN**

THE so-called normal electrocardiogram of healthy subjects without heart disease shows differences with age, sex and body-build and, therefore, should be discussed at least by classifying the subjects according to age and sex. The normal values of the amplitudes of the standard twelve lead electrocardiogram have been published by the New York Heart Association¹ and by Simonson.² The former deals with only the normal values for heterogeneous groups of subjects classified according to age, 0 to 1 year and thereafter by every ten years, and takes no account of variations with sex and body-build. The latter monograph takes account of variations in sex and body-build but deals with the groups of normal subjects over twenty years of age, classified by every twenty years thereafter. Although it is appropriate for the latter to strongly point out differences between sexes, the subjects studied deviated in that they were mostly railroad employees; hence there was no sufficient consideration on the influence of the body-build on the electrocardiogram. Electrocardiographic deflections show considerable differences be-

tween age intervals of 1 to 2 years when infants and school children who are growing rapidly become the object of the study, and, therefore, the normal values should be most desirably provided for classes with the age-intervals of 1 to 2 years. The case is practically the same with vectorcardiogram as well as corrected orthogonal electrocardiogram. Even if, for example, data indicating the presence of highly significant simple and/or multiple correlations of the R and T waves on Z-axis with the age and body weight were obtained,³ it represents no more than a numerical expression of what is evident by inspection. The parameters usually employed for the expression of body-build such as body height, body weight, chest circumference and sitting height are mutually highly correlated. Consequently, even if linear regression analysis performed by taking an electrocardiographic deflection, e.g., RV_5 as a random variable and these parameters as fixed variables, yields a significant regression coefficient or a significant multiple correlation coefficient, the results obtained cannot directly be construed as appropriate because of their multicollinearity.

These considerations stress vital needs for pursuit of studies with much account taken of the problems heretofore pointed out. The present investigation, therefore, seems to be of value

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* Department of Internal Medicine, Health Insurance Hospital of Shiga, Fujimidai, Otsu

** Shionogi Computing Center for Mathematical, Statistical and Biomedical Analysis,
Dosho-machi, Higashi-ku, Osaka

TABLE I LINEAR REGRESSION ANALYSIS—RELATIONSHIP BETWEEN RV_5 , AND BODY HEIGHT (X_1), BODY WEIGHT (X_2), CHEST CIRCUMFERENCE (X_3) AND SITTING HEIGHT (X_4)

Sex	Body-build	No. of subjects	$a/(X_3)^2$			$b/(X_3)$			$c/(X_3)$		
			a^+	error variance	Fo	b^+	error variance	Fo	c^+	error variance	Fo
male	normal + obese	100	1479,080*	1,501.09	3.490	37,318.2*	1,523.34	3.258	-2.694	1,648.46	1.611
	normal + obese	110	63,376	2,234.82	0.173	983.4	2,235.22	0.107	0.117	2,235.23	0.103
male	normal	70	1101,150	1,471.28	1.974	29,638.6*	1,465.33	2.043	-5.026*	1,458.17	2.125
female	normal	64	-353,471	2,846.23	0.590	-10,363.5	2,842.42	0.654	2.019	2,835.97	0.750
male	obese	30	1396,230	1,365.61	1.346	32,468.5	1,351.67	1.445	-3.377	1,347.93	1.471
female	obese	46	408,515	1,537.14	0.837	7,913.0	1,544.20	0.654	-0.422	1,559.12	0.362

* : Significant at 5 per cent level. + : a, b, and c are regression coefficients in each case.

Correlation Coefficients between X_1 , X_2 , X_3 , and X_4 in 70 male subjects of 13 to 14 years of age

	mean	S.D.	X_1	X_2	X_3	X_4
X_1	160.0	8.76		0.39	-0.12	0.55
X_2	49.1	8.11	0.87		0.82	0.37
X_3	78.9	4.80	0.71	0.90		-0.27
X_4	85.6	4.65	0.89	0.84	0.65	

Correlation Coefficients between X_1 , X_2 , X_3 , and X_4 in 64 female subjects of 13 to 14 years of age

	mean	S.D.	X_1	X_2	X_3	X_4
X_1	154.1	5.50		0.53	-0.38	0.72
X_2	46.4	5.84	0.64		0.77	-0.12
X_3	76.5	4.38	0.41	0.79		0.35
X_4	83.8	3.04	0.78	0.55	0.49	

In lower 2 tables: downside up; simple correlation coefficients.

upside down; partial correlation coefficients.

