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RELATIONSHIPS BETWEEN HUMAN FACIAL COLD RESPONSE AND DIMENSIONS OF FACIAL FORM: AN EXPERIMENTAL STUDY IN PHYSICAL ANTHROPOLOGY

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
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TABLE OF CONTENTS

		Page
ACKNOWLEDGMENTS		ii
LIST OF TABLES		iv
LIST OF ILLUSTRATIONS		v
LIST OF APPENDICES		vi
Chapter		
I.	DEFINITION OF THE PROBLEM AND APPROACH	1
II.	METHODS OF DATA COLLECTION	3
	The Sample Measurement of Morphological Variation Measurement of Thermal Response Selection of Measurement Sites Experiment Format	
III.	ANALYSIS OF DATA	13
	Charting and Data Selection Variation Correlation Analysis Difference of Means Analysis Thermal Fluctuation Experimental Results in Summary	
IV.	DISCUSSION AND CONCLUSION	37
	Hypothesis Frostbite Selection Anthropological Implications: Morphology Anthropological Implications: Race Critique of Methods Projected Research Summary	
APPENDICES		48
LITERATURE CITED		78

LIST OF TABLES

Table		Page
1.	Instructions to the Subject	9
2.	Facial Skin Temperatures: Variation at 23°C. and 1°C. (N = 27)	16
3.	Facial Skin Temperatures: Individual Variation of Two Subjects at 1°C. (Three Trials, Ninety Minutes Each)	17
4.	Temperature-Morphology Correlations	20
5.	Cold Facial Extremity-Morphology Correlations	23

LIST OF ILLUSTRATIONS

Figure		Page
1.	Anthropometric Model of the Face Showing Datum Points (letters) and Cords	5
2.	Thermal Map of the Face after Cold Exposure .	7
3.	Thermocouple Sites on the Head	7
4.	A Subject in Position During Cold Exposure .	11
5.	Racial Comparison of Some Mean Final Cold Exposure Temperatures	29
6.	Thermal Response Chart, Reactive Record . . .	32
7.	Thermal Response Chart, Non-Reactive Record .	33

LIST OF APPENDICES

Appendix		Page
I.	EQUIPMENT	48
II.	BODY DIMENSIONS AND INDICES	50
III.	HEAD AND FACE DIMENSIONS AND INDICES	53
IV.	SELECTED INDIVIDUAL SUBJECT DATA	56
V.	INFORMATION REQUESTED OF EACH SUBJECT	60
VI.	STATISTICAL TESTS	62
VII.	SCATTERGRAMS: MEAN, COLDEST FACIAL TEMPERATURES - MORPHOLOGY	65
VIII.	SITES AND MAGNITUDES OF THERMAL RESPONSE FLUCTUATION	69
IX.	FROSTBITE, SITES OF ELECTION AND DEGREE, WESTERN POPULATIONS	72
X.	COLD PATHOLOGY DATA, ARCTIC POPULATIONS . . .	75

CHAPTER I

DEFINITION OF THE PROBLEM AND APPROACH

Despite its striking variation within our species, the face has gone unexamined as an area of experimental physical anthropology; facial studies in the literature of other disciplines (Edwards and Burton 1960; Froese and Burton 1957; Lewis 1930b; Proetz 1953) have not been useful in answering anthropological questions. Considering regular variation in facial form with latitude (Newman 1953; 316-322) and assuming that human variation can be explained as a function of its natural selective history, it is now imperative that research be started to investigate form-function relationships of the face. This dissertation will experimentally define thermal patterns of the human facial skin during artificial cold stress. The results will be tested against anthropologically significant dimensions of variation within the sample such as gross facial "sharpness," subcutaneous fat thickness, and "race." If thermal variation can be explained by gross morphological characteristics, one can assume the same regular variation of function with form within the species as a whole. That is, we will be in a better position to speculate about the adaptive significance of human facial variation in relation to cold climate biology.

Since this experimental approach has no precedent in

anthropology, a secondary goal will be to discover how maximum information may be had with a minimum of measurement. The dissertation will serve as a pilot study for extensive field investigation to be launched in the future. Methods comprise the second chapter; characteristics of the human sample, how its morphological variation was quantified, measurement of thermal response, and the nature of the cold exposure with controls on sources of experimental error will be discussed in order. The remainder of the work consists of the analysis of thermal responses obtained from the experiments and the extent to which the non-thermal variables can be used to explain them.

Finally, some commentary will be offered concerning the anthropological implications of the study, and a methodological critique and suggestions for further research conclude the dissertation.

CHAPTER II

METHODS OF DATA COLLECTION

The Sample

Thirty young, male, paid volunteers were accepted, three of which were later eliminated due to suspected recorder malfunctions or because they had eaten breakfast (see Table 1). All were regular full-time students at the University of Michigan and were assumed to have been in the same state of light acclimatization to the mild 1963-1964 Ann Arbor winter. None were involved in University athletics nor were active in winter sports elsewhere. The tests were conducted over a two-and-a-half month period beginning early in February. None of the men showed signs of general ill health, colds, high blood pressure or skin diseases which might have been prejudicial to the results (see interview, Appendix V).

Measurement of Morphological Variation

Data on the subjects are presented in Appendix IV. To insure racial and morphological contrast, eleven Japanese students were included within the sample. Variation was quantified by use of anthropometrics. Since not all anthropometric dimensions and landmarks are standard, Appendix II defines the body measurements, taken on the left side of the body were unilateral and in metrics unless otherwise stated.

Preliminary to all head and face measurements the following points were palpated and marked with a skin pencil: Nasion (N), Gonion (G), Progonion (PG), Pronasale (PRN), Alare (A), Subnasale (SN), and Labrale Superius (LS) (Montagu 1951:452). Others were Lateral Orbitale (LO), the most anterior point in the middle of the lateral margin of the bony eye orbit, close to and sometimes the same as Ectocanthion, and Zygomaxilare (ZM) which corresponds to the suture on the inferior zygomatic margin of the zygoma and maxilla bones; the latter was palpated by having the subject tense his masseter muscles ("grit his teeth") without moving his other facial muscles. ZM, corresponding to the skeletal point of the same name, is usually directly below LO and is a good marker of "mid-cheek" position despite minor variation in location (see Figure 1 for all points). Standard anthropometric instruments were used and are listed in Appendix I. Appendix III gives head and face measurements as well as the derived angles and indices.

Measurement of Thermal Response

Thermal data were collected with a Leeds and Northrup recording potentiometer (Appendix I). Thermoelectricity and recording devices are discussed by R. L. Weber (1950:49-59; 147-154). Copper-constantan thermocouples were manufactured in the laboratory, and the recorder was set to measure temperatures from zero to fifty degrees Centigrade. Calibration tested the thermocouples and recorder against a range of temperatures

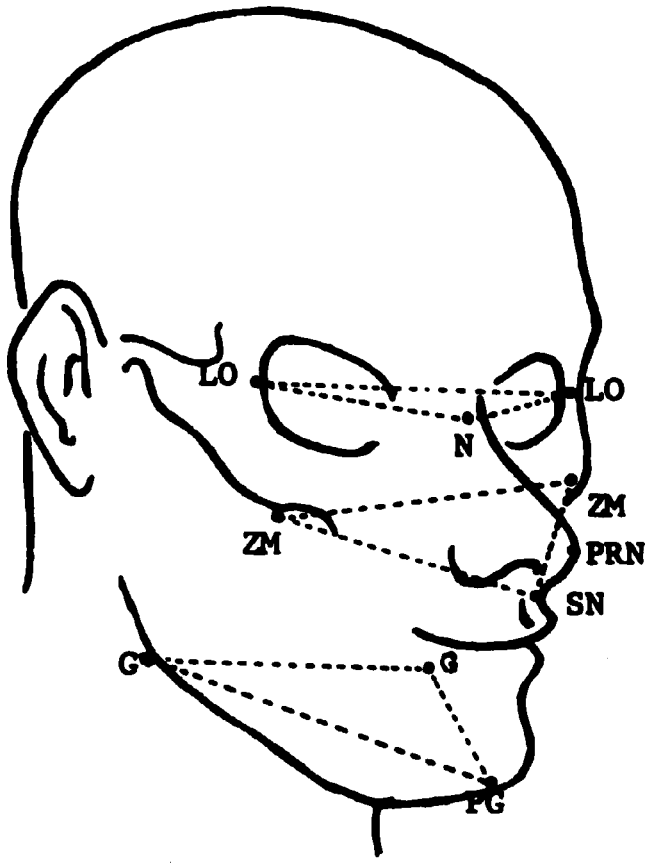


FIGURE 1.--Anthropometric model of of the face showing datum points (letters) and cords.

(water baths) representing the operating range (verified by readings from a U.S. Bureau of Standards mercury thermometer). The resulting curve not only checked continuing accuracy but was the basis of conversion tables from millivolts to degrees Centigrade. The night preceding each experiment, thermocouples were tested and repaired as necessary. Calibration was also checked occasionally and remained constant.

Thermocouples (twelve skin, one air, and one rectal) were manufactured on the ends of six foot leads and soldered into a master junction which was mounted on the subject's coat. The rectal thermocouple lead was shielded by a fine Neoprene tube covered with a 3/16 inch rubber one. The junction itself was mounted in epoxy resin and covered with a rubber tip only slightly larger than the 3/16 inch tube. This design was serviceable and durable. A cable connected the machine junction to that on the subject's coat. Figures 6 and 7 are reduced versions of thermal charts which were derived from each "long" record.

Selection of Measurement Sites

One end of this study is the definition of the relatively coldest and warmest facial areas, and the model presented in Figure 2 has been used as a guide to facial thermocouple placement. Figure 3 is juxtaposed to Figure 2 as an illustration of the reasons for testing the following points:

