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PHYSIOLOGICAL BASE-LINE STUDIES OF ZOOLOGICAL SPECIMENS

THE ELECTROCARDIOGRAM OF THE YOUNG CHIMPANZEE

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FOREWORD

The authors wish to express their appreciation to the following veterinary personnel at the Bioastronautics Research Laboratory at the Holloman Air Force Base, New Mexico: Major James E. Cook, USAF, VC; Captain Vernon Carter, USAF, VC; Captain William Britz, USAF, VC, and to the following technical personnel at the University of Texas Medical Center: Miss Mary Ellen Wolf, Mrs. Mary Coerver, Miss Sally Absten and Mr. William Hamilton for their valuable assistance and cooperation in this project.

ABSTRACT

Routine standard and precordial lead electrocardiograms were obtained on 36 chimpanzees in the range from 1 to 10 years. Analysis of the tracings relative to the duration of the electrocardiographic intervals, the amplitude of the waves, the mean electrical axes and cardiac rhythm was performed. The relationship of these electrocardiographic data to age, body weight and heart rate were studied and a comparison of these observations with children of comparable age and body weight was performed. Similar age and heart rate relationships in the electrocardiographic intervals of the human and chimpanzee were noted. Of particular interest were the findings of a lower amplitude and duration of the ventricular depolarization process (QRS) in the chimpanzee and a marked difference in the projection of the T waves. These observations on the electrocardiogram of the chimpanzee demonstrate the feasibility of obtaining and analysing the electrocardiogram in this animal and the applicability of the information derived to the understanding of the human electrocardiogram.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

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I. INTRODUCTION

Recent interest in the chimpanzee as an experimental subject for studies in space flight has prompted an evaluation of the normal cardiovascular parameters in this animal. Since previous studies on the primate electrocardiogram (1-4) include little information on the electrocardiogram of the chimpanzee, the present study on the normal limits of the electrocardiogram in this animal and their comparison with the human electrocardiogram was undertaken.

II. METHODS

Electrocardiographic tracings were obtained in 36 chimpanzees (Pan Species) presently inhabiting the animal colony at the Bioastronautics Research Laboratory AFMDC Holloman Air Force Base. All of the animals were procured from their natural habitat in the French Cameroons and at the time of the tracings ranged in estimated age from 1 to 10 years. There were 9 females and 27 males in the group. Standard techniques employed in man for obtaining and recording the electrocardiograms were followed in this study. All electrocardiographic tracings were obtained with the subject in the supine position. Wrist and ankle electrode attachments were employed in obtaining recordings of standard leads I, II, III and aVR, aVL and aVF. Precordial leads were recorded from the standard positions including leads V1, V3 and V5 in all of the animals, and V2, V4 and V6 in 15 of the group. An additional lead, the axillary lead (Ax) was obtained in 22 of the animals by fastening the right and left arm leads of standard lead I in the right and left axilla at the level of the second intercostal space, and recording from the lead I position. Electrodes were applied to glabrous or shaved areas. All tracings were obtained on a direct writing electrocardiogram (Cambridge Simple-Scribe apparatus) with a standardization of 1 millivolt equivalent to 10 millimeters of deflection, at a paper speed of 25 millimeters per second. Typical electrocardiograms on 3 of the animals are illustrated in Figure 1.

No pharmacologic preparation of the animals was employed. In order to minimize the emotional arousal from an unusual experience, each of the animals was introduced repeatedly to the techniques employed in the electrocardiographic laboratory over a period of several weeks prior to obtaining the tracings. Despite these maneuvers, movement and vocalizing were frequent during the recordings and arm and leg restraints were generally required. Aroused animals responded well to reassurance by the veterinarian staff so that complete tracings were recorded in every subject.

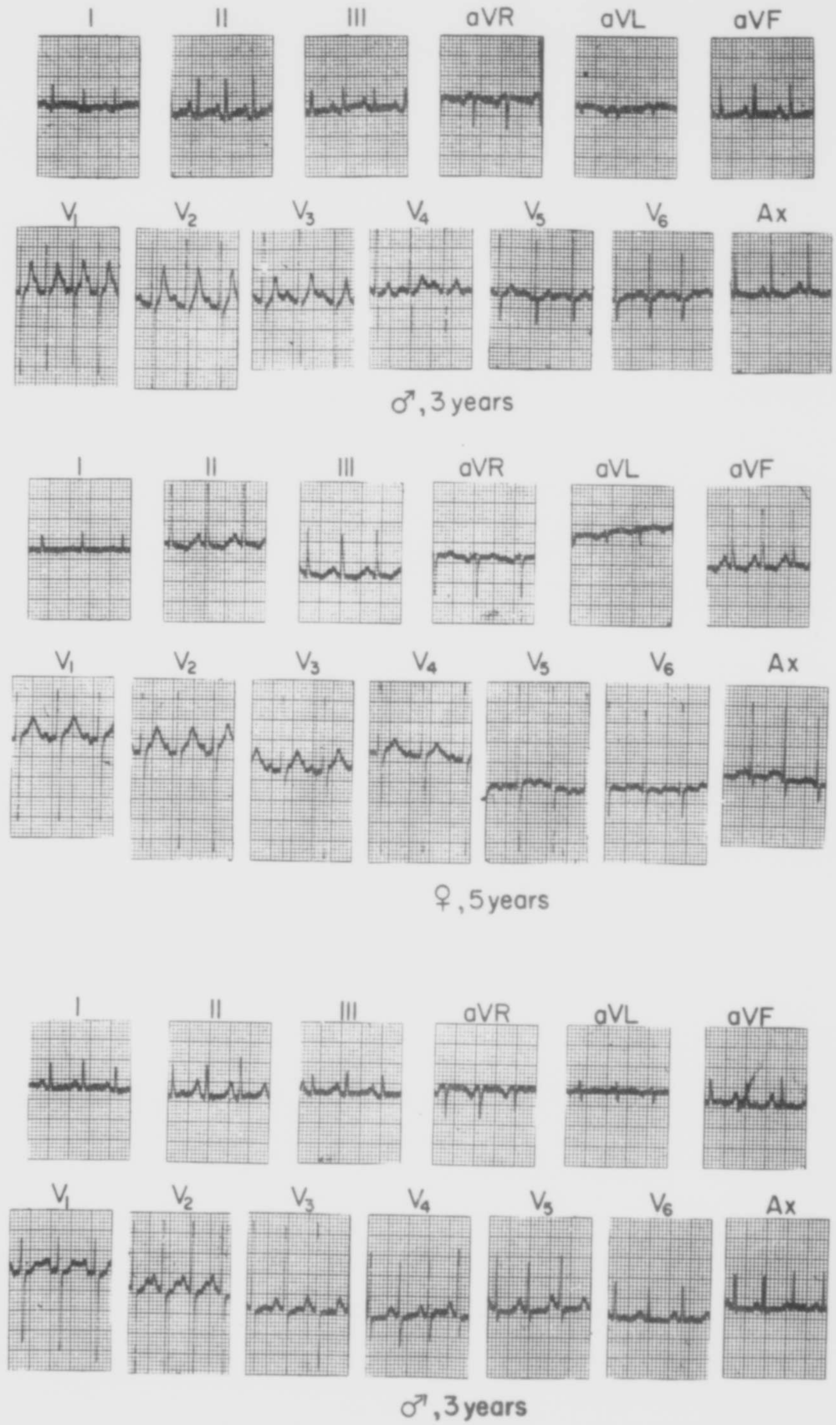

Figure 1. Representative Electrocardiograms in Three Young Chimpanzees

Analysis of the components of the electrocardiogram was performed according to the methods described by Birch and Windsor (5). Since spontaneous variations in heart rate were often observed measurement of the various electrocardiographic intervals including P, P-R, QRS, Q-T and T intervals are reported relative to the R-R interval in the lead in which they were measured. Because of the greater projection of the P wave in the standard leads (frontal plane), interval measurements relative to the P wave were made in the standard lead with the largest P deflection (usually standard lead II). Since the T wave projection was greatest in the precordial plane, all measurements of the intervals relating to the T wave were made in the precordial lead demonstrating the largest T deflection (usually V2 and V3). The QRS intervals were measured in both the standard and the precordial lead with the longest measurable QRS duration. The amplitudes of the P, Q, R, S and T waves were measured in each lead. Each recorded interval and amplitude represents the average of measurements made in five to ten complexes per lead. Determination of the mean P, QRS and T axes was performed according to the methods described by Grant (6).