Almost all of these correlation coefficients indicate highly significant correlation.

insomuch as it involves adequate consideration in these respects.

SUBJECTS AND METHODS

As shown in Table I, 134 subjects of normal body-build at 13 to 14 years of age, 70 male and

64 female, and 76 subjects with the same age showing *Rohrer's* index over 160, 30 male and 46 female, were admitted to the present study. Linear regression analyses performed taking RV_5 as a random variable and body height, body weight, chest circumference and sitting height as

TABLE II MULTIPLE AND PARTIAL CORRELATION COEFFICIENTS—RELATIONSHIP BETWEEN RV_5 , AND BODY HEIGHT (X_1), BODY WEIGHT (X_2), CHEST CIRCUMFERENCE (X_3), AND SITTING HEIGHT (X_4)

Multiple correlation coefficients								
		$1/(X_3)^2$			$1/(X_3)$		(X_3)	
Sex	body-build	No. of subjects	multiple correlation	Fo	multiple correlation	Fo	multiple correlation	Fo
male	normal + obese	100	0.565**	11.163	0.557**	10.675	0.503**	8.062
female	normal + obese	110	0.316*	2.904	0.315*	2.899	0.315*	2.899
male	normal	70	0.287	1.462	0.295	1.554	0.302	1.625
female	normal	64	0.162	0.399	0.167	0.423	0.173	0.456
male	obese	30	0.361	0.937	0.372	1.006	0.376	1.030
female	obese	46	0.289	0.936	0.282	0.889	0.266	0.782
Partial correlation coefficients								
		$1/(X_3)^2$			$1/(X_3)$		(X_3)	
Sex	body-build	No. of subjects	partial correlation	to	partial correlation	to	partial correlation	to
male	normal + obese	100	0.336**	3.480	0.317**	3.257	-0.163	-1.611
female	normal + obese	110	0.017	0.172	0.011	0.115	0.010	0.103
male	normal	70	0.237	1.969	0.247*	2.058	-0.255*	-2.124
female	normal	64	-0.076	-0.585	-0.086	-0.661	0.097	0.750
male	obese	30	0.260	1.347	0.277	1.439	-0.282	-1.470
female	obese	46	0.129	0.838	0.113	0.727	-0.057	-0.363

* : significant at 5 per cent level.

** : significant at 1 per cent level.

TABLE III AGE, SEX, BODY-BUILD, DEGREE OF HARDNESS OF SPORTS, AND MEANS (M) AND STANDARD DEVIATIONS (S.D.) OF PARAMETERS EXPRESSING BODY-BUILD

Sex	Age (yr.)	Body-build and/or degree of hardness of sports	body height (cm)		body weight (kg)		chest circumference (cm)		sitting height (cm)		No. of case
			M.	S.D.	M.	S.D.	M.	S.D.	M.	S.D.	
male	13-14	normal, none	160.0	8.8	49.1	8.1	78.9	4.8	85.6	4.7	70
	13-14	obese, none	154.2	7.7	64.5	12.0	92.6	9.2	83.5	4.5	30
	about 20	normal, none	168.7	5.2	58.2	6.3	85.8	4.8	89.8	2.9	80
	about 20	normal, not hard	168.9	4.9	59.5	6.5	87.5	4.5	89.8	3.0	99
	about 20	normal, hard	169.1	5.3	62.3	8.0	89.9	5.3	90.0	3.1	99
female	13-14	normal, none	154.1	5.5	46.4	5.8	76.5	4.4	83.8	3.0	64
	13-14	obese, none	152.7	5.5	62.7	9.7	90.4	9.6	84.5	2.9	46
	about 20	normal, none	155.6	5.0	52.3	6.5	82.5	4.6	84.7	2.8	90
	about 20	normal, not hard	156.7	4.2	51.6	4.4	82.4	3.2	84.5	2.7	78

fixed variables respectively, failed to show any significant correlations partly because of the presence of multicollinear relationships among the fixed variables as can be seen from the data presented in the lower half of Table I, nor did regression analyses performed separately in these four groups of children yield any practically significant regression coefficients. By contrast, the same statistical analyses performed in a group of 100 male subjects and another of 110 female subjects, pooling those of normal body-build with children of obese constitution, relatively frequently brought forward significant correlation coefficients although it remained unknown whether this phenomenon represented merely apparent correlations derived from dealing with the qualitatively different groups in the lump. Furthermore, as can be noted from Table II, when the F-values and t-values were determined by taking the chest circumference as it was, $1/(\text{chest circumference})$, or $1/(\text{chest circumference})^2$, the F-values obtained increased in that order in general and the multiple and partial correlation coefficients, too, increased accordingly. Therefore, it is an important task which parameters were chosen to indicate the body-build. In order to clarify these circumstances, as shown in Table III, male subjects of 13 to 14 years and about 20 years of age having no heart disease were divided into two to three groups, i.e., subjects who were compelled to "hard training" in such as boxing, jūdo, field and track events, and so forth, those who took part in "not-

hard" athletic activities other than the foregoing, and others who did not belong to any athletic clubs at all. Females of comparable physiological conditions and age were also selected and divided into two groups, i.e., those belonging to athletic clubs and others. This classification was based on the generally accepted views that physical exercises have influence on the heart and therefore upon the electrocardiogram. Apart from this, five age-groups of either sex (i.e., 13, 14, 15, 16 and about 20 years of age) were studied to examine for age-related electrocardiographic changes, by determining regression equations by the backward elimination procedure taking RV_5 as a random variable and age as a fixed variable respectively. The samples constituting these eight age-groups (13, 14, 15 and 16 years) were in an environment virtually comparable to those with normal body-build in Table III, and the samples constituting the other two age-groups (about 20 years) were the subjects of normal body-build who were not doing any particular sports in Table III. According to *Draper and Smith*,⁴ the best regression equation should include all the fixed variables as many as practicable that are deemed necessary and all the functions such as, for example, geometrical products, squares, and their reciprocals and thereby aimed at determination of the reliable fitting value or values. However, insomuch as incorporation of numerous fixed variables into the regression equation inevitably leads to increases in time and cost, it is desirable to employ fixed variables as few as

TABLE IV PARAMETERS EXPRESSING BODY-BUILD ADOPTED IN THIS STUDY

Measure No. of items	body height	body weight	(chest circum- ference) ²	sitting height	$\left(\frac{\text{chest depth} \times}{\text{chest width}}\right)^{-1}$	$\left(\frac{\text{sitting height} \times}{\text{chest depth} \times \text{chest width}}\right)^{-1}$	(chest depth) ²	(chest width) ²	chest depth	chest width
4										
6										
8										
10										

possible. We decided, consequently, to adopt the backward elimination procedure and the stepwise regression procedure as the most desirable measures for the present purposes. With the former procedure, a regression equation involving all the fixed variables was obtained and, thereafter, the partial F-testing values were calculated by treating all the variables concerned as if they were variables finally introduced into the regression equation; and if the lowest partial F-testing value obtained proved to be less than the preset value of some significance level it was eliminated from consideration, and the same procedure was repeated with the remaining variables to eliminate all removable variables. With the latter analytical procedure, a simple correlation matrix was prepared and the fixed variable showing the highest correlation with the random variable was introduced into the regression equation and the highest partial correlation coefficient between the remaining fixed variables and the random variable was calculated; and the fixed variable showing the highest correlation was then introduced into the regression equation to determine the partial F-testing value for the introduced fixed variable and, if this partial F-testing value proved statistically significant, it was left as it was and computation was further continued in search for partial correlation coefficients between the remaining fixed variables and the random variable successively to cover all the fixed variables involved. These methods are applicable no matter how multicollinear relationship is existent or not, and permit analyses without neglecting any of the fixed variables that have to be taken into account.

It is also one of the important problems which are chosen as the fixed variables. The component of the heart dipole which is believed to indicate the cardiac electromotive force, according to *Barber and Fischmann*,⁵ is equal to the quotient obtained by dividing the product of the lead voltage in the direction of the axis involved and the body surface area orthogonal to this axis by the mean resistivity of the human body. That is to say, the relationship of

$$M = VA/\rho$$

where M is the component of the heart dipole, V represents the lead voltage in the direction of the axis involved, and ρ the mean resistivity of the human body, respectively. The reason why such a manipulation was required is that the amplitude on the orthogonal axis in the corrected orthogonal lead, e.g., Frank system, does not

TABLE V STEPWISE REGRESSION PROCEDURE BETWEEN SAGITTALLY DIRECTED DIPOLE

	4 items					6 items				
	N.H.**		H***		N.H.		N.H.		H	
	male*	male	male	female*	female	male*	male	male	female*	female
RV_5	4.98	N.S.****	14.1	N.S.	N.S.	4.98	N.S.	14.1	N.S.	N.S.
	X_4		X_2			X_4		X_2		
$RV_5 \times (X_4 \times X_6)$	N.S.	6.53	39.6	8.49	N.S.	6.86	36.8	24.1	10.1	N.S.
		X_2	X_2	X_2		X_6	X_6	X_2	X_6	
								X_6		
$RV_5 + SV_1$	7.13	N.S.	4.37	N.S.	N.S.	7.13	N.S.	4.37	N.S.	N.S.
	X_4		X_4			X_4		X_4		
$(RV_5 + SV_1) \times (X_4 \times X_6)$	N.S.	N.S.	9.07	4.59	N.S.	4.85	30.4	18.3	21.1	N.S.
			X_2	X_2		X_6	X_6	X_4	X_6	
			X_4			X_4		X_6		

Numbers indicate F-values * : not engaged in sports ** : engaged in not-hard sports
 X_1 : Body height, X_2 : Body weight, X_3 : Chest circumference, X_4 : Sitting height

change markedly in accordance with physical growth inasmuch as the increase in cardiac electromotive force associated with bodily growth tends to be masked by the concurrent increase of the chest size. Therefore, it is most desirable to adopt such as the equation of Barber and Fischmann in order to examine for the component of cardiac dipole.⁶ However, there do exist views that the amplitudes of the electrocardiogram in the corrected orthogonal system change substantially in association with alterations in the age, body height, body weight, chest circumference, and so forth,⁷ and, in view of this, we studied on the following four cases:

Case 1: RV_5

Case 2: $RV_5 \times (\text{sitting height} \times \text{chest depth})$

Case 3: $SV_1 + RV_5$

Case 4: $(SV_1 + RV_5) \times (\text{sitting height} \times \text{chest depth})$

The RV_5 and $(SV_1 + RV_5)$ were employed as the approximate values for lead voltage of the electromotive force in the sagittal direction parallel to the frontal plane, and the (sitting height $\times$ chest depth) as the approximate value for body surface area perpendicular to the sagittal direc-

tion, respectively. The series of ten different parameters of body-build were adopted as shown in Table IV. The chest depth, chest width and their products and reciprocals as well as body height, body weight and sitting height were taken into account. The facts that the cardiac electromotive force existed within a volume conductor and that the potential recorded on the chest wall was inversely proportional to the square of distance from the center of the heart electromotive force, and so forth, too, were reflected in these analyses.

RESULTS

Regression equations were sought by the backward elimination procedure, taking RV_5 as a random variable and age as a fixed variable respectively, with the following results:

$$\text{Male: } y = 114.37 - 16.36X + 2.56X^{3/2}$$

F-testing value, 49.28; standard deviation of residual errors, 4.52

$$\text{Female: } y = 208.61 - 93.44X^{1/2} + 11.15X$$

F-testing value, 22.67; standard deviation of residual errors, 3.96

MOMENT AND PARAMETERS EXPRESSING BODY-BUILD IN ABOUT 20 YEAR-OLD SUBJECTS

8 items					10 items				
	N.H.	H.		N.H.		N.H.	H.		N.H.
male	male	male	female	female	male	male	male	female*	female
49.8	N.S.	14.1	N.S.	N.S.	4.98	N.S.	14.1	N.S.	N.S.
X_4		X_2			X_4		X_2		
7.67	33.4	23.5	19.4	N.S.	7.67	36.8	24.1	19.4	N.S.
$(X_6)^{-2}$	$(X_4 \times X_3 \times X_5)^{-1}$	$(X_4 \times X_6 \times X_5)^{-1}$	$(X_6 \times X_5)^{-1}$		$(X_6)^{-2}$	X_6	X_2	$(X_6 \times X_5)^{-1}$	
7.13	N.S.	4.37	N.S.	N.S.	7.13	N.S.	4.37	N.S.	N.S.
X_4		X_4			X_4		X_4		
5.88	24.1	15.3	20.9	N.S.	5.88	30.4	15.3	21.1	N.S.
$(X_6)^{-2}$	$(X_6)^{-2}$	$(X_4 \times X_6 \times X_5)^{-1}, (X_5)^{-2}$	$(X_3)^{-2}$		$(X_6)^{-2}$	X_6	$(X_4 \times X_6 \times X_5)^{-1}, (X_5)^{-2}$		

*** : engaged in hard sports **** : N.S. no significance
 X_5 : chest width, X_6 : chest depth

The results are shown graphically in Fig.1, where the vertical lines represent the respective means plus and minus standard errors. As evident from the graph, it is important to establish the normal values for every one to two year age-groups in these age ranges where the physical

Fig.1. Curves of the regression equations of RV_5 on age.

growth and development are very rapid. The powers of $3/2$ and $1/2$ were adopted in these equations as it seemed desirable to take such exponentials into account as a result of plotting the values of RV_5 against age. Table V shows the results of stepwise regression procedure and the F-testing values of the regression equations in the respective groups of subjects at about 20 years of age. As can be noted, the F-testing values for Case 2, or $RV_5 \times (\text{sitting height} \times \text{chest depth})$ proved to be the greatest. With Case 3 or $(RV_5 + SV_1)$, the results obtained are hardly interpretable since the sitting height alone emerged. When four fixed variables were involved, the body weight and nextly the sitting height emerged; and, similarly, when the number of fixed variables concerned was six, eight, and eight or ten, the chest depth and nextly the sitting height, $(\text{chest depth})^{-2}$ and $(\text{chest depth} \times \text{chest width})^{-1}$, and $(\text{chest depth} \times \text{chest width} \times \text{sitting height})^{-1}$ which represented the characteristics as volume conductor emerged respectively. Even though the F-testing values determined in relation to $RV_5 \times (\text{sitting height} \times \text{chest depth})$ was the highest, this fact possibly reflected the inclusion of (sitt-

TABLE VI MEANS (M) AND STANDARD DEVIATIONS (S.D.) OF SEVERAL ELECTROCARDIOGRAPHIC DEFLECTIONS FOR 446 HEALTHY MALES AND FEMALES OF ABOUT 20 YEARS OF AGE BY DEGREE OF HARDNESS OF SPORTS AND SEX GROUPS

Sex	male		male		male		female		female	
Degree of Hardness of Sports	none		not hard		hard		none		not hard	
	M.	S.D.	M.	S.D.	M.	S.D.	M.	S.D.	M.	S.D.
R _{II}	13.31	5.21	15.25	4.46	15.18	4.74	12.17	3.69	12.48	3.61
T _{II}	3.68	1.55	4.47	1.54	4.58	1.65	3.44	1.40	3.53	1.24
RaVF	10.91	5.09	13.21	4.85	12.63	4.61	9.94	3.93	9.73	3.50
TaVF	2.51	1.20	2.98	1.31	2.92	1.47	2.16	1.09	1.98	1.04
RV ₄	17.61	7.17	20.63	6.15	19.46	5.94	13.87	4.30	14.19	4.36
TV ₄	8.13	3.44	9.39	3.52	8.49	3.61	5.75	2.36	5.63	2.16
RV ₅	15.68	6.77	19.70	5.18	18.40	4.94	13.67	4.10	14.08	4.23
TV ₅	5.76	3.04	7.33	2.71	6.85	2.62	5.14	1.89	5.04	1.89
RV ₆	11.88	5.35	14.59	4.22	13.78	4.13	11.59	4.05	12.34	3.66
TV ₆	3.69	1.99	4.77	1.81	4.57	1.64	3.74	1.56	4.07	1.61

ing height $\times$ chest depth) into the random variables. Therefore, RV₅ or Case 1 was decided to be used thereafter as a random variable. The results of the backward elimination procedure were virtually the same as those obtained by the stepwise regression procedure. Accordingly the table which summarized these results was omitted.

As a result of regression analyses performed by taking RV₅ as a random variable and age, body height, body weight, chest circumference, sitting height and their transformed values as fixed variables, six different regression equations for either sex were obtained inasmuch as groups of 70 boys of normal body-build at 13 to 14 years of age, 30 obese boys of the same age, 80 male subjects of about 20 years of age, 64 girls of normal body-build at 13 to 14 years of age, 46 obese girls of the comparable age and 90 women at about 20 years of age (Table 3) were studied, where y stood for RV₅, x_1 for the body height, x_2 for the body weight, x_3 for the chest circumference, x_4 for the sitting height, and x_5 for the age, respectively. The calculations were also made with respect to cases with $1/(\text{chest circumference})^2$, with $(\text{age})^{1/2}$ and with $(\text{age})^{3/2}$ as well. As a result, the same equations were ob-

tained both with a backward elimination procedure and with a stepwise regression procedure, both displaying practically comparable degrees of significance of regression. With both sexes, the equations with $1/(\text{chest circumference})^2$ were found to give higher regression than those with the chest circumference itself. The results were:

$$\text{Male: } y = 18.167 + 66728 X_3^2 - 5.83 X_5$$

F-testing value, 22.93; standard deviation of residual errors, 5.46

$$\text{Female: } y = 8.023 + 41200 X_3^2$$

F-testing value, 11.18; standard deviation of residual errors, 4.23

DISCUSSION

It has long been known that the normal electrocardiogram showed differences by age, sex and body-build.^{1,2} As for variations related to age and sex, it appears that there exist no methodological problems as, for example, tests for differences in means of individual deflections of the electrocardiogram between sexes and among age-groups would suffice.² However, the types of distribution of the individual electrocardiographic deflections do not show always normal distribution, and, if at all, not all populations

are of equal variance. Furthermore the usual test procedure to assess differences of means is unapplicable to the populations of normal distribution with unequal variance. It follows, in a strict sense of the term that an appropriate normal transformation should be performed and followed by the t-test if the type of distribution is of equal variance, or by the Welch-test if of unequal variance.⁸ The problem of the greater importance lies in how the differences associated with the body-build appears and how to detect it from the electrocardiogram. *Simonson*² found that an "overweight" groups showed significantly smaller defections of the electrocardiogram in the precordial leads when samples admitted were classified into three groups according to body weight, i.e., "underweight", ideal weight and "overweight", and the data thereby obtained were examined by chi-square test. *Kilty et al.*⁹ studied the relationship of ponderal index with $R_I + S_{III}$, $RV_5 + SV_1$ and so forth. *Walker et al.*¹⁰ adopted height-weight index in a series of children. The orthodox procedure, nevertheless, consists in the study of interrelationship between the electrocardiographic deflections and the fundamental parameters expressing body-build such as the body height, body weight, chest circumference, sitting height and so forth.^{3,11-14} Even with such an orthodox procedure, however, a question of which of the two parameters – the specified electrocardiographic deflection (e.g., RV_5) and the geometrical product of it and body surface area – is to be taken as a random variable remains unsettled. Since a high multicollinearity exists among the body height, body weight, chest circumference, sitting height, and so forth, it is important to take advantage of it ingeniously on one hand and to eliminate unfavorable points that arise from it on the other hand, to make analyses for the present study. For these purposes we adopted the procedures of *Draper* and *Smith* and presented appropriate correction formulas. With the groups of male subjects, the formula eventually contained terms for the chest circumference and age, indicating that the amplitude of RV_5 diminished essentially when the chest circumference and age increased. With the groups of females, in contrast, the formula was found to contain the term for chest circumference alone to preclude that for age. This seems to stem possibly from less marked differences in the random and fixed variables other than age in females as compared to those in males (Table III and VI and Fig.1). While the chest depth was

noted to be conspicuously influential in the best regression equations for the groups of subjects at about 20 years of age (Tables IV and V), it seems that the chest depth became replaced with the chest circumference, and the body weight with age respectively, due to inclusion of age in the correction formulas. There were evidently significant differences in the mean values of RV_5 among the two or three groups of subjects of either sex in about 20 year old groups, classified according to the intensity of physical exercise, i.e., hard training, not-hard training, and no athletic activity (Table VI), but any correction formulas by body-build could not be obtained for these subgroups.

SUMMARY

In a series of healthy subjects ranging in age from 12 to about 20 years, having no cardiac disorders, the interrelationships between the amplitude of the R wave in lead V_5 and the various parameters of the body-build including age were clarified as follows:

1. When groups of subjects of comparable age were compared, evidence was obtained for significant differences to exist in these respects between the sexes.
2. Age-related differences in the electrocardiographic deflections are remarkably wide in the male subjects, whereas in the females at 15 to 16 years of age and in those at about 20 years, they were observed to be not significant.
3. Since a high multicollinearity exists among the parameters of the body-build, regression analyses on the relationship between the body-build and the electrocardiogram should involve adequate considerations of it. As a means for excluding this multicollinearity, we adopted the procedures of *Draper* and *Smith* and presented correction formula with age and chest circumference taken into due account.
4. Among the various parameters of the body-build employed, it was found to hold true for both sexes that $1/(\text{chest circumference})^2$ showed apparently greater regression than the chest circumference itself. Account should be taken, therefore, of the chest circumference in the interpretation of the electrocardiogram.
5. A question remains to be unsettled as to whether the amplitude of the R wave in lead V_5 itself is suitable or not to be taken as a random variable in the above-mentioned regression equation.
6. The intensity of physical exercise was observ-

ed to cause significant differences in the individual parameters of the body-build as well as the amplitude of lead V_5 , but statistical analyses failed to yield any appropriate correction formulas for them. This requires further consideration in the future.

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