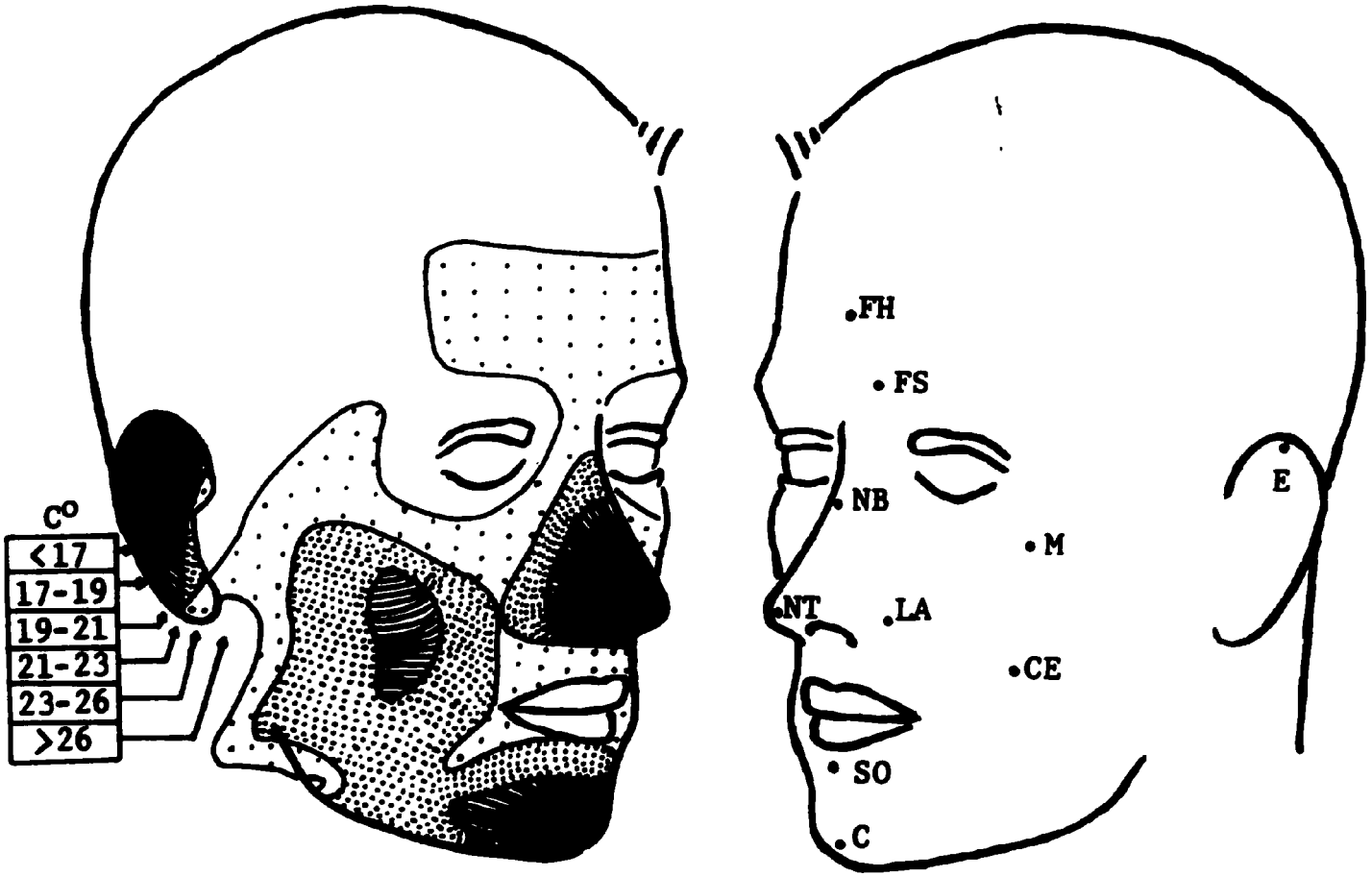


FIGURE 2.(left)--Thermal map of the face following cold exposure (modified from Edwards and Burton 1960:210). Numbers indicate degrees Centigrade.

FIGURE 3.--Thermocouple sites on the head. Letters correspond to those used in the text.

Thermocouple 1 - Nasal Bridge - medial, where nasal cartilage joins the bone,

Thermocouple 2 - Nasal Tip - medial, most anterior point,

Thermocouple 3 - Chin - medial, most anterior point,

Thermocouple 4 - Sublabial - medial, 5 mm below inferior labial margin,

Thermocouple 5 - Cheek - a point just below the malar and anterior to the masseter,

Thermocouple 6 - Malar - just below and a little posterior to LO, centered on the high point of the malar,

Thermocouple 7 - Forehead - medial, centered on the forehead 20 to 25 mm above glabella,

Thermocouple 8 - Frontal sinus - slightly to the left of midline, centered over the highest point on the supraorbital ridge,

Thermocouple 9 - Lateral Alare - on the maxilla, about 10 mm lateral to the most lateral point of the left nasal alae,

Thermocouple 10 - Ear Vertex - highest point on the top of the left pinna.

Four other sites were also recorded, including the mid-phalangeal dorsum of the left index finger (#11), the terminal phalanx of the left great toe, about 5 mm back from the nail (#12), rectal (probe inserted 8 cm past the sphincter, #13), and the chamber air temperature (#14).

Experiment Format

Before the morning of testing the subject was contacted and an explanation of the testing procedures was made. A list of instructions was also issued; they are summarized in Table 1 along with the possible error factor they were to control.

TABLE 1

INSTRUCTIONS TO THE SUBJECT

	Instructions	Controls for
1.	No alcohol the preceding night	"Hangover," fatigue
2.	Seven hours of sleep	Fatigue
3.	Eat no breakfast	Metabolic variation, SDA of food
4.	No coffee or other stimulants beforehand (including tobacco)	Vasoconstriction or vasodilation (MacNalty 1961: 238; Wynder 1955:73)

Other controls were used to establish a consistent test situation. Circumstances did not permit keeping the subjects overnight in the lab so they were cautioned to get up just before the test, not to move around unnecessarily, and to refrain from taking showers which might disturb their thermal state.

The volunteer was brought to the laboratory in a warm car. He was again apprised of the experimental routine and of

his role, and a preliminary inquiry was made to insure instructions had been followed. Two men forgot and had a cigarette each, and three had to walk about a block. The subject was checked for blood pressure and suited (Appendix I). After being seated, face and body sites were daubed with Ace Adherent (surgical) for a dry firm field, and the thermocouples were affixed using a fine, thin surgical tape, Blenderm (1/2 x 1/2 inch squares); care was exercised to be sure that the leads did not "pull" (to avoid disturbing superficial circulation). The application took about forty-five minutes during which the man rested comfortably. He was fitted with heavy stockings and his thermal record was begun (10 minutes at room temperature). The subject was then placed in the cold chamber.

The termperature of the cold room was maintained between zero and three degrees Centigrade and cycled continuously between these limits under the control of an automatic thermostat. A fan circulated air, but there was no draft on the subject's face and the relative humidity, checked by an electric hygrometer, remained constant for each run, usually about seventy-seven per cent.

Suspension for the volunteer in the chamber was provided by a nylon web, aluminum frame chaise lounge (Figure 4). His back and legs were padded with a wool blanket and a foam rubber pad under his buttocks prevented sliding down on the slick nylon. Each man was asked to sit quietly and read if he wished (as long as the book was not held up to the face),

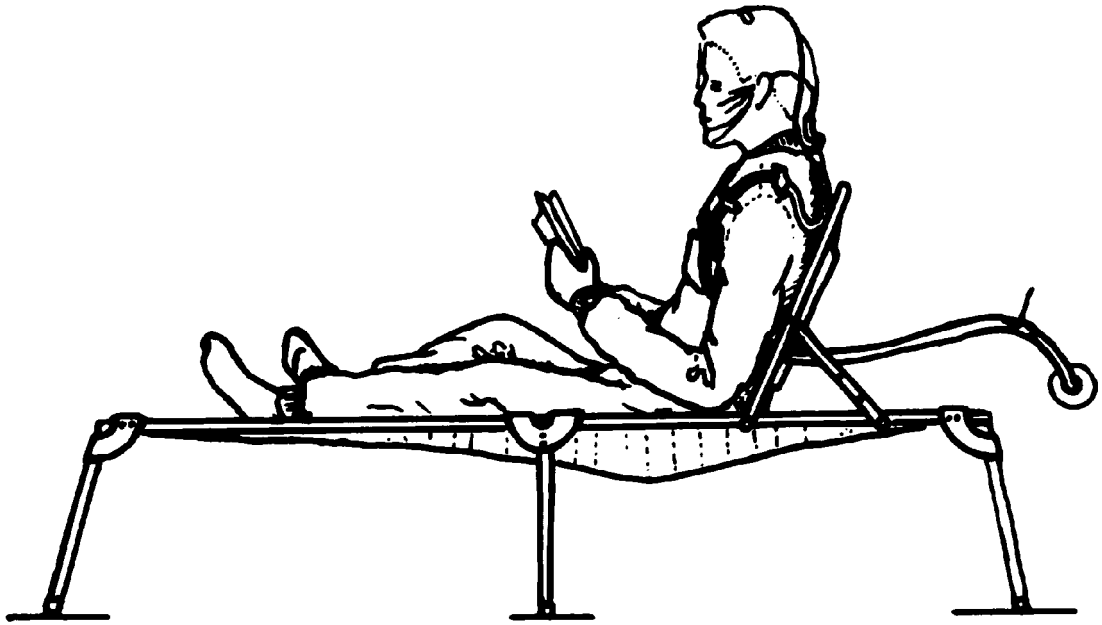


FIGURE 4.--A subject in position during cold exposure. Notice how thermocouple wires enter through the wall of the cold chamber, go under the left arm, and are secured to the jacket.

and the hands were gloved. The only postural variations observed occurred when a subject would occasionally slouch down far enough to rest his head on the back rest; these men were told to sit up, and otherwise instructions were followed. During the 90 minute cold stress period, reports of shivering activity were requested but were too irregular to be of analytic value.

By about 10:30 A.M., the test period was usually finished, and the subject was relieved of the thermocouples. He was asked to provide more personal data (Appendix V), weighed and measured, and lastly, photographed.

CHAPTER III

ANALYSIS OF DATA

Charting and Data Selection

The first task in the data analysis was to convert the millivolt readings to temperature graphs. The thirteen different temperatures were plotted in contrasting color for ease of reading. On each ninety minute chart, the first sixty minutes were the least important so each temperature was read only twelve times during this period (i.e., once every five minutes). However, if there was any unusual fluctuation, more frequent plottings were made. There was fluctuation noted in many cases after entry into the cold room and until the skin and thermocouple junction plug (which lost heat more slowly than did the thermocouples) came to equilibrium. During the terminal thirty minutes, temperatures of the nasal bridge, nasal tip, chin, sublabium, cheek, and malar were charted once every ninety-six seconds, or about eighteen to twenty times total; forehead, frontal sinus, and lateral alare, were recorded once every 144 seconds, and rectal, hand, foot, and air from 144 to 288 seconds apart, depending on their stability.

Data included temperatures, temperature fluctuations, and differences between temperatures. Of most importance was

the definition of temperatures representing the stable cold response near the end of the run, for which an arithmetic mean of the final twelve to fifteen minutes was elected. Some of the temperatures were showing cycles of a few tenths of a degree, some rising slightly, and some falling. When this was particularly marked and the last few minutes were stable they were used for the average. Other data used were the following: (a) average of the last three to four minutes of room temperature responses, (b) spot temperatures at thirty and forty-five minutes, (c) percentage of total fall attained by forty-five minutes, and (d) hunting responses. Some of the temperatures were combined and/or subtracted and each could then be used as an individual datum. They were (a) average facial (average of lateral alare, malar, cheek, chin, and nasal tip), (b) mean of the three warmest facial sites, (c) mean of the three coldest facial sites (exclusive of ears), (d) mean warmest minus mean coldest, (e) forehead minus malar, (f) lateral alare minus nasal tip, and others.

As one of the most used datum, the mean of the three coldest facial temperatures (excluding the ear) requires discussion. Its low individual variation (Table 3) recommended it over more variable single sites and its relationship to frostbite potential is easily assumed. In this sample, its components were as follows:

NT,NB,C	8 cases,	NT,CE,M	3 cases,
NT,NB,CE	7 cases,	NT,CE,LA	1 case,
NT,CE,C	3 cases,	NT,CE,SO	1 case, and,
NT,C,M	3 cases,	NT,NB,SO	1 case.

This must not be looked upon as surprising since in many cases the contrasting sites (such as C and CE) were nearly the same temperature. The nasal tip site was invariably a component and is probably the best single site datum for this type of investigation.