Age estimates of the animals were made from dental eruption (7, 8). Statistical analysis of the data was performed according to the methods described by Snedecor (9). For the purposes of studying age trends the animals were divided into 3 age groups. Only the groups with the larger number of subjects (age groups 1 to 3 and 4 to 6) were compared statistically for age trends. The analysis of regression data was performed on an IBM 650 computer.

III. RESULTS

The animals studied represented an estimated age range from 1 to 10 years and a weight range from 11.5 to 102 pounds. In an attempt to study age trends in the data, the animals were divided into 3 groups, 1 to 3 years (20 animals), 4 to 6 years (13 animals), and 7 plus years (3 animals), (Figure 2). The weight distribution of the animals in these 3 groups is shown in Figure 3. The average heart rate of the 3 groups as derived from the standard limb leads is demonstrated in Figure 4. The bars in Figures 3 and 4 represent one standard deviation about the mean. The relative constancy in the mean and range of heart rates for the 3 groups permitted convenient analysis of the effects of age and/or body weight as well as the effects of heart rate on the various parameters measured in this study.

1. Interval Analysis

The P wave averaged .071 second and ranged from .04 to .10 second. The P-R interval ranged from .07 to .15 second and was related inversely to heart rate (Table 1, Figure 5). Regression analysis revealed significant

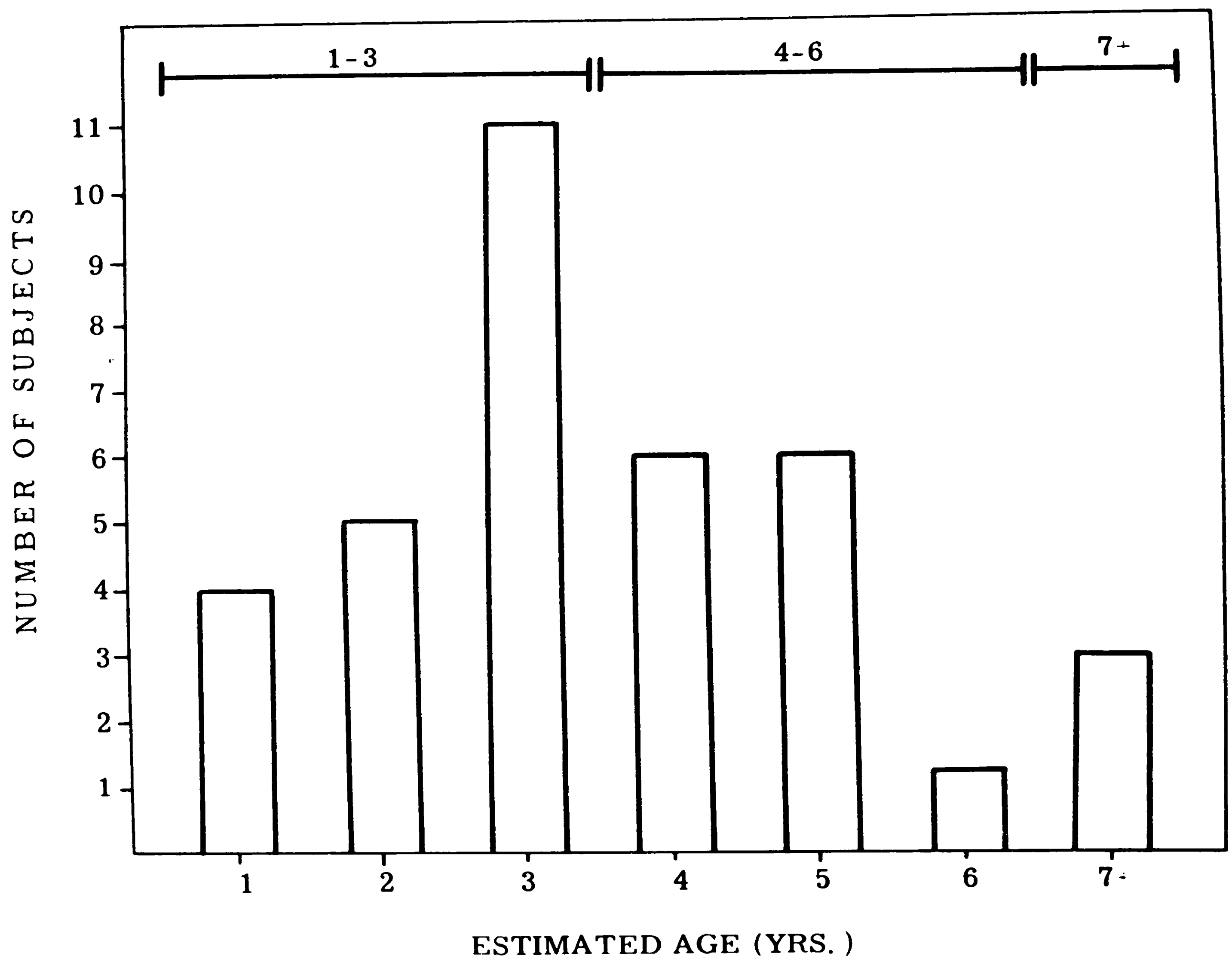

Figure 2. Age Distribution of the Animals Studied

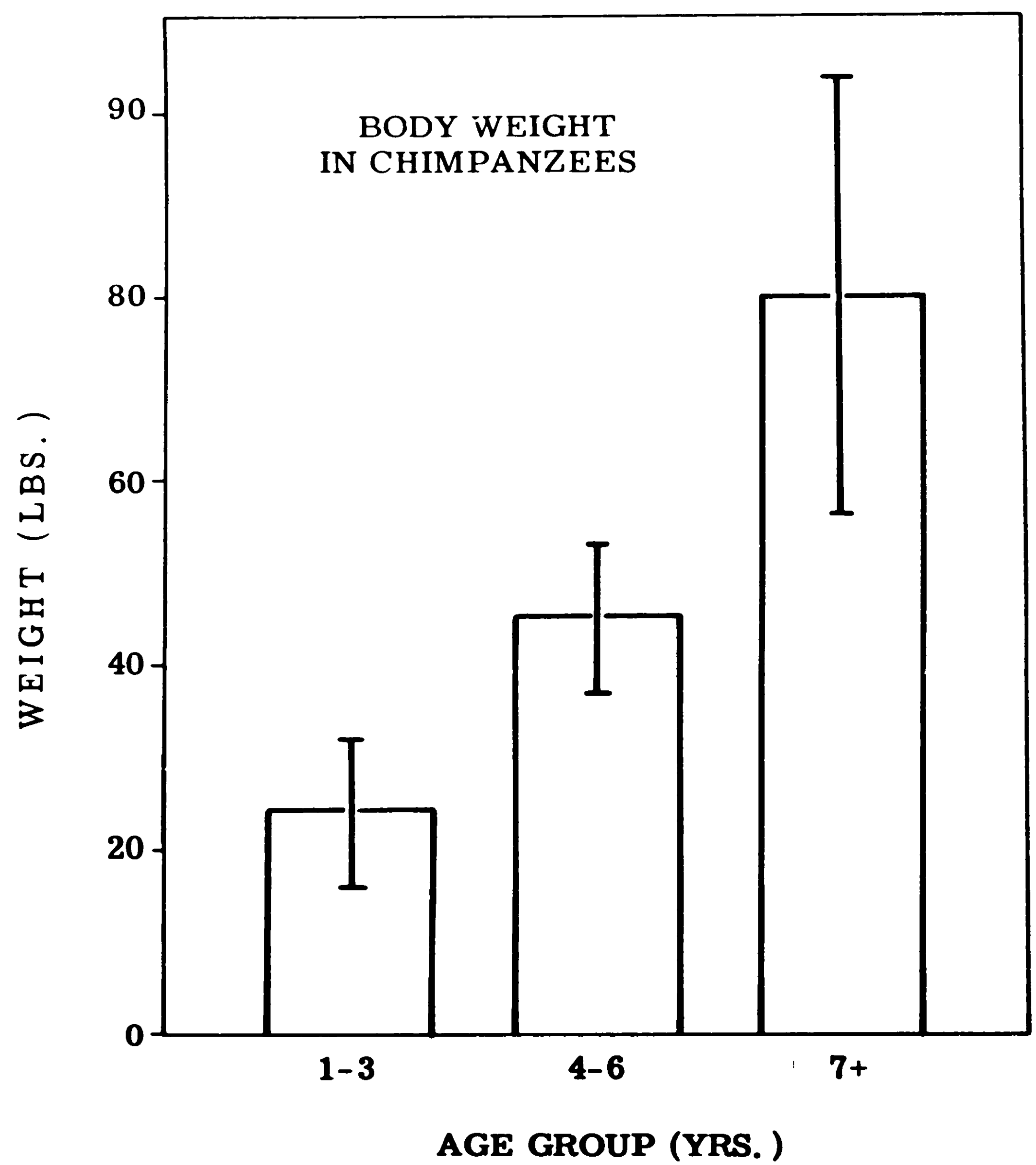

Figure 3. Body Weight in the Chimpanzees Grouped According to Age

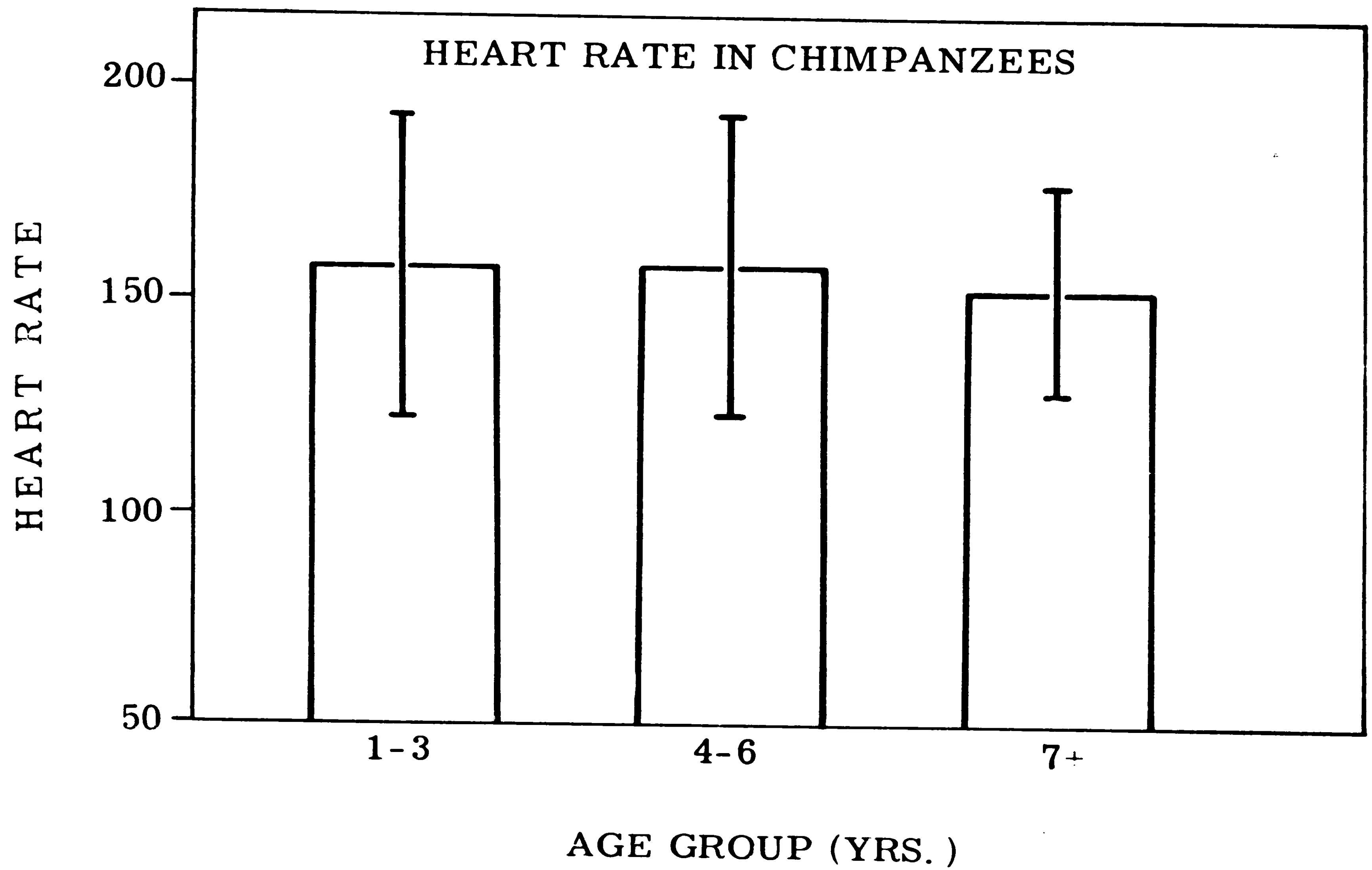

Figure 4. Heart Rate in the Chimpanzees Grouped According to Age

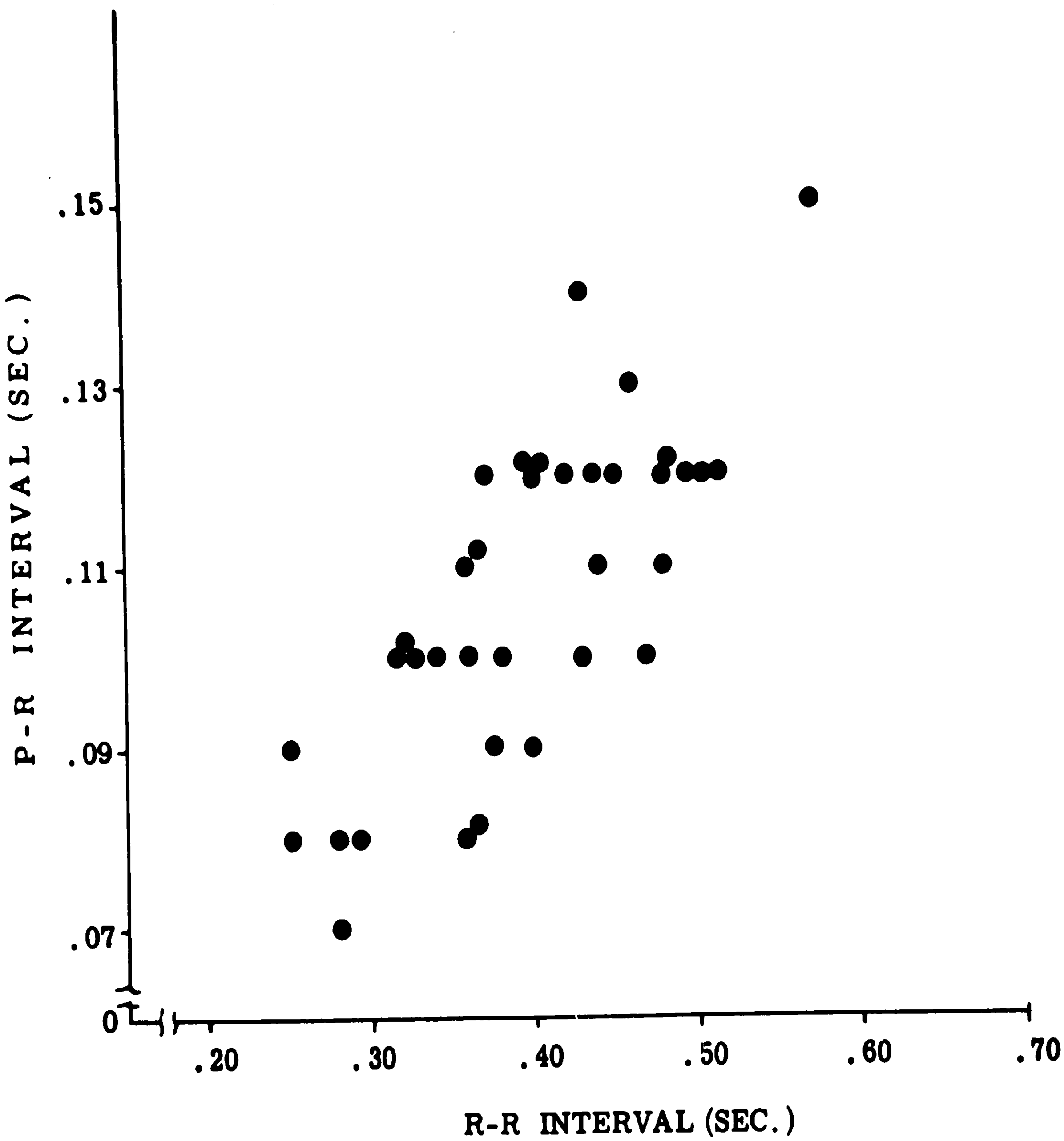

Figure 5. Relationship of P-R Interval to R-R Interval

Table 1. P-R INTERVAL RELATED TO AGE AND HEART RATE

HEART RATE	1 - 3 YEARS		4 - 6 YEARS		7+ YEARS	
	No.	Sec.	No.	Sec.	No.	Sec.
100 - 124	3	.12	1	.15		
125 - 149	5	.11	4	.12	2	.125
150 - 174	6	.10	5	.11		
175 - 199	3	.10	1	.10	1	.11
200 - 224	2	.075	1	.08		
225 - 249	1	.08	1	.09		

Table 2. DURATION OF P-R INTERVAL (AVERAGE DATA)

AGE GROUP	HEART RATE	P-R
1 - 3 Yrs.	159	.102
4 - 6 Yrs.	159	.110
7+ Yrs.	152	.120

linear relationships between the P-R interval and both the R-R ($p < .01$) and the square root of the R-R ($p < .01$) with equivalent variance about both regression lines. A tendency for the P-R interval to increase with age was also noted, ($p < .2$) (Table 2).

The QRS interval as measured from the standard leads ranged from .03 to .07 second and averaged .045 second (Table 3). In the precordial leads the QRS ranged from .03 to .08 second and averaged .047 second. A tendency for the QRS to vary inversely with heart rate was best observed in the four to six year age group. In addition, the QRS tended to increase slightly with age, ($p < .1$) (Table 4).

The Q-T interval ranged from .18 to .32 second. An inverse relationship of the Q-T to the heart rate was noted in all age groups, (Table 5, Figure 6). No significant age trend in the Q-T interval was noted (Table 6). Regression analysis revealed a significant linear relationship between the Q-T interval and both the R-R ($p < .01$) and the square root of R-R ($p < .01$) with slightly less variance about the Q-T/RR equation. The corrected Q-T interval, ($Q\text{-}T/\sqrt{RR}$), ranged from .34 to .43 and averaged .375. The S-T segment averaged .187 second and ranged from .14 to .28 second. The duration of the T wave averaged .122 second and ranged from .05 to .18 second. The electrocardiographic intervals in the axillary lead are summarized in Table 7.

2. Amplitude Analysis

Analysis of the data according to the average height of the P, Q, R, S and T waves is summarized in Tables 8 and 9. In the standard leads the P wave tended to be maximal and the T wave small. In contrast, in the precordial leads the P wave tended to be low while the T wave reached its maximal amplitude. Q waves were most frequently noted in the standard and left precordial leads. The Q waves were notably of low amplitude and of short duration, exceeding .02 second in only two animals, (.025 and .03 second respectively). The maximal amplitudes of both the R and S waves were found in the precordial leads. An R' was noted in eight of the animals appearing in leads III and aVF most frequently. Large initial downward deflections in lead aVR were considered S waves in the present study.

3. Mean Electrical Axes

The position of the mean electrical axes of the P, QRS and T waves as derived from the standard leads is illustrated in Figures 7, 8 and 9.

Table 3. QRS INTERVAL RELATED TO AGE AND HEART RATE*

HEART RATE	1 - 3 YEARS		4 - 6 YEARS		7+ YEARS	
	No.	Sec.	No.	Sec.	No.	Sec.
100 - 124	3	.04	1	.06		
125 - 149	5	.05	4	.05	2	.06
150 - 174	6	.04	5	.05		
175 - 199	3	.04	1	.04	1	.05
200 - 224	2	.05	1	.04		
225 - 249	1	.04	1	.04		

*Standard Leads

Table 4. DURATION OF QRS INTERVAL (AVERAGE DATA)*

AGE GROUP	HEART RATE	QRS
1 - 3 Yrs.	159	.043
4 - 6 Yrs.	159	.051
7+ Yrs.	152	.057

*Standard Leads

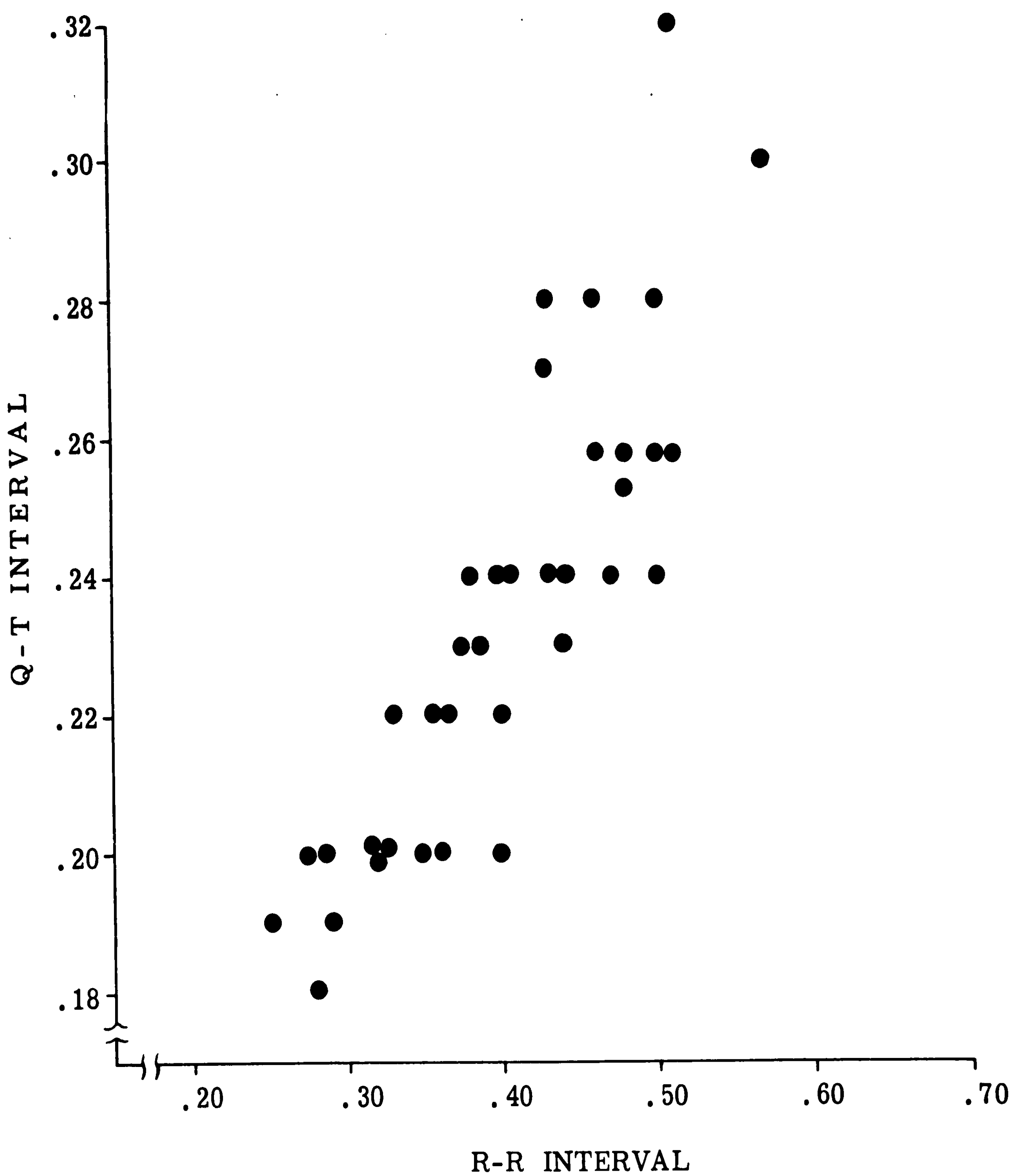

Figure 6. Relationship of Q-T Interval to R-R Interval

Table 5. Q-T INTERVAL RELATED TO AGE AND HEART RATE

HEART RATE	1 - 3 YEARS		4 - 6 YEARS		7+ YEARS	
	No.	Sec.	No.	Sec.	No.	Sec.
100 - 124	4	.28	1	.30		
125 - 149	6	.25	3	.27	2	.26
150 - 174	4	.22	6	.23		
175 - 199	3	.21	1	.20	1	.22
200 - 224	3	.20	1	.19		
225 - 249	0	-	1	.19		

Table 6. DURATION OF Q-T INTERVAL (AVERAGE DATA)

AGE GROUP	HEART RATE	Q-T
1 - 3 Yrs.	154	.233
4 - 6 Yrs.	160	.233
7+ Yrs.	152	.243

Table 7. ELECTROCARDIOGRAPHIC INTERVALS* IN THE AXILLARY LEAD

	R-R	P	P-R	QRS	Q-T	T
Mean	0.39	.059	.115	.046	.23	.10
Range	.25-.54	.04-.10	.08-.18	.03-.08	.14-.30	.06-.20

*in seconds

Table 8. AMPLITUDE OF P, Q and R WAVES IN CHIMPANZEE ELECTROCARDIOGRAM

		I	II	III	aVR	aVL	aVF
	No. Tracings	36	36	36	36	36	36
P Wave	No. Present*	32	36	34	36	25	36
	% Present	89	100	95	100	69	100
	Average (mm)	.6	1.7	1.3	-1.1	-.3	1.4
	Range (mm)	.2-1	.5-4	.5-4	(-.5)-(-3)	(-1)-1	1-4
Q Wave	No. Present*	14	14	12	-	12	13
	% Present	39	39	33	-	33	36
	Average (mm)	.4	.6	.6	-	.5	.7
	Range (mm)	.2-.5	.2-1.5	.2-2.5	-	.2-1	.2-1
	Duration (sec.)	.01-.03	.01-.02	.01-.02	-	.01-.025	.01-.02
R Wave	No. Present*	36	36	36	36	36	36
	% Present	100	100	100	100	100	100
	Average (mm)	3.8	8.2	4.9	.6	1.4	6.2
	Range (mm)	1-6	2-17	.5-13	.1-5	.2-7	.5-16

*Refers to presence of upright, inverted or biphasic wave.
**Biphasic in 70%

Table 8 (cont.). Amplitude of P, Q and R Waves in Chimpanzee Electrocardiogram

		V1	V2	V3	V4	V5	V6	Ax
	No. Tracings	36	15	36	15	36	15	22
P Wave	No. Present*	31	11	22	12	33	14	20
	% Present	86	73	61	80	92	93	91
	Average (mm)	+7/-.6**	.8	.8	.7	.8	.7	.9
	Range (mm)	(-1)-2	(-1)-3	(-.5)-3	(-.5)-2	(-.5)-2	.3-2	.2-2
Q Wave	No. Present*	4	2	2	3	14	4	14
	% Present	11	13	6	20	39	27	64
	Average (mm)	.3	.4	.5	.2	.5	.6	.6
	Range (mm)	.2-.5	.2-.5	-	-	.2-1.5	.2-1.3	.5-1
	Duration (sec.)	.01	.01	.01	.01	.01-.02	.01-.02	.01-.02
R Wave	No. Present*	36	15	36	15	36	15	22
	% Present	100	100	100	100	100	100	100
	Average (mm)	5.1	10.2	15.7	17	13.2	9.8	12.3
	Range (mm)	.5-16	2-16	1-24	12-28	4-26	4-20	4-21

*Refers to presence of upright, inverted or biphasic wave

**Biphasic in 70%

Table 9. AMPLITUDE OF S and T WAVES IN CHIMPANZEE ELECTROCARDIOGRAM

		I	II	III	aVR	aVL	aVF
	No. Tracings	36	36	36	36	36	36
S Wave	No. Present*	11	13	16	36	28	34
	% Present	31	36	44	100	75	95
	Average (mm)	1.3	2.5	2.2	5.3	2.2	2.4
	Range (mm)	.3-4	.5-9	.5-6	2-10	.2-12	1-24
T Wave	No. Present	26	26	28	28	21	28
	% Present	72	72	78	78	58	78
	Average (mm)	.6	.4	.1	-.1	.4	.2
	Range (mm)	(-1)-2	(-1)-2	(-1)-2	(-1)-1	(-.5)-1	(-.5)-3

*Refers to presence of upright, inverted or biphasic wave.

Table 9 (cont.). Amplitude of S and T Waves in Chimpanzee Electrocardiogram

		V1	V2	V3	V4	V5	V6	Ax
	No. Tracings	36	15	36	15	36	15	22
S Wave	No. Present	36	15	36	15	31	10	10
	% Present	95	100	97	100	86	67	45.4
	Average (mm)	12.5	16.4	12.0	9.1	4.6	2.9	3.6
	Range (mm)	1-24	5-27	.5-30	3-24	.5-10	.5-7	1-8
T Wave	No. Present	36	15	36	14	34	13	19
	% Present	100	100	100	93	94	93	86
	Average (mm)	3.0	4.6	4.2	3.1	1.6	.9	1.2
	Range (mm)	(-2)-9	.5-10	.5-11	1-5	(-.5)-4	(-.5)-2	(-1.4)-5

*Refers to presence of upright, inverted or biphasic wave.

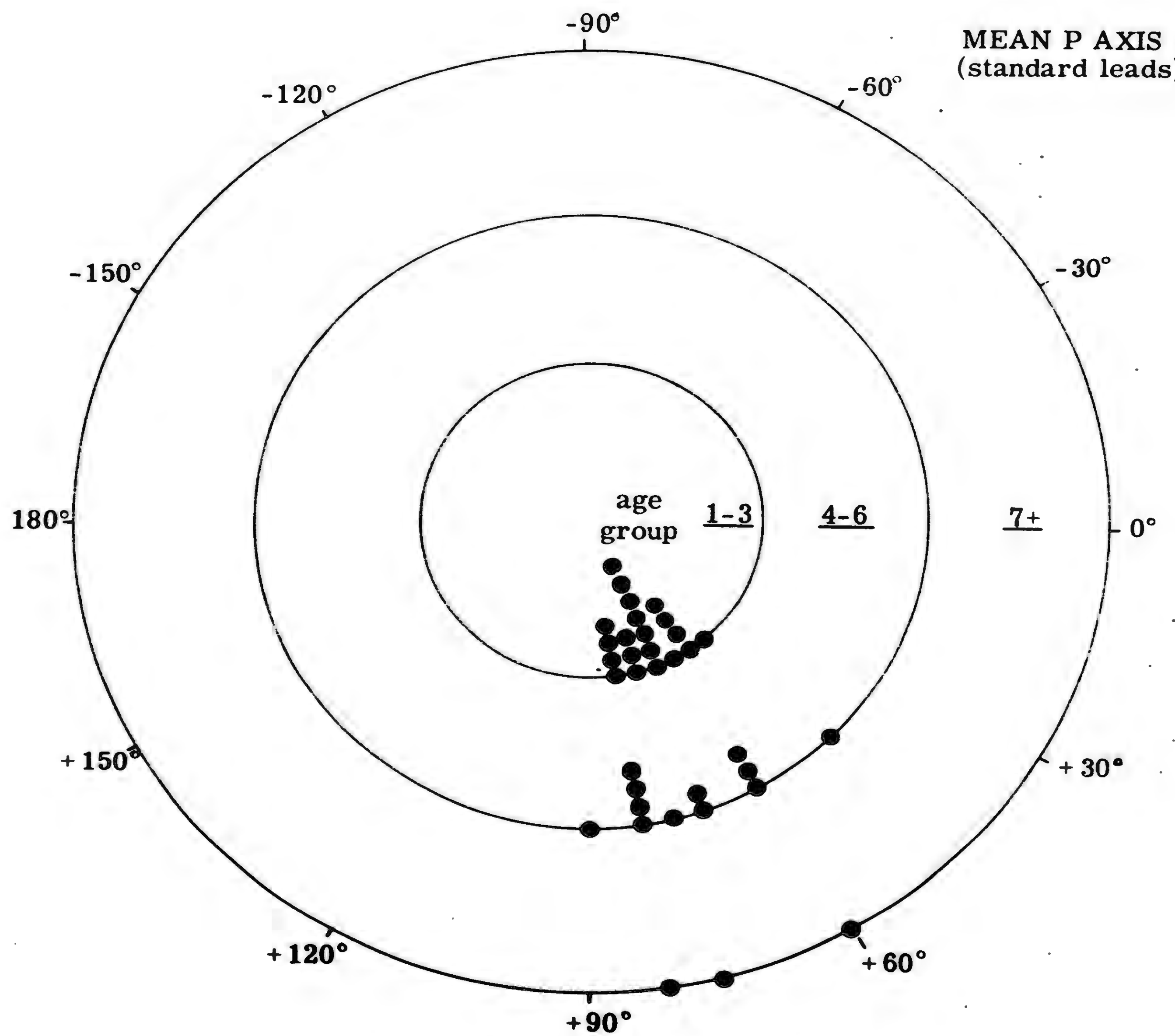

Figure 7. Distribution of the Mean P Axis in the Frontal Plane

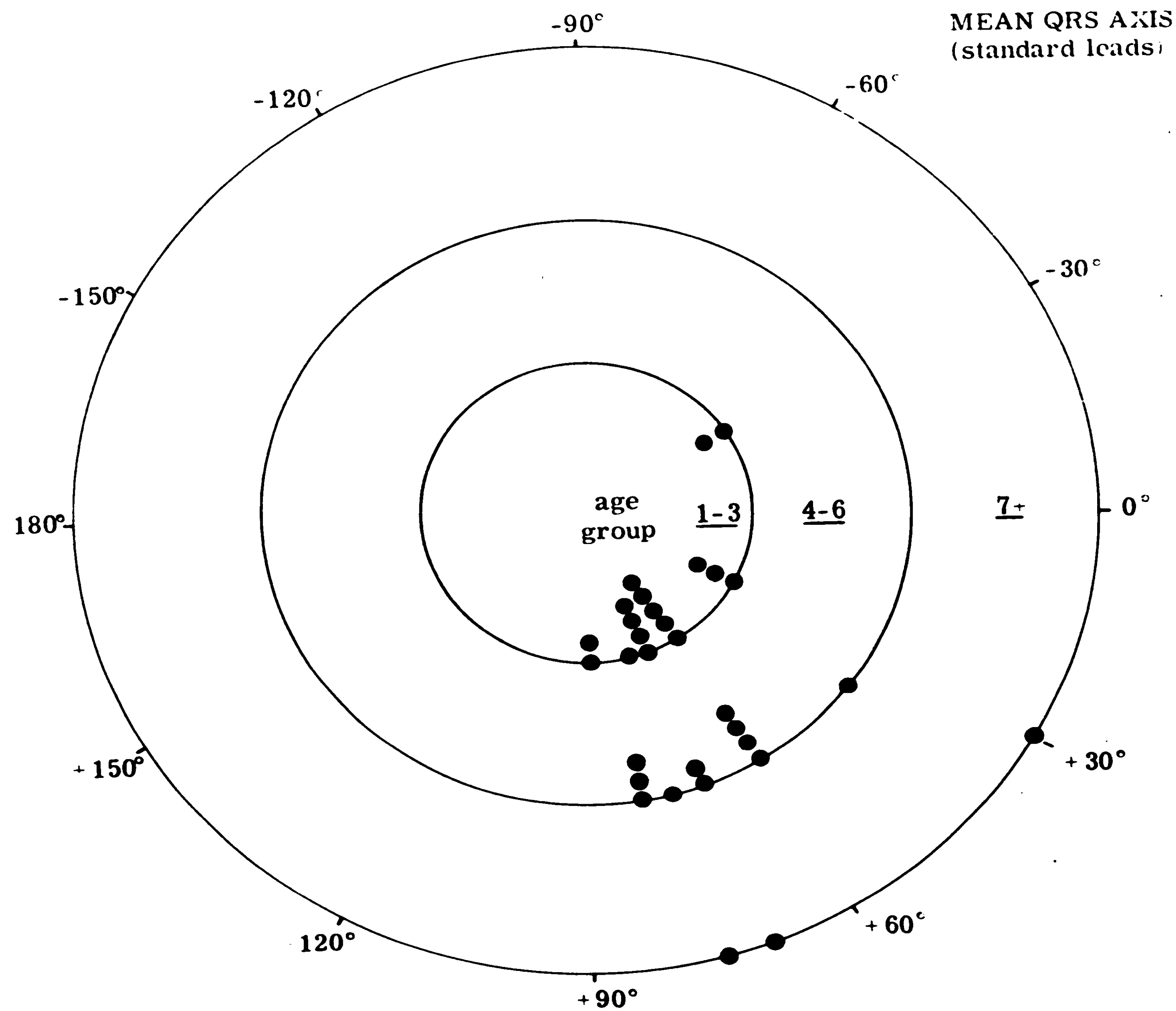

Figure 8. Distribution of the Mean QRS Axis in the Frontal Plane

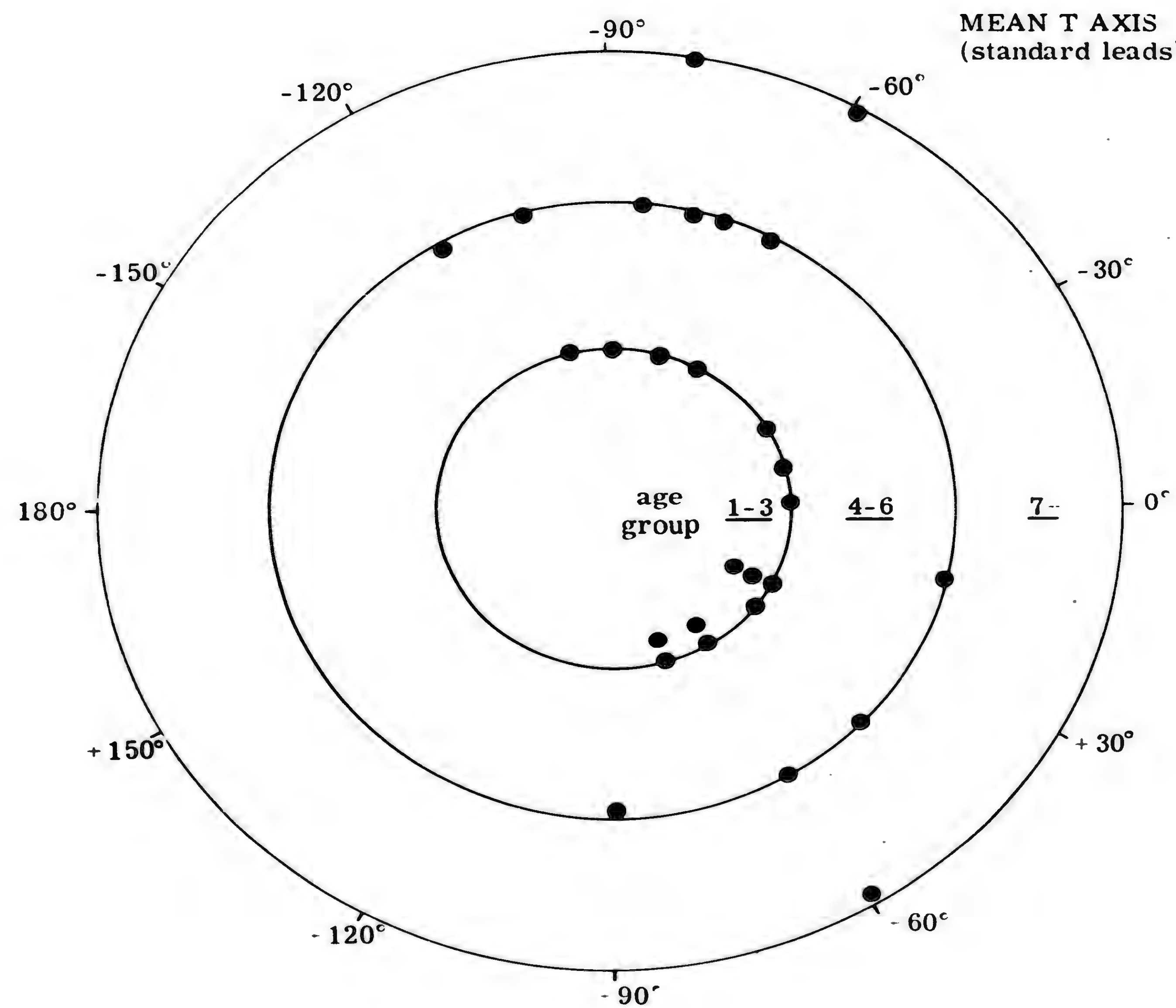

Figure 9. Distribution of the Mean T Axis in the Frontal Plane

The character of the P and T wave is further described in Table 10. The mean axis of the P wave projected mainly in the frontal plane in the range of +45^{o} to +90^{o} with a slight posterior tilt in the precordial plane. The mean axis of the T wave, projected maximally in the precordial plane in a markedly anterior position. The anterior projection of the T wave accounts for the wide distribution of the T waves in the frontal plane, and the relatively low amplitude of the T waves in the standard leads. The mean spatial QRS axis projected in a mid-position with respect to the standard and precordial leads ranging from -30^{o} to +90^{o} in the frontal plane with a moderate posterior tilt in the precordial plane, (transitional QRS zone V2-V4). In six animals the finding of equivalent positive and negative deflections throughout the electrocardiographic tracing (broad QRS vector loop) did not permit evaluation as to the mean QRS axis.

4. Heart Rate and Rhythm

The heart rate in the animals studied ranged from 105 to 240 beats per minute. Of note was the tendency for heart rate to change spontaneously in the course of the electrocardiographic tracing as the degree of emotional arousal varied. Sinus arrhythmia was noted in seven of the animals and was frequent when the heart rate was relatively slow, (less than 125 beats per minute). One animal demonstrated a wandering pacemaker from the sinus to the A-V node. Rare premature atrial beats were observed. No ventricular premature beats were recorded. The mean heart rate in the leads where the P-R and QRS intervals were measured averaged 159, 159 and 152 respectively for the three age groups. The average heart rate in the course of the Q-T and T wave measurements was 154, 160 and 152 respectively for the three groups.

5. Comparison With Human Electrocardiogram

The extensive electrocardiographic data accumulated by Ziegler (10) on normal children offered an opportunity to compare the human electrocardiogram with that of the chimpanzee of comparable age. The age group three to five was chosen as the most convenient one for comparison for several reasons. The three to five year group is one of the age subdivisions in the above human series. The relatively large number of subjects in the chimpanzee group in this age limit (twenty-two) permits a more valid comparison with the human. The average weight of the chimpanzees in this age group, 37.7 pounds, compared well with the mean weight of children of comparable age,

Table 10. SHAPE OF P AND T WAVES IN CHIMPANZEE ELECTROCARDIOGRAM*

		I	II	III	aVR	aVL	aVF	V1	V2	V3	V4	V5	V6	Ax
	No. Tracings	36	36	36	36	36	36	36	15	36	15	36	15	22
P Wave	U	89	100	94	-	19	100	17	53	53	74	89	93	91
	In	-	-	-	97	47	-	-	-	-	-	-	-	-
	Is	11	-	6	-	31	-	14	27	39	20	8	7	9
	B	-	-	-	3	3	-	69	20	8	6	3	-	-
T Wave	U	69	42	39	28	44	45	86	100	97	93	85	86	77
	In	3	19	31	44	8	22	11	-	-	-	3	7	14
	Is	28	28	22	22	42	22	-	-	-	7	6	7	9
	B	-	11	8	6	6	11	3	-	3	-	6	-	-

*Figures represent percentage of total tracings for each lead:
U - upright, In - Inverted, Is - Isoelectric, and B - Biphasic.

36.6 pounds (11). Finally, the ratio of cardiac weight to total body weight in 19 healthy young chimpanzees dying of incidental cause at the Bioastronautics Research Laboratory, in the age range of one to eleven years, has been found to be 0.51% (range 0.4% to 0.7%), a value similar to that in children of comparable age 0.44% as derived from Boyd (11). The electrocardiographic tracings were compared as to the amplitudes of the P, Q, R, S and T waves, the mean P, QRS and T axes, and the P, P-R, QRS, S-T, Q-T and T intervals. The data are summarized in Table 11 through 13.

Comparison of the amplitudes of the components of the electrocardiogram in the two groups must take into account differences in the spatial position of the P, QRS and T vectors (Table 12). In this light, the spatial position of the mean QRS axes differed only slightly. Greater differences in the mean P axes and marked differences in the distribution of the mean T axes were observed. Of note was the finding of a diminished amplitude of the total QRS complex throughout the standard and precordial electrocardiogram in the chimpanzee (Table 11). Only little difference in the amplitude of the P waves was apparent. Since the spatial position of the T waves differed so greatly, comparison as to their relative amplitudes was not considered valid without more complete vector loop analysis.

In comparing the various electrocardiographic intervals differences relative to heart rate must be considered. The uniform shortening of the various electrocardiographic intervals in the chimpanzee is therefore explained in part by the faster heart rate in these animals (Table 13). However, shortening of the QRS interval, (63% of the human) was greater than the P-R or S-T intervals (83% and 80% of the human levels respectively). When the intervals were corrected for heart rate by dividing by the square root of the R-R interval the average corrected P-R intervals (.166 sec. and .165 sec. in chimpanzee and child, respectively) and the average corrected S-T intervals, (304 sec. and .310 sec. in chimpanzee and child) were similar in both series. The corrected Q-T interval was shorter in the chimpanzee (.379 as compared to .402 in the human). These data lend the impression that the QRS component of the Q-T interval in the chimpanzee is shorter than could be explained by differences in the heart rate alone.

IV. Discussion

The problems in obtaining the electrocardiogram in the chimpanzee proved comparable to those encountered under similar conditions in children. With proper attention to the emotional lability in these animals

Table 11. Comparison of Average Amplitude of P, Q, R, S and T Waves in Human and Chimpanzee Electrocardiogra

		I	II	III	aVR	aVL	aVF	V1	V2	V3	V4	V5	V6
P Wave	Human	1.1	1.7	0.6	-1.2	.4	1.2	1.0	1.2	1.1	1.0	0.9	0.8
	Chimp.	0.6	1.8	1.3	-1.2	-.4	1.6	0.6	0.6	0.8	0.7	0.9	0.6
Q Wave	Human	1.2	1.6	2.5	-	1.3	1.7	0	0	1.0	1.7	2.1	1.8
	Chimp.	0.4	0.6	0.8	-	0.4	0.8	0.2	0.2	0.5	0.2	0.5	0.6
R Wave	Human	6.9	12.6	9.1	1.8	3.4	9.9	7.8	13.5	16.0	24.0	19.8	13.0
	Chimp.	3.5	8.0	4.7	0.3	1.1	6.1	4.6	10.6	14.3	14.9	12.4	8.4
S Wave	Human	2.5	2.2	2.1	10.0	4.2	2.0	13.0	22.8	13.1	5.9	2.8	0.6
	Chimp.	1.3	1.8	2.0	5.2	1.8	1.6	13.1	16.1	13.9	12.0	4.9	3.0
T Wave	Human	2.8	3.3	0.5	-2.9	1.4	2.0	-4.8	-4.2	0.3	4.6	4.6	3.6
	Chimp.	0.5	0.3	0.1	0	0.1	0.5	3.5	5.0	4.8	3.2	1.5	0.7

*Age group 3 - 5 years, human data according to Ziegler

Table 12. Comparison of Mean P, QRS, and T axes in Human and Chimpanzee Electrocardiogram *

		P	QRS	T
Human	Mean	50	64	35
	Range	0 - 75	0 - 90°	(-10)-60
Chimp.	Mean	71	58	-26
	Range	45 - 90	(-30)-90	(-105)-90

* Age groups 3 - 5 years, human data according to Ziegler

Table 13. Comparison of Electrocardiographic Intervals in Human and Chimpanzee*

		R-R	P	P-R	QRS	S-T	T	Q-T	$Q\text{-}T_c$
Human	Mean	.57	.072	.125	.071	.235	.147	.306	.402
	Range	.25-.88	.04-1.0	.10-.16	.04-.09	.18-.28	.10-.21	.22-.37	.349-.465
Chimp.	Mean	.38	.066	.103	.045	.186	.123	.233	.379
	Chimp.	.25-.55	.04-1.0	.07-.15	.03-.06	.14-.28	.05-.18	.19-.32	.339-.462

* Age groups 3 - 5 years, human data according to Ziegler

and to their conditioning to the environment of the electrocardiographic laboratory, the obtaining of electrocardiographic tracings of consistently good technical quality was feasible. While the attainment of a basal physiologic state under these circumstances proved difficult, the data derived in the present study lends a formulation of the normal variation in the electrocardiogram of the chimpanzee and forms a basis for comparison with the electrocardiogram in the human.

A comparison of the human and chimpanzee electrocardiogram suggests the presence of an absolute shortening of the QRS interval and a diminished amplitude of the QRS complex in the chimpanzee. Ziegler (10) has observed that the average QRS interval varies no greater than .012 second in the child over an age range of six months to twelve years, and over a mean heart rate range from 80 to 180. The magnitude of the difference in mean QRS duration between human and chimpanzee of .026 second would offer further support for the presence of an absolute decrease in the duration of ventricular depolarization in the chimpanzee. A more rapid ventricular depolarization process and a low QRS amplitude might be explained by a relatively smaller cardiac size in the chimpanzee. However, from the analysis of the post mortem heart weight data it would appear that the relative cardiac size in the chimpanzee is similar or even slightly greater than in the human. An alternate explanation for the lower QRS amplitude in the chimpanzee is the presence of a greater impedence from the heart, the source of electrical energy, to the extremity electrodes. In this regard, the relatively greater length of the upper extremities in the animals might explain these differences in the standard leads (12). However, the observation of a similar chest girth in the child and the chimpanzee (13), cannot support such a simple anatomic explanation relative to the QRS complex in the precordial electrocardiogram. It would appear therefore as if the ventricular depolarization process proceeds at a more rapid rate and at a lower amplitude of electrical energy in the chimpanzee. Further studies employing direct recordings from the ventricular surface are necessary in order to establish whether such an absolute decrease in the rate and amplitude of ventricular depolarization process is indeed present in this species.

In the age group three to five years, a marked variance between the human and chimpanzee in the relative spatial position of the mean T axis was evident. The mean T axis of the chimpanzee projects mainly in an antero-posterior position manifesting maximal positive amplitude in the right precordial leads and slight deflections in the frontal plane. In contrast, the mean T axis in the child projects more posteriorly in the precordial plane, manifesting negative waves in the right precordial leads (juvenile pattern), and is well projected with sizeable amplitude on the standard limb leads. While the present study does not define the underlying mechanism for the more postero-inferior spatial projection of the T vector of the child, future comparative studies in the chimpanzee and the child might elucidate the mechanism of these so-called juvenile T waves.

Except for the appearance of sinus arrhythmia rhythm disturbances were unusual in the animals studied. No premature ventricular beats were observed in the entire series.

As a means for the experimental monitoring of electrocardiographic data in the chimpanzee the axillary lead was devised. The axillary leads are covered by a protective vest which prevents their removal by the animal under laboratory conditions. The axillary lead proved to be similar in form and amplitude to lead V5 or V6. From the point of view of analysis, projection of the P, QRS and T waves proved adequate for measurement of the various electrocardiographic intervals and for monitoring rhythm changes.

V. SUMMARY

In the present paper an analysis of complete electrocardiograms obtained on 36 young chimpanzees is presented. Age, weight and heart rate trends in the electrocardiogram were observed and a comparison with the human electrocardiogram was made. Of note in this comparison were the findings of a lower amplitude and duration of the QRS complex in the chimpanzee and a marked difference in the projection of the T wave between the groups. The axillary lead obtained in 22 animals proved adequate for monitoring cardiac rate, rhythm and electrocardiographic intervals when single lead recordings are required in this animal.

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