Variation

Table 2 presents information on group facial skin temperature variation (N = 27), at room temperature (23° C.) and after thirty and ninety minute periods of 1°C. cold. A summary of temperature change (from 23°C. to 1°C., ninety minutes) is added. At 23°C. there is less variation than after cooling; a range of 9.5°C. was seen in facial temperatures and only 5.4°C. in their means. In contrast, there was a facial skin temperature range of 22.0°C., and a 16.37°C. range of their means at 1°C. after thirty minutes; these came down to 20.2°C. and 15.53°C. respectively with an additional sixty minutes of cold exposure. The latter change was probably due to different speeds at which individuals came to equilibrium. Table 2 and Figures 6 and 7 demonstrate that there was relatively less change at the warm forehead sites than elsewhere on the face.

Individual variation data of the same type were gathered on only two subjects due to time limitations; they appear in Table 3. Although individual facial skin temperatures show appreciable variation, those for the entire sample are much larger. The two men contrasted in weight, face shape, and

TABLE 2

FACIAL SKIN TEMPERATURES: VARIATION AT 23°C., 1°C. (30 MINUTES), 1°C. (90 MINUTES), AND CHANGE FROM 23°C. TO 1°C. (90 MINUTES). N IS 27 AND LETTERS (SITES) ARE IDENTIFIED IN FIGURE 3

		FH	FS	SO	LA	M	C	CE	NB	NT	E
(1) At 23°C.	X	34.55	34.34	34.43	34.08	33.3	33.06	33.2	33.63	33.75	29.15
	Range	33.1	32.3	30.4	33.2	31.3	28.5	31.3	31.2	26.2	26.6
		35.5	35.6	35.7	35.1	35.0	34.7	35.1	35.6	35.1	34.4
(2) 30 min. at 1°C.	X	28.22	26.97	26.58	25.35	22.62	23.43	21.91	21.66	15.94	11.85
	Range	24.7	23.0	23.1	20.1	18.8	18.8	16.4	15.6	11.9	9.3
		30.8	31.3	30.4	29.5	26.1	27.6	28.5	27.0	24.9	18.6
(3) 90 min. at 1°C.	X	27.07	25.32	23.04	22.5	20.47	19.73	19.55	19.15	13.01	11.54
	SD	1.419	1.765	2.441	1.913	1.917	2.277	2.144	2.490	1.733	1.819
	Range	24.2	21.85	18.0	19.57	16.34	15.3	15.01	12.98	10.61	9.06
		29.26	28.98	28.12	27.33	23.2	24.82	25.98	24.72	16.73	15.96
Change from 23°C. to 1°C. (90 min.) [1-3]	X	7.48	8.97	11.49	11.95	11.99	13.33	13.67	14.82	20.64	17.56
	SD	1.260	1.319	2.663	1.600	2.080	2.387	1.630	2.405	1.904	1.692
	Range	6.05	7.29	3.48	7.34	9.69	6.8	9.12	8.68	14.92	13.5
		10.0	12.35	14.8	14.93	16.56	17.6	16.46	19.52	23.5	20.9

TABLE 3

FACIAL SKIN TEMPERATURES: INDIVIDUAL VARIATION OF 2 SUBJECTS AT 1°C. (3 RUNS, 90 MINUTES EACH)

	Run	R	FH	FS	SO	LA	M	CE	C	NB	NT	E	X 3 Codes
Subject No. 1	I	36.90	26.08	25.66	23.01	21.58	18.25	17.53	20.00	19.58	14.23	13.50	16.67
	II	36.90	26.00	26.23	25.91	21.10	20.32	16.75	21.43	19.41	13.92	12.30	16.69
	III	36.90	25.40	24.00	25.31	20.80	20.72	18.64	20.97	18.35	[14.07]	14.54	17.02
	Range	0.0	0.68	2.23	2.90	0.78	2.47	1.89	1.43	1.23	0.31	2.24	0.35
Subject No. 27	I	36.55	29.26	27.36	24.65	22.10	20.56	19.55	20.47	18.80	13.28	10.40	17.21
	II	37.06	28.00	25.76	22.94	20.65	19.77	17.11	17.72	18.60	13.45	10.30	16.09
	III	37.03	28.70	26.73	23.56	21.13	18.38	17.29	19.61	20.61	12.15	10.25	15.94
	Range	0.51	1.26	1.60	1.71	1.45	2.18	2.44	2.75	2.01	1.30	0.15	1.27
Range 1 + Range 27 / 2		0.25	0.97	1.41	2.30	1.11	2.32	2.16	2.09	1.62	0.80	1.20	0.81

Note: Subject 1, NT temperature III (bracketed) was estimated at half-way between I and II. Thermocouple failure made this necessary.

other dimensions (Appendix IV) yet they showed similar range averages at the 10 facial sites (1=1.61; 27=1.68). The last row of the table is the average variation for both subjects at each site. This was their order from least variable to most:

Least - NT<FH<LA<FS<NB<C<CE<SO<M - Most;

Least - FH<NT<FS<LA<M-CE<C<SO<NB - Most.

Below the first ordering is similar information on the group variability, derived from Table 2. The means of the three coldest facial temperatures show low individual variation despite high variation in some of their components (e.g., NB, C, and CE).

Correlation Analysis

The most meaningful type of analysis for this study would define how independent variables (fat, shape) relate to the dependent ones (thermal), either singly or additively. Correlation analysis was suitable (Blalock 1960:285). The University of Michigan Computing Center had a linear stepwise regression program available (Westervelt's) which produced the following information; (a) sum, mean, and standard deviation for each variable, (b) product-moment correlation coefficients (simple r) between all variables entered in each problem, and (c) multiple correlation (R) between a designated dependent variable and any independent variables put in a step at a time (from the most explanatory to the least).

Problems were run with one temperature variable and

three other (independent) variables. It was advisable to run a number of shorter problems, since an error in any deck would stop the run. After completing the first run of fifteen problems, it became apparent that variability was so great and sample size so small (N = 27) that multiple correlations resulting from the runs would not provide the best information. To illustrate, let me present problems one and fourteen (the only two to reach significant levels).

(1) Y (dependent variable) = final rectal temperature
X_1 = % Body Fat
X_2 = Body Weight
X_3 = Linearity Index

Steps in Correlation	R	Analysis of Variance	
1. Enter X_1	+.4948	F = 8.106	Sig. at .01
2. Enter X_2	+.5157	F = 4.344	Sig. at .05
3. Enter X_3	+.5733	F = 3.196	Sig. at .05

(14) Y (dependent variable) = difference between rectal and forehead temperature (a rough measure of insulation gradient)
X_1 = % Body Fat
X_2 = Body Surface Area
X_3 = Linearity Index

1. Enter X_1	+.4951	F = 8.120	Sig. at .01
2. Enter X_2	+.5027	F = 4.146	Sig. at .05
3. Enter X_3	+.5486	F = 3.312	Sig. at .05

Each multiple correlation coefficient (R) was tested to see if it explained a significantly higher percentage of the variation (Appendix VI). None did, rendering further use of R

here unproductive, though it does not negate the usefulness of the approach on a larger sample. A number of simple linear correlations (r) were also generated by the processing. It is worthwhile to present these results despite the fact that they represent only one step, that of the "exploratory analysis" (Table 4).

TABLE 4

TEMPERATURE - MORPHOLOGY CORRELATIONS

Variable 1	-	Variable 2	r	Level of Significance
1a. Rectal Temp.		% Body Fat	.4948	.01
1b. Rectal Temp.		Linearity Index	.3934	.05
1c. Rectal Temp.		Body Weight	.1314	-
2a. Rect. Te.-FH Te.		% Body Fat	.4951	.01
2b. Rect. Te.-FH Te.		Linearity Index	.4180	.05
2c. Rect. Te.-FH Te.		Surface Area	.0648	-
3a. X Warm Face Te. - X Cold Face Te.		Head Index D	-.4365	.05
3b. X Warm Face Te. - X Cold Face Te.		Head Index A	-.3379	-
3c. X Warm Face Te. - X Cold Face Te.		Head Index G	-.3213	-
3d. X Warm Face Te. - X Cold Face Te.		Cephalic Index	-.3135	-
3e. X Warm Face Te. - X Cold Face Te.		Linearity Index	-.2260	-
3f. X Warm Face Te. - X Cold Face Te.		Nasal Index	-.1653	-
3g. X Warm Face Te. - X Cold Face Te.		% Body Fat	-.1326	-
3h. X Warm Face Te. - X Cold Face Te.		Body Density	.1299	-
3i. X Warm Face Te. - X Cold Face Te.		Weight	-.1243	-
3j. X Warm Face Te. - X Cold Face Te.		X Face Skin-fold Log	-.0926	-
4a. Mean Face Te.		X Face Skin-fold Log	-.2458	-
4b. Mean Face Te.		Linearity Index	-.2028	-

TABLE 4 (Continued)

Variable I		Variable 2	r	Level of Significance
4c.	Mean Face Te.	%Body Fat	-.2015	-
4d.	Mean Face Te.	Body Weight	.1243	-
4e.	Mean Face Te.	Head Index G	.0579	-
4f.	Mean Face Te.	Head Index C	.0524	-
4g.	Mean Face Te.	Head Index A	.0217	-
4h.	Mean Face Te.	Body Surface Area	.0145	-
5a.	$\bar{X}$ Warm Face Te.	$\bar{X}$ Face Skinfold Log	-.3040	-
5b.	$\bar{X}$ Warm Face Te.	Body Weight	-.1440	-
5c.	$\bar{X}$ Warm Face Te.	Head Index A	-.1376	-
6a.	$\bar{X}$ Cold Face Te.	$\bar{X}$ Face Skinfold Log	-.1965	-
6b.	$\bar{X}$ Cold Face Te.	Head Index A	-.1577	-
6c.	$\bar{X}$ Cold Face Te.	Head Index D	-.0768	-
6d.	$\bar{X}$ Cold Face Te.	Linearity Index	.0498	-
6e.	$\bar{X}$ Cold Face Te.	Body Weight	-.0183	-
7a.	LA Te.-NT Te.	Nasal Index	-.3640	-
7b.	LA Te.-NT Te.	Ave. Face Angle	-.3270	-
7c.	LA Te.-NT Te.	$\bar{X}$ Skinfold Log	-.2175	-
8a.	Toe Te.	% Body Fat	.1420	-
8b.	Toe Te.	Foot Index	-.0599	-
8c.	Toe Te.	Linearity Index	.0537	-

Note: All termperatures are coded (Te.) and represent mean final temperatures for each subject. FH, LA, etc. refer to points on the face already identified, and $\bar{X}$ indicates an arithmetic mean.

At the end of this run series, one American was removed from the sample for reasons which are evident in Appendix VII. He is represented by the dot at the top left of the scattergrams; the high facial temperature in this case may have resulted from a weekend of skiing which preceded the day of the test.

From the results of the initial analysis, it is evident that facial temperatures are not statistically correlated with the morphological parameters used in this test series.

A topic of concern in this analysis is the relationship between the coldest (i.e., most stressed and peripheral) facial areas and other factors. Using the computer program for its secondary information, the mean of the three coldest facial temperatures (exclusive of the ear) was run against twenty-two other variables to expand the results seen in Table 4, number 6. Table 5 presents the outcome of the second run (N = 26). None of the correlations were significant, even at the .05 level. However, as in the previous run, these very patterns do not appear to be random. Many of the facial form indices and dimensions (13, 17, and 18) fall just below the level at which they would be significant.

Appendix VII should be used with Table 5. It graphically shows the covariations of nine different facial dimensions and indices with the mean of the three coldest facial temperatures. Furthermore it may be seen why the cephalic index, facial angle, and head indices B and D were used in the section to follow; their patterns simply appeared to be the least random of the nine. They are also, of course, obvious components of facial sharpness. It can be seen, too, that the distributions seem to be linear as demanded when using correlation analysis.

Difference of Means Analysis

Rather than accept the most obvious conclusion from the previous analysis, I elected to try another approach to insure that significant information was not being lost. The sample of twenty-six was subdivided according to different

TABLE 5

COLD FACIAL EXTREMITY - MORPHOLOGY RELATIONSHIPS

Variable	r Correlation with $\bar{X}$ 3 Coldest Facial Temp. (N=26)
1. $\bar{X}$ Face Skinfold	-.1771
2. % Body Fat	-.0580
3. Stature	-.1733
4. Weight	-.1847
5. Linearity Index	-.1325
6. Head Length	-.3371
7. Head Width	.2200
8. Head Height	-.2891
9. Bizygomatic Width	.2227
10. Face Height	-.0501
11. Maxillary Angle (ZM/SN)	.2417
12. Average Face Angle	.2280
13. Cephalic Index	.3072
14. Face Index A	-.0141
15. Nasal Index	.2352
16. Head Index A	.2993
17. Head Index B	.3496
18. Head Index C	.3447
19. Head Index D	.2899
20. Head Index G	.3405
21. Rectal Temperature	.0597
22. Drop in FH Temperature at 45 minutes	.3523

criteria (temperature, facial form, race, etc.). The sub-samples were compared for differences of means by use of the t - test. Since the possibility of non-comparable variances existed, especially in the racial comparisons, each pair of groups was tested using the F or variance-ratio test. Though variance differences will be noted, all were acceptable as equivalent (.05 level).

Problem One - The sample was evenly divided using

the criterion of Head Index D (1/2 average face angle + nasal index/2), one of the better facial form indices. Thirteen subjects with an index of greater than 63.4 fell into a "flat" or "round" face group, and thirteen into the less than 63.4, "sharp" faced group. The object was to see whether the flat faced group maintained higher cold facial temperatures or not, independent of other factors. Of course, in a racially mixed group, the division by face form also reflects the racial difference; the flat faced group had four Americans and nine Japanese, and the sharp, eleven Americans and two Japanese.

[H = Hypothesis, $\bar{X}$ = Arithmetic mean]

H - $\bar{X}_1$ (flat) warmer than $\bar{X}_2$ (suspected from previous analysis).

	Flat	Sharp
N = 13		13
X	221.23	212.36
$\bar{X}$	17.02 (C.°)	16.33 (C.°)
x^2	13.18	26.42
SD	1.0479	1.4837
SD^2	1.0983	2.2016

DF - 24; .05 P. Level; 1-tailed test since direction predicted. To reject H, problem t must not be larger than t from probability curve.

Problem t $= \frac{.69}{.5096} = 1.345$; .05 t = 1.711

Therefore, H is rejected and the means are not significantly different (.69°C). Both sub-groups were likewise tested for

facial skinfold thickness and percentage body fat differences; neither were significantly different.

Parameter	Flat	Sharp
$\bar{X}$ % Body Fat	13.55	14.74
$\bar{X}$ Face Skinfold Log	184.77	184.15

The results of problem one agree with those of the correlation analysis (i.e., no thermal-morphology correlation).

Problem Two - Essentials of the previous problem were retained except that Head Index B (Cephalic Index + Nasal Index/2) was used as the splitting criterion instead of D. The composition again was; flat (H.I. B greater than 74.0), eleven Americans and two Japanese (though not all the same in distribution).

	Flat	Sharp
N	13	13
X	221.85	211.76
$\bar{X}$	17.06 (C°.)	16.29 (C°.)
χ^2	11.349	27.47
SD	.9724	1.5129
SD^2	.9457	2.289

Again the mean difference was small (not significant at .77° C.). The case is growing in one direction, away from evidence for significant relationship between facial linearity and cold facial periphery.

Next, the parameters were reversed. That is, the mean of the three coldest facial temperature itself was the sample splitting criterion and morphological differences

were compared.

Problem Three - Thirteen subjects with mean three coldest facial temperatures below 17.04° C. formed the "cold" group (four Japanese, nine Americans), and above that, the warm (seven Japanese and six Americans).

Parameter	Cold	Warm
$\bar{X}$ Head Index D	64.47	64.31
$\bar{X}$ Average Face Skinfold Log	183.7	185.23
$\bar{X}$ % Body Fat	14.06	14.20

None were significant differences at the .05 level.

The results support the conclusion that neither fat nor morphological facial relief contribute to an explanation or low peripheral facial temperatures. Also, when the diagonal products of the racial distribution above are considered, it becomes evident that the "warm" group is overloaded with Japanese, and the "cold" with Americans.

At this point a t-test was used to compare the means of Head Index B using Americans only, and dividing them into one eight-man "cold" group and one seven-man "warm." The warm group showed a flatter facial form by 2.32 index points, again a statistically non-significant difference. Subsequently, the last problem of the series was designed to elucidate possible racial differences in cold response; it would be as independent of morphology as problem three allowed.

Problem Four - The eleven Japanese and fifteen American subjects formed two natural groups. They were first compared for sample means of mean coldest facial temperature.

H, $\bar{X}_1$ is greater than $\bar{X}_2$ (suspected from problem three)

DF = 24; 1-tailed test; .05 level; t = 1.711

	Japanese	Americans
N	11	15
X	190.5	243.09
$\bar{X}$	17.32	16.206
x^2	12.794	22.047
SD	1.1311	1.2548
SD^2	1.2794	1.5747

To reject H, problem t must be less than 1.711.

$$t = \frac{17.32 - 16.206}{.4901} = 2.273$$

Therefore we accept the hypothesis that Japanese have a higher mean cold facial temperature at the .05 level. It also would have been accepted at less than the .025 level. The difference of 1.114° C. has at least statistical significance. Further t-tests were run and the Japanese showed a smaller difference between their average coldest and average warmest facial temperatures, while maintaining a mean warmest temperature almost identical to that of the Americans:

Parameter	Japanese	Americans	Sig. at
$\bar{X}$ (Xwm-Xcld)	8.08	9.23	.025
Xwm	25.40	25.39	-

Neither body nor facial fat seem to affect these cold facial temperatures.

There might be a small negative correlation of

temperatures with face fat (Table 5, number 1) but it would not, even if real but undetected, cause differences of this magnitude. However, because fat figures into some anthropological hypotheses, the following comparisons are presented:

Parameter	Japanese	Americans	Sig. at
$\bar{X}$ % Body Fat	13.82	14.36	-
$\bar{X}$ Face Skinfold Log	183.18	185.4	-

Neither difference is significant, and the log unit difference amounts to only about one or two tenths of a millimeter. I also decided to compare the distribution of fat on the face; that is, to see if the cheek fat of the Japanese was greater than that of the Americans. Again, the t-test was used with a .01 significance level and the two-tailed test (since direction was not predictable). Mean Japanese cheek skinfold log was 176.0 and the American was 178.5, a difference not statistically significant.

There was another factor which had to be clarified as to the Japanese-American differences. It was possible, since these temperatures were all taken from the ends of aribtrary ninety minute periods, that one group was still losing temperature rapidly while the other had stabilized. The method by which the two average curves were tested was by comparison of the two means of percentage of the total temperature loss sustained at the forty-five minute mark. One warm point (LA) and one cold (CE) were utilized in the

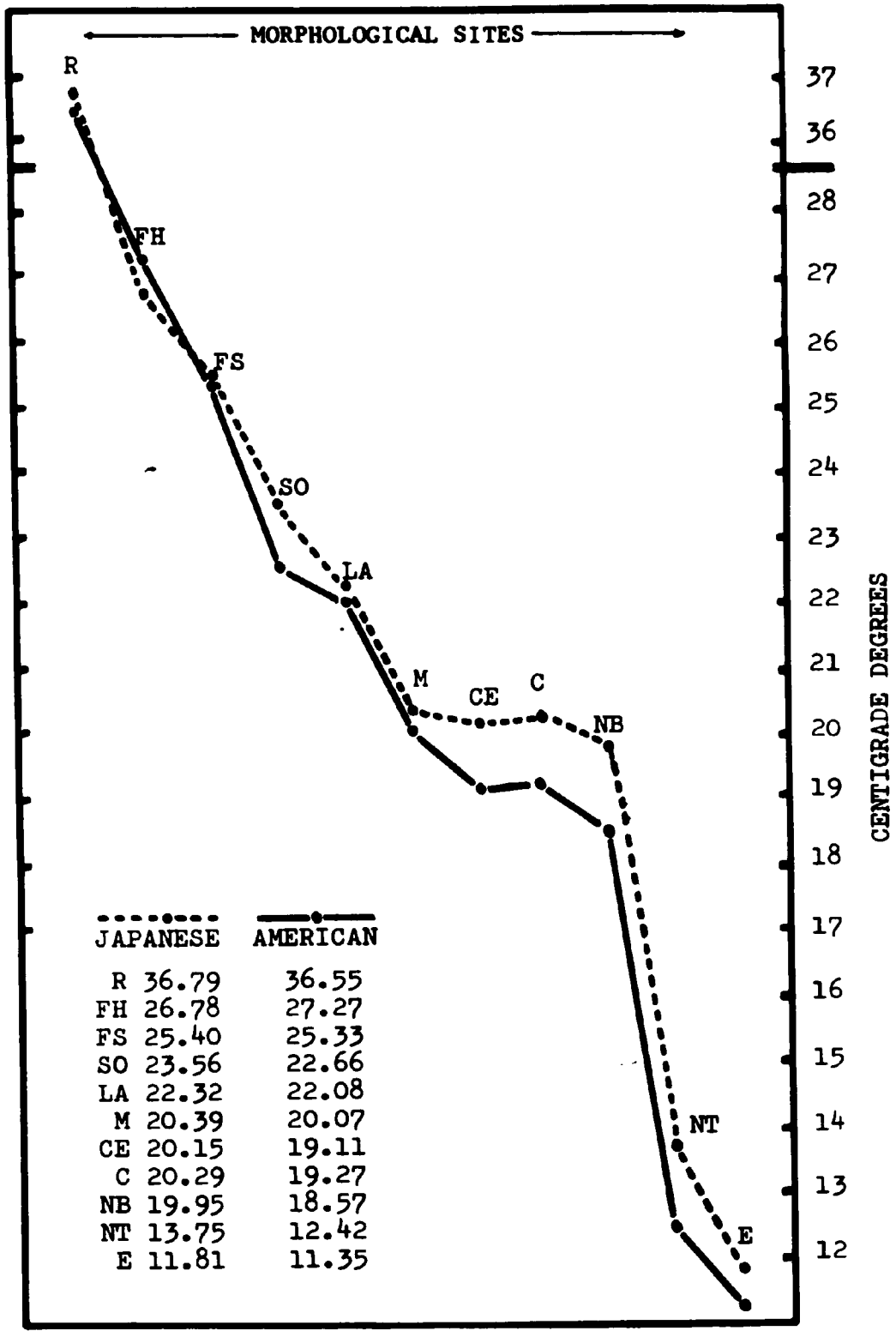


FIGURE 5.--Racial Comparison of some mean final cold exposure temperatures. Letters correspond to core (R) and facial sites discussed in the text.

test, with the same limitations as discussed in the previous paragraph.

Parameter	Japanese	Americans
$\bar{X}$ % Loss at 45 min., LA	83.1	85.2
$\bar{X}$ % Loss at 45 min., CE	87.5	88.7

The pattern is consistent. There was no significant difference.

Since it was clear that there was a general difference between facial temperatures of the two groups, it was worthwhile to define which sites contributed most to the difference. The means of final temperatures were calculated for both groups and plotted (Figure 5). Principal differences lie in the maintenance of nearly equal temperatures of the Japanese malar, cheek, chin, and nasal bridge, whereas the same points showed progressive cooling in the American (M>C>CE>NB). That the Japanese maintain average warmer ear and check temperatures suggests that differences between the groups may be largely vascular rather than morphological since these sites are not really involved with facial linearity.

Thermal Fluctuation

Before this analysis section is summarized, one more factor in evidence on the temperature charts deserves consideration; it is the presence of Lewis waves or the "hunting response" (Lewis 1930a:183). Reflex vasoconstriction is of minor importance in facial skin (Blair *et al.* 1961:119; Cooper 1962:149). Vasomotor activity (including hunting) is

primarily controlled by arteriodilatators operating on arteriovenous anastamoses which are found in the ear, chin, nose, and forehead (Hertzman 1959:292, 298; Lewis 1930a:177). Neither can the additional influence of local chemical vasoactivating substances be overlooked (Burton 1961:119-120; Folkow et al. 1963:352-353). Sometimes the cycles at different sites were simultaneous, but more often not (also observed by Hertzman and Dillon, 1939:673). The facial cycles started at temperatures much higher (Appendix VIII) than would be expected if they had a tissue protection function, and were of lesser magnitude than those seen in the hands. Figures 6 and 7 contrast stable and reactive thermal records. Racially, there were some differences in these variations as summarized below.

(1) Nasal Tip - Eighteen subjects showed one or more cycles. The racial ratios were little different with seven of eleven Japanese and eleven of fifteen Americans being included. However, the Japanese were more reactive, averaging 2.57 cycles to the Americans' 1.64 for the same ninety minute period.

(2) Nasal Bridge - Seven subjects experienced one or more cycles during the ninety minutes. Four of them were Japanese.

(3) Chin - Three out of the four subjects who reacted were Japanese. I am unable to determine the significance of either this observation or the preceding one since they started rather high.

(4) Ear - Only two subjects, both Japanese, showed hunting

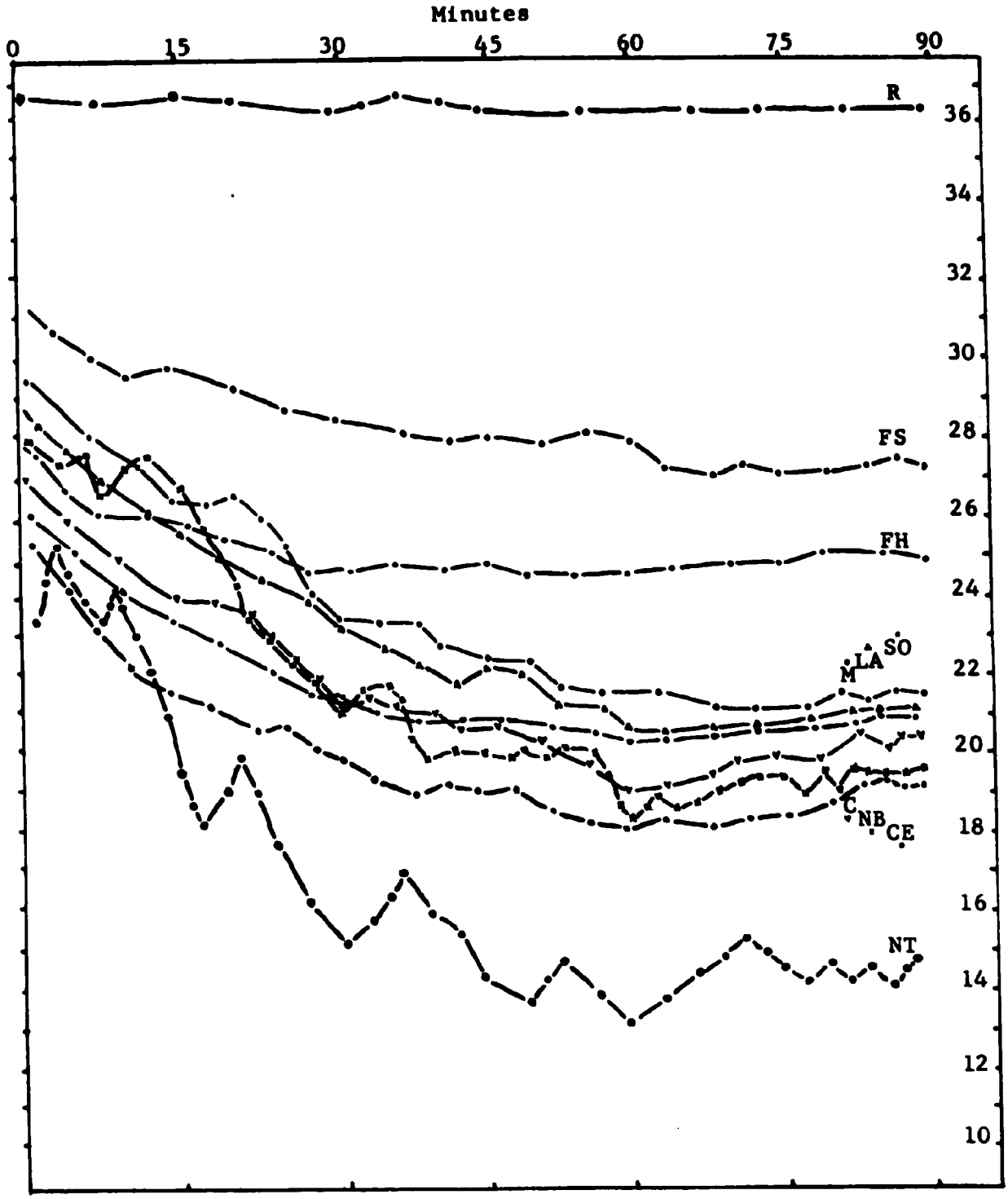


FIGURE 6.--Thermal Response Chart, Reactive Record. Subject 15 Exposed to 1°C. Air for 90 Minutes. Vertical Scale Is Centigrade Degrees and Letters Identify Thermocouple Sites Seen in Figure 3.

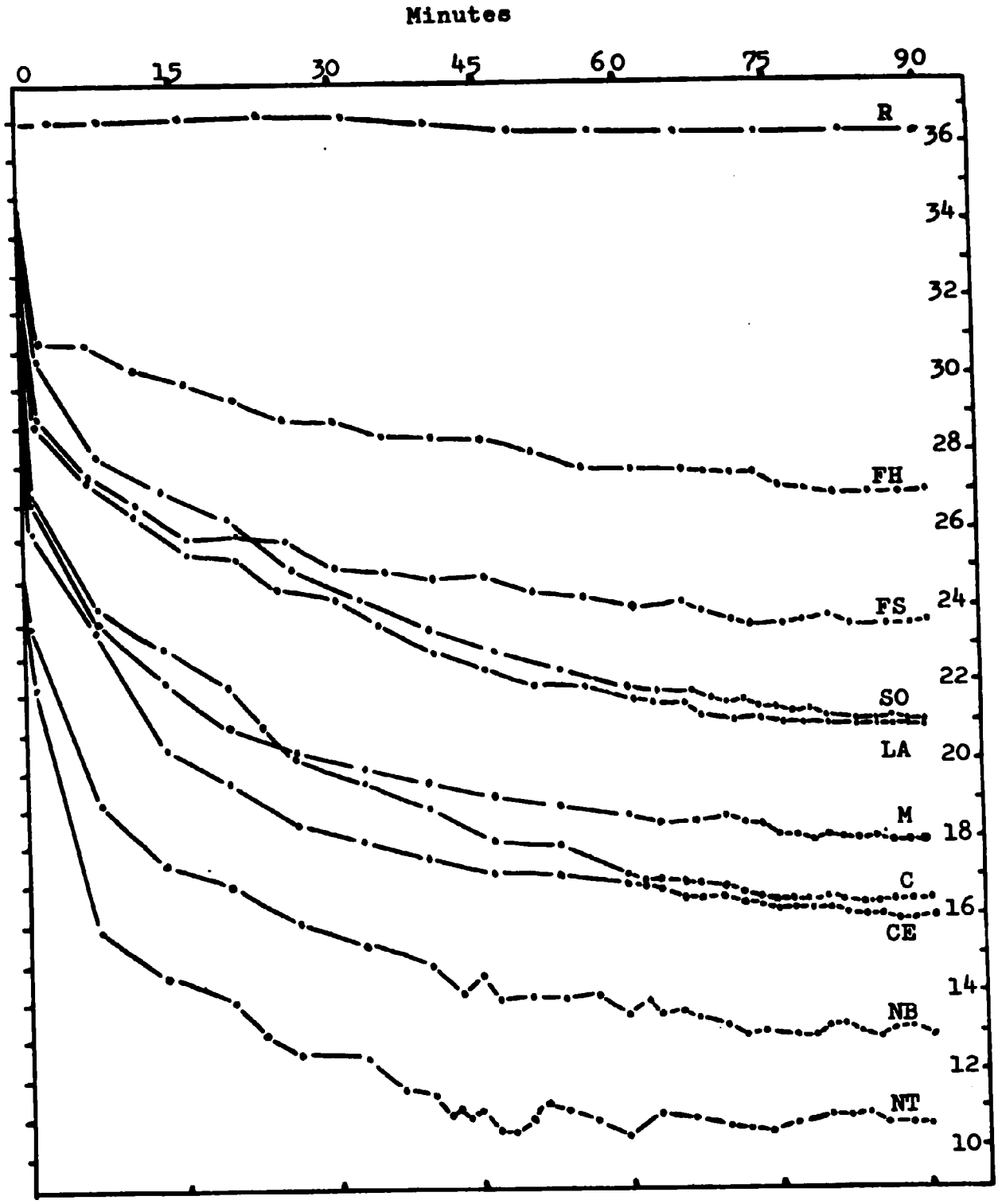


FIGURE 7.--Thermal Response Chart, Non-Reactive Record. Subject 16; Time, Temperature, and Facial Sites as in Figure 6.

responses of the ear.

The Japanese were more reactive. At the coldest areas of the face, most of the temperatures were fairly stable when the final data readings were taken. If the nose temperatures of the Japanese had all been on the "upswing" of a cycle, and those of the Americans on the fall, it would prejudice the results; however, that was not the case. The effect of an average greater number of cycles at the nasal tip of Japanese may have been one of changing the temperature curves.

Experimental Results in Summary

1. There was no significant difference between mean coldest facial temperatures when the sample was divided evenly on a basis of facial sharpness (Head Index D). (a) The two groups showed almost no difference in percentage body fat. (b) The two groups showed almost no difference in average facial skinfold thickness.

2. A similar problem basing the division on Head Index B again produced a non-significant difference of means.

3. Revising the approach, the sample was again halved evenly into groups of the coldest mean cold facial temperatures and the warmest. Again, the means for Head Index D were nearly identical. (a) The two groups were also nearly the same for mean percentage body fat. (b) There was no significant difference between the two in average facial skinfold thickness.

4. The sample of fifteen Americans was divided into two groups of eight coldest and seven warmest mean facial temperatures. Once more the difference between the two groups for Facial Index B was not significant.

5. A number of linear correlations were run on the total sample. (a) Percentage body fat and final core temperature in no way affect mean cold face temperatures but have a positive intercorrelation of .49. (b) There is no correlation between average facial skinfold and mean cold facial temperature.

6. Race, no matter what biological components may have been involved, was the single largest factor in mean cold facial temperature variation. The two groups experienced a difference in means of greater than one degree Centigrade which is statistically significant (.025 level), with the Japanese being the higher. This must be considered when interpreting the preceding five statements since race and the morphology by which it is partly defined are not strictly separable. (a) The two groups showed no real difference in average warm face temperature, percentage body fat, or average face skinfold, and so were equivalent in these parameters. (b) There was an insignificant difference in distribution of facial fat, and in the relative speed of temperature change on the face. (c) The latter, as judged by percentage of total fall sustained at forty-five minutes did not differ racially at warm or cold sites, though actual temperature fall

was slightly less for the Japanese at colder sites (not to be confused with the point that Japanese faces were radiating more heat). (d) The temperature differences may be in part a result of greater "hunting response" in critical facial areas. Four men, all American, showed no hunting; the Japanese also averaged a greater number of responses, and experienced them at more sites on the face.

CHAPTER IV

DISCUSSION AND CONCLUSION

Hypothesis

Before the anthropological significance of the experimental results can be presented, it is necessary to quote and discuss one widely known explanation of the evolution of facial flatness in arctic peoples.

> The most critical portion of their anatomies was thus the face, from eyebrows to cheekbones to the jawline and chin. . . . A man with thin, bony features, especially a narrow, prominent nose, would be in danger of freezing his face. . . . Out of this climatic circumstance came a type of human being with a flat face, padded with fat, . . .
>
> (Coon, Garn, and Birdsell, 1950:67)

Hence frostbite was put forward as one selective cause of facial flatness, but a hypothetical one with no data in support. Without that information, neither can skin temperature-form relationships be used to examine the theory, so the model of frostbite selection must be considered.

Frostbite Selection

The selective power of frostbite cannot be proved; we only assume its operation through incapacitation or as an opening for fatal secondary infection. The former type of damage mainly affects the hands and feet whereas the latter may involve any frostbite site. Twenty per cent of Kiyishev's

World War II frostbite cases became infected, of which a fourth died or were crippled (Appendix IX). Complications include celulitis, neuritis, arthritis, anerobic gangrene, and tetanus, the latter two resulting in one hundred per cent mortality (Aryev 1939:10). More primitive conditions would doubtless intensify the incidence as suggested by this observation on the Eskimo. "Several deaths resulted from scabes as a result of the boils and inflammation set up by scratching with unwashed fingers" (Rawson 1951:587). Frostbite creates a broad opening to infection; even in otherwise mild second degree damage, infection is a major complication (Sutton 1956:106). The assumed selective power of frostbite, therefore, is not unsupported.

The assumption can be further complemented by data on election sites of frostbite (Appendices IX and X). Military statistics contrast with those from non-military groups due in part to the influence of more restrictive footwear and reduction in freedom of movement to restore circulation; relatively greater hand and foot damage is seen.

From the survey which the two appendices represent arise these implications of frostbite in primitive populations. (1) When skin surfaces are under pressure (clothing, boots), frostbite is more likely to become infected. (2) Only third and fourth degree frostbite result in loss of subdermal tissue (Orr 1953:571-572), though second degree becomes infected. (3) The face seldom gets frostbitten, and when it does there is no evidence that the injury exceeds second degree.

"Conditions capable of producing any significant degree of freezing in the ears and nose are just the conditions for causing a fatal hypothermia" (Aryev 1939:9). Both high facial temperatures and cultural practices are preventatives of frostbite.

The following model is an attempt at quantification of facial form-frostbite selection in a primitive Arctic group; (a) assume per generation, .10 of total injuries result from frostbite, (b) of those, assume .30 to be facial, and (c) and of those, .05 result in fatality. Therefore, .1 x .3 x .05, or .0015 of total injuries lead to death involving the face. This only applies to males who sustain most of the total cold injury, so the influence of the force on genetic change is halved (to .00075). Accepting the results of the present research, only perhaps .2 of that relates to facial form (the remainder being circulatory); .00075 x .2 = .00015. With a population of 20,000, only three men would fail to pass on their genes for the traits in question.

In summary, frostbite doubtless operated as an agent of natural selection on cold stressed populations but the speed with which it would have acted on the face would have been less than implied by the opening quotation of this chapter.

One more assumption needs be defended before skin temperature data can be applied to the Coon, Garn, and Birdsell hypothesis--that the coldest sites on the experimentally

cooled face (Figures 2 and 5) are those with the least resistance to frostbite. Sir Thomas Lewis observed that "there are certain maladies in which the symptoms are shown mainly by skin of . . . organs such as the fingers, pinna, and nose. Thus in these three, frostbite is common" (1930b: 351). By use of thermocouples he found "the usual order of coldness is finger, ear, nose, cheeks . . . the order in which . . these parts are prone to present the symptoms of maladies named in the opening paragraph" (ibid. 352). Data in Appendices IX and X render the same conclusion; ears, nose, and cheeks are the most frequent facial frostbite sites.

Anthropological Implications: Morphology

If the above assumptions are sound, experimental results from this study apply to the Coon-Garn-Birdsell hypothesis, but the limitations of the experimental design and sample size are obvious. Frostbite is not sustained while in a basal state with mobility minimized and convectional heat loss from the face all but eliminated. The research design proposed in the final section will compensate for some of those problems and when the project is executed, may completely change the present conclusions. That which follows, then, is based strictly upon the current state of research.

Assuming low facial temperatures are not a function of facial sharpness, selection of flatter faces by frostbite is not an acceptable explanation. This is not to say facial

flatness is not functionally related to cold, or is not a product of cold selection. The face is not unaffected by changes in the body.

A further implication is that facial fat thickness has little to do with facial skin temperature (and therefore frostbite selection), contrary to the hypothesis. This is not true of skin temperatures of the body (Buskirk et al. 1963:435). If the arctic face is fat padded, it would more likely be related to insulation. Furthermore, aside from experimental results, Eskimos have an average cheek skinfold of 12 mm compared to 11 mm for Caucasians (Elsner 1963:841), though it is relatively high when compared to their own body skinfolds; consequently, their facial shape is more a matter of bone structure than fat and their faces are not really well-padded by fat. To the credit of the hypothesis stands the fact that though frostbite was the only selective agent discussed, it was noted that cold adapted faces were developed for protection of the nose and eye and to conserve heat (Coon, Garn, and Birdsell 1950:69); the contradiction between adaptive change for a warmer surface (frostbite protection) and for a colder one (insulation) was not seen.

Anthropological Implications: Race

The racial difference in facial cold response constitutes an anthropological contribution which goes beyond the limit of form-function implication, since evidence suggests that the warmer temperatures of the Japanese face (Figure 5)

were controlled by circulatory rather than form differences. Morphologically neither the cheek or ear sites of the Japanese were "less peripheral" than those of the Americans, yet they were warmer. Also, greater reactivity at four facial sites characterized the Japanese and probably contributed to the higher final temperatures. This point is of anthropological significance for three reasons. (1) No matter how slow in acting, selection by facial frostbite would act more rapidly upon circulatory characteristics than upon dimensions of facial form (assuming the conclusions of this study are correct); the Japanese are descendents of populations which were supposedly cold adapted (Beardsley 1955; Hulse 1957; Kidder 1959) and could still carry such changes. (2) Extremity circulatory differences (especially "hunting") are among the clearest of contrasting cross-racial responses to cold (Baker 1963; Milan 1963:339-340, 344, 352). Data derived from the present research are the first to suggest the same is true of the face. (3) If the Japanese - American difference in facial temperature is equivalent to an arctic-adapted/non-arctic adapted difference, another point of interest arises--cold adapted faces radiate more heat and are not "designed" for thermal conservation, though a warm surface would protect deeper structures. Northern populations of our species have relatively large faces and heads (Newman 1953:316-322), and the head radiates great quantities of heat (Froese and Burton 1957:239). Then the arctic head and face is a means of increasing heat loss rather than conserving it.

The implication is that heat loss is not a problem in the arctic (unlikely) or that head traits are to some extent what they are for other reasons. The only explanation I will suggest is that an increase in head size resulted from its allometric relationship to increased body size, which in turn was an evolutionary response to core temperature maintenance demands. Newman's illustrations (1953:314-322) substantiate the morphological regularities.

Critique of Methods

Morphology

(1) Facial Form: By inspection the most valuable individual measurements were average facial angle (transverse), nasal index, and cephalic index; they were also useful when combined into head indices "B", "C", and "D". For future work, a device is being designed which will measure two planes of facial sharpness with one or two motions; it will save time and combine data which were used here as separate paramaters. Monophotogrammetry (Pierson 1962:399-402) adapted to the polaroid type camera might be just as fast and accurate.

(2) Facial Fat: The Harpenden caliper is to be recommended for measuring body and facial fat, and its use will be continued in future research. Stanley Garn (personal communication 1965) suggested X-ray procedures be used in conjunction with the calipers.

They take time but the value for accurate fat estimation and their cephalometric worth are obvious.

Temperature

(1) Facial Sites: Of greatest racial contrast were the cheek, chin and nasal tip cold sites and they will therefore be used in the future. The forehead and frontal sinus proved adequate as warm references.

(2) Apparatus: The recording potentiometer and thermocouples offered adequate sensitivity and output of data; however their use required millivolt-temperature conversions which were very time consuming. Future work will consequently employ thermistor recorders of the type manufactured by Yellow Springs Instrument Company (accuracy .15° C., .5 second time constant). They are dial-read, record directly and are now standard in much of the field work in climatic physiology due to their light weight, battery power, and dependability.

Other: Each subject required about 48 hours to process. In the future, economies suggested in this section will reduce the time required. Especially, it will be possible to run two to four subjects simultaneously, possibly for shorter periods, without sacrificing information. Also, the ends of the study were not enhanced by subject discomfort; in the future, warmer dress is needed.

Projected Research

Due to the sample size, the results of this study must be verified in both their morphological and racial aspects; a proposal toward that end has been presented to the American IBP Committee and is outlined below. On Hawaii, sizeable sub-populations are found from which samples would be matched for acclimatization, diet, morphology, social class, etc., or factors which might have intruded undetected variation into the present study. The only obvious contrast would be the genetic character of the sub-groups. Matched samples of occidentals, orientals, and hybrids (40 each) would be tested in three ways. (a) Face and core temperatures in response to cold air would be recorded under experimental conditions similar to those described previously, with the following modifications; two separate, identical experiments on each subject would last 60 minutes, and facial cooling would be speeded by either lower temperatures, by air flow, or both. Again, facial characteristics would be tested against temperatures. This time, however, the samples would be large enough so that within and between group analyses would have higher statistical validity. (b) In another experiment, alcohol induced face and hand vasodilation patterns will be examined thermally and by color reflectometry; a pilot study is now being prepared to test this approach, and in Hawaii, the "A" sample would be used. (c) Finally, thermal response to immersion of the fingers in stirred ice water, on the same sample, would form a third physiological

dimension. Its correlative value with previous data and role in answering the questions posed is obvious.

The results will verify or modify conclusions of this dissertation with all their anthropological implications, as well as furnishing new questions, new data, and new answers.

Summary

No correlations between temperatures of air cooled human facial skin and various dimensions of facial sharpness and fat padding could be detected. Race, whatever its contributing components, was the only variable to which contrasting facial temperatures could be directly attributed; the mean cold facial temperature remained 1.114° C. higher in the Japanese, contrasted to Americans, after ninety minutes at 1° C. Modification of techniques and expansion of the sample and controls are suggested in order to verify these findings.

APPENDIX I

EQUIPMENT

Anthropometric Instruments

1. Anthropometer (GPM #1, Siber Hegner & Co.)
2. Sliding Caliper (GPM #4, Siber Hegner & Co.)
3. Spreading Caliper (GPM #6, Siber Hegner & Co.)
4. Steel Millimeter Tape (GPM #10, Siber Hegner & Co.)
5. Spring Scale, Graduated in Pounds
6. Harpenden Skinfold Caliper (H. E. Morse & Co., Holland Mich.)

Photographic Equipment

1. Asahi Pentax, 35mm Camera with an f2, 58mm lens
2. Honeywell Prox-O-Lite (strobe flash, ring-type)
3. Hershey Sunlite "700" (AC power source for strobe)
4. Ednalite Adapter Ring, #663
5. Valiant Tripod (domestic type, tubular aluminum)

Thermal and Environmental Apparatus

1. Speedomax Type G Recorder, Model S, 6000 Series with Multiple Point Printer (Leeds & Northrup Co.)
2. Hygrodynamics Electric Hygrometer Indicator, AC Type 15-3000, with Wide Range Humidity Sensing Element 15-1810
3. Walk-in type cold room (Hydor Therme Corp.)
4. Blenderm Surgical Tape (3M Co.)
5. Ace Adherent (Becton, Dickinson, & Co.)
6. Underwear - Sears Roebuck & Company heaviest grade, nylon shell, nylon quilted hunter's underwear and boot socks; zipper front with knit stretch wrists, ankles, and neck
7. Mittens - canvas shell, flannel lining, hunting type
8. Subject Support - tubular aluminum frame, nylon webbing Chaise Lounge with adjustable backrest

APPENDIX II

BODY DIMENSIONS AND INDICES

Anthropometric methods follow Hrdlička 1957 (page is after code "Hrd") and Montagu 1951 (page is after code "Mt").

1. Stature - Hrd 82
2. Sitting Height - Hrd 84-85
3. Biacromial Width - Hrd 205
4. Total Upper Extremity Length - Mt 445
5. Axillary Chest Girth - Mt 448
6. Waist Girth - Hrd 308
7. Hand Length & Width - Mt 449
8. Foot Length & Width - Mt 448
9. Weight - Taken in pounds on a spring scale; subtract two pounds for clothing, and converted to Kilograms
10. Sitting Height Index - $\frac{\text{Sitting Height} \times 100}{\text{Stature}}$
    - increases as legs shorten
11. Trunk Index - $\frac{\text{Biacromial Width} \times 100}{\text{Sitting Height}}$
    - increases as thorax narrows
12. Rotundity Index - $\frac{\text{Average of Chest and Waist Girth} \times 100}{\text{Sitting Height}}$
    - increases with general rotundity of build
13. Upper extremity Index - $\frac{\text{Upper Extremity Length} \times 100}{\text{Stature}}$
    - increases with linearity of body build
14. Stature-Weight Index - $\frac{\text{Weight}}{\text{Stature (cm)}}$
    - increases with laterality of body build
15. Hand Index - $\frac{\text{Hand Width} \times 100}{\text{Hand Length}}$ - increases with width
16. Foot Index - $\frac{\text{Foot Width} \times 100}{\text{Foot Length}}$ - increases with width
17. Extremity Index - Average of 15 & 16 - increases with width
18. Total Body Linearity Index - $\frac{\text{Stature-Weight I.} + \text{Rotundity I.}(.404) + \text{Sitting Height I.}(.683)}{3}$

    This formula weighs each of the three indices evenly. It was derived by giving the sample mean of the Stature-Weight I. a value of one. The other sample means were then divided into this first sample mean since they were larger values, and the percentage derived was then the amount by which they were multiplied to make all indices of equivalent weight. The index value goes up as the body build becomes rounder and stubbier.

19. Body Surface Area - calculated according to the DuBois regression using Stature (cm) and Weight (kg)

20. Body Skinfold Thickness - taken by Harpenden caliper (see Appendix I) according to the instruction sheet.

    Sites: a) Tricep - vertical pinch over the tricep halfway down the left arm between the tip of the acromion and the top of the radius

    b) Subscapular - just below the angle of the left scapula at about a forty-five degree angle off horizontal so as to follow the skin grain

    A logarithmic conversion provided with the caliper plus the site information may also be found in Edwards, et al., 1955.

21. Estimate of Percent Body Fat - Damon and Goldman (1964:38) presented evidence that two skinfold sites (those used above) give a very good estimate of percent body fat. They found Grande's formula (Behnke 1959:128) to be the best.

$$\% \text{ Body Fat} = \frac{4.0439}{\text{Density}} - 3.6266$$

22. Estimate of Body Density - The density estimates from two sites mentioned above were derived by Pascale et al. (1956:172).

    D = 1.0923 - 0.0202 (tricep skinfold in cm)
    D = 1.0896 - 0.0179 (subscapula skinfold in cm)

    I averaged the two estimated densities for use in the body fat formula.

APPENDIX III

HEAD AND FACE DIMENSIONS AND INDICES

References are as in Appendix II.

1. Maximum Head Length - Hrd 87
2. Maximum Head Width - Hrd 88
3. Minimum Frontal - Hrd 92
4. Bizygomatic - Hrd 93
5. LO to LO
6. N to LO
7. Nose Length - Hrd 94
8. Nose Width - Hrd 94
9. Nose Height - Hrd 200 - later decided to be of doubtful accuracy
10. A to PRN
11. ZM to ZM
12. ZM to SN
13. ZM to PRN
14. ZM to LS
15. Aricular Head Height - Hooton 1946:758
16. Total Face Height - Hrd 92
17. Bigonial - Hrd 92
18. G to LS
19. G to PG
20. Mouth Width - Hrd 95
21. Mouth Height - Hrd 201
22. Ear Length - Hrd 95
23. Ear Width - Hrd 95
24. Cephalic Circumference (horizontal) - Hrd 92
25. Cephalic Circumference (vertical) - from the lowest anterior point of the chin to the highest point on top of the head. Later decided to be of doubtful accuracy.
26. Cephalic Index - $\frac{\text{Width x 100}}{\text{Length}}$ - increases with roundness
27. Head Height Index - $\frac{\text{Height x 100}}{\text{Width}}$ - increases with height
28. Face Form Index "A" - $\frac{\text{Bizygomatic x 100}}{\text{Head Width}}$ - increases with face width
29. Face Form Index "B" - $\frac{\text{Minimum Frontal x 100}}{\text{Bizygomatic}}$

30. Face Form Index "C" - $\frac{\text{Total Face Height} \times 100}{\text{Bizygomatic}}$

31. Face Form Index "D" - $\frac{\text{Bigonial} \times 100}{\text{Bizygomatic}}$
- decreases with face width

32. Nasal Index - $\frac{\text{Nasal Width} \times 100}{\text{Nasal Length}}$ - increases with width

33. Nasal Height Index - $\frac{\text{Nasal Height} \times 100}{\text{Nasal Length}}$
- increases with height

34. Angle LO-N-LO - gives facial protrusion across orbits, decreasing as protrusion increases

35. Angle ZM-SN-ZM - gives same information as 34, across maxilla

36. Angle G-PG-G - gives same information as 34, across mandible

37. Average Facial Angle - $\frac{34 + 35}{2}$

Note: 34, 35, and 36 were drawn on graph paper. As in 34, LO-LO was used as the triangle base with N-LO being used for the two remaining sides. Bilateral facial asymmetry was not assumed to be a significant source of error. A protractor was then used to measure the angles (see Figure 1).

38. Head Index "A" - $\frac{\text{Cephalic I.} + 1/2 \text{ Average Facial Angle}}{2}$

39. Head Index "B" - $\frac{\text{Cephalic I.} + \text{Nasal I.}}{2}$

40. Head Index "C" - $\frac{\text{Cephalic I.} + \text{Nasal I.} + 1/2 \text{ Average Facial Angle}}{3}$

41. Head Index "D" - $\frac{\text{Nasal I.} + 1/2 \text{ Average Facial Angle}}{2}$

42. Head Index "E" - $\frac{\text{Cephalic I.} + (160 - \text{Face Form I. "C"})}{2}$

43. Head Index "F" - $\frac{(160 - \text{Face Form I. "C"}) + 1/2 \text{ Ave. Face Angle} + \text{Angle 36}}{3}$

44. Head Index "G" - $\frac{\text{Cephalic I.} + \text{Nasal I.} + 1/2 \text{ Ave. Face Angle} + (160 - \text{Face I. "C"})}{4}$

45. Head Inex "H" - $\frac{\text{Cephalic I.} + \text{Nasal I.} + 1/2 \text{ Ave. Face Angle} + (150 - \text{Head Height I.}) + (160 - \text{Face Form I. "C"})}{5}$

Note: Subtractions in Index formulas 42 to 45 function to make the expression numerically equivalent to others as well as causing them to increase or decrease symmetrically. All indices decrease as facial "sharpness" increases.

46. Facial Skinfolds - Procedures are same as in Appendix II, #20. Facial Skinfolds are often difficult to measure due to facial skin tightness; tries were made until I was satisfied as to accuracy.
    Sites: a) Cheek - vertical pinch just inferior to ZM
    b) Malar - Horizontal pinch just posterior and inferior to LO
    c) Jaw - A-P pinch, posterior to PG

47. Photograph - A frontal and lateral 35mm photograph set was taken of each subject with Kodachrome II, a film very true for skin color tones. Lens to subject distance was six feet; a strobe ring light reduced highlights to a minimum and the aperture was set at f2.5. A metric scale, focus scale, color patch (for power consistency) and ID number were included in each picture (for equipment see Appendix I).

48. Other observations (subjective) were made on hair and beard characteristics and general facial "cragginess."

APPENDIX IV

SELECTED INDIVIDUAL SUBJECT DATA

APPENDIX IV

SELECTED INDIVIDUAL SUBJECT DATA

Variable	AMERICAN, SUBJECT NUMBERS: 1	2	4	8	9	10	11	13	14	16	20	21	22	27	29	MEAN	SD
Age	23	26	30	28	20	18	22	20	20	21	19	19	21	28	20	22.33	3.7034
Stature,cm	175.8	176.5	178.1	175.1	173.1	179.0	171.1	165.1	161.1	167.9	181.4	176.3	170.8	171.0	178.9	173.41	5.6262
Weight,kg	78.00	62.10	69.90	57.40	72.10	68.20	86.50	53.70	75.00	57.30	71.80	64.00	62.00	52.80	79.20	67.33	9.9839
Cheek Skinfold,cm	1.41	1.02	1.02	.93	.71	.76	1.69	.96	1.46	.85	.99	1.02	1.01	.96	.60	1.03	.2902
Malar Skinfold,cm	1.01	.70	1.12	.65	.71	.80	1.40	.63	1.02	.66	.74	.80	.74	.82	.62	.83	.2137
$\bar{X}$ Body Skinfold,cm	1.24	.61	1.12	.64	1.12	.91	1.66	.58	2.02	.59	.75	.87	.66	1.02	.73	.97	.4182
% Body Fat	16.05	12.26	15.41	12.10	15.23	13.93	18.84	11.77	21.55	11.87	12.88	13.74	12.26	14.76	12.78	14.36	2.7800
Linearity Index	39.69	34.73	36.33	33.56	38.16	34.77	40.50	33.96	41.30	34.46	36.23	34.80	34.54	34.82	36.33	36.28	2.4828
Bizygomatic Width,cm	14.9	13.4	13.5	13.3	13.7	13.7	13.8	13.2	13.7	13.5	14.2	13.4	13.4	13.2	13.2	13.6.	.4495
Total Face Height,cm	12.3	12.0	11.9	11.2	11.6	11.9	12.7	11.1	11.0	12.0	10.5	12.5	11.5	10.8	12.9	11.73	.7608
Ave. Face Angle	125	121	105	109	114	105	113	118	126	121	114	107	115	121	98	114.1	8.2812
Cephalic Index	78.6	74.6	73.4	75.2	74.9	75.0	76.0	78.3	78.9	73.8	80.0	83.7	77.2	81.3	77.0	77.22	2.9439
Face Index A	92.0	87.6	90.6	88.7	93.8	89.5	92.6	86.8	91.3	90.6	93.4	87.0	89.9	86.8	87.4	89.87	2.3560
Nasal Index	80.4	78.4	57.4	62.3	61.5	51.7	64.1	70.8	62.0	59.6	68.0	58.9	76.0	53.3	60.7	64.34	8.6996
Head Index B	79.5	76.5	65.2	69.0	68.2	63.3	70.0	74.5	70.4	66.7	74.0	71.3	76.6	67.3	68.8	70.75	4.6090
Head Index D	71.4	69.4	54.9	58.4	59.2	52.1	60.3	64.9	62.5	60.0	62.5	56.2	66.7	56.9	54.8	60.68	5.5778
$\bar{X}$ Final Temp., R	36.90	36.27	36.80	35.60	37.00	37.17	36.70	36.50	37.40	36.50	36.83	35.80	36.70	36.55	35.58	36.55	.5420
" " FH	26.08	25.05	26.63	27.51	28.02	28.15	24.98	26.56	26.47	27.05	28.83	26.50	29.15	29.26	28.81	27.27	1.4009
" " FS	25.66	21.85	26.50	26.75	23.60	27.85	25.45	23.98	22.33	23.64	25.56	24.60	28.98	27.36	25.78	25.33	4.0240
" " SO	23.01	18.00	21.41	22.86	27.00	25.90	19.48	22.94	23.33	21.33	20.35	23.32	24.77	24.68	21.56	22.66	2.4008
" " LA	21.58	24.85	23.20	22.63	23.10	22.40	21.28	23.00	20.13	21.07	21.56	20.36	22.32	22.10	21.56	22.08	1.2096
" " M	18.25	21.67	21.85	23.20	22.91	21.72	21.32	18.55	17.40	18.07	19.19	19.55	22.24	20.56	21.58	20.07	1.9438
" " CE	17.53	21.01	21.78	21.25	20.70	18.95	19.24	18.98	15.01	16.14	19.16	17.46	19.36	19.55	20.60	19.11	2.5613
" " C	20.00	15.97	18.16	18.83	21.51	23.45	18.23	20.26	18.94	16.54	15.30	19.82	21.78	20.47	20.70	19.27	2.2489
" " NB	19.58	19.70	17.05	19.86	18.76	16.56	22.52	18.98	18.58	12.98	16.61	16.30	22.20	18.80	20.12	18.57	2.4200
" " NT	14.23	14.14	13.50	13.80	12.82	11.00	11.28	11.35	11.48	10.61	13.53	11.88	11.04	13.28	12.38	12.42	1.2553
°C. Drop, FH, 90 Min.	9.12	8.85	7.87	6.99	6.08	7.35	8.60	8.04	7.73	8.05	6.17	7.50	6.05	6.24	6.29	7.39	1.0521
" " CE "	16.70	13.59	12.12	12.05	11.80	14.85	14.76	13.92	16.29	16.46	13.64	13.84	13.64	14.95	13.50	14.14	1.5440
% of Total Drop, FH at 45 Min.	93	93	81	84	88	84	97	93	97	80	90	88	100	91	89	89.86	5.9023
% of Total Drop, CE at 45 Min.	87	90	91	84	100	84	77	92	94	92	88	87	93	90	82	88.66	5.5870
$\bar{X}$ 3 Final Warmest Facial Temps.	25.15	23.91	25.43	25.82	26.20	27.30	24.31	24.51	24.04	23.99	25.30	24.80	27.63	27.09	25.39	25.39	1.7000
$\bar{X}$ 3 Final Coldest Facial Temps.	16.67	16.02	16.23	17.49	17.42	15.50	16.25	16.29	14.63	13.24	15.40	15.21	17.39	17.21	17.70	16.21	1.2500

Variable	JAPANESE, SUBJECT NUMBERS: 6	7	12	15	17	19	23	24	25	26	28	MEAN	SD
Age	25.0	25.0	28.0	25.0	27.0	26.0	24.0	29.0	30.0	24.0	23.0	26.0	2.5690
Stature,cm	168.2	164.5	168.4	162.0	166.6	164.6	164.3	166.5	162.3	169.8	173.0	166.38	3.3140
Weight,kg	69.90	57.30	56.00	57.70	50.05	58.70	52.80	51.50	53.30	61.50	69.00	57.98	6.5917
Cheek Skinfold,cm	1.41	1.03	.68	1.10	.65	1.06	.78	.94	1.12	1.05	1.06	.99	.2158
Malar Skinfold,cm	.95	.68	.44	.68	.52	.95	.77	.60	.82	1.05	.88	.77	.1680
X̄ Body Skinfold,cm	1.71	1.26	.92	.85	.58	.66	.67	.80	.99	.69	.94	.91	.3266
% Body Fat	19.41	16.30	14.00	13.48	11.77	12.26	12.29	13.20	14.46	12.15	12.71	13.82	2.2600
Linearity Index	38.23	34.98	34.00	35.86	32.59	35.87	33.89	33.12	35.04	35.18	37.77	35.14	1.7606
Bizygomatic Width,cm	14.7	14.0	14.3	.512	15.1	14.8	14.4	14.4	14.5	15.0	14.5	14.63	.3690
Total Face Height,cm	11.7	1.16	12.0	12.0	12.7	11.8	11.4	12.1	11.1	13.1	12.7	12.02	.6046
Ave. Face Angle	148	119	136	124	136	136	125	149	121	133	126	132.1	10.197
Cephalic Index	86.6	84.9	89.5	92.8	86.6	93.2	84.8	89.9	92.8	92.8	80.6	88.60	4.2406
Face Index A	94.8	89.2	88.3	90.5	93.2	89.1	92.3	89.4	85.8	89.8	94.1	90.60	2.7233
Nasal Index	76.9	67.3	77.3	75.5	58.9	69.2	63.6	55.6	67.3	60.0	69.8	67.40	7.4866
Head Index B	81.7	76.1	83.2	84.1	72.7	81.2	74.2	72.7	80.0	76.1	75.2	77.90	4.2167
Head Index D	75.4	63.4	72.6	69.2	63.4	68.6	63.0	65.0	63.9	63.2	66.1	66.70	4.1771
X̄ Final Temp., R	37.25	37.00	36.80	36.37	36.73	36.85	36.73	36.97	36.73	36.23	37.06	36.79	.2937
" " FH	24.20	27.13	26.97	25.08	26.98	28.32	28.04	28.67	27.40	24.86	27.00	26.78	1.4939
" " FS	23.40	24.90	25.52	27.21	25.75	26.91	26.13	26.15	25.02	22.87	25.57	25.40	2.3237
" " SO	23.15	26.92	22.80	21.51	21.08	24.10	25.97	28.12	21.10	20.77	23.63	23.56	2.3157
" " LA	21.25	19.85	20.90	21.23	19.57	22.68	27.33	25.83	24.92	19.60	22.37	22.32	2.6349
" " M	20.60	22.95	19.00	21.07	19.27	19.59	23.07	22.66	20.87	16.34	18.87	20.39	2.0533
" " CE	18.90	20.30	19.62	19.23	19.35	20.44	25.98	22.50	20.28	17.61	17.40	20.15	2.3854
" " C	18.46	21.70	19.42	20.51	18.77	19.50	22.74	24.82	17.81	17.44	22.06	20.29	2.3022
" " NB	18.35	24.72	20.08	19.58	19.06	17.58	17.34	20.08	21.41	17.58	23.75	19.95	2.4676
" " NT	15.70	13.24	12.67	14.81	11.70	14.92	14.80	13.58	13.03	10.90	16.73	13.75	1.8934
°C. Drop, FH, 90 Min.	10.00	6.97	7.54	8.32	8.12	6.68	6.76	6.43	7.00	9.34	6.70	7.62	1.1940
" " CE "	14.00	12.00	11.98	12.37	14.25	13.76	9.12	12.50	13.92	15.20	14.30	13.04	1.6805
% of Total Drop, FH at 45 Min.	83	84	79	100	91	97	93	94	90	95	89	90.4	6.4246
% of Total Drop, CE at 45 Min.	80	93	85	100	87	92	83	85	83	88	87	87.5	5.6372
X̄ 3 Final Warmest Facial Temps.	23.58	36.31	25.09	24.51	24.60	26.44	27.16	27.65	25.78	22.83	25.44	25.40	1.4100
X̄ 3 Final Coldest Facial Temps.	17.50	17.79	17.03	17.87	16.50	17.30	18.29	18.96	17.04	14.56	17.66	17.32	1.1300

APPENDIX V

INFORMATION REQUESTED OF EACH SUBJECT

1. Name
2. Age
3. Birthplace
4. Childhood Home
5. Ethnic group
6. Father's birthplace and ethnic group
7. Mother's birthplace and ethnic group
8. Length of time in Ann Arbor
9. Length of time in U.S.A.
10. Do you consider yourself to be in good health?
11. Have you ever undergone a serious illness or major surgery?
12. Have you ever experienced any abnormal skin conditions, particularly of the face?
13. Have you ever suffered any serious heat or chemical burns, become ill from heat or cold, or sustained frostbite?
14. Are you more comfortable in heat or cold?
15. Do you ever use coffee, tea, cola drinks, alcohol, tobacco, or other stimulants? If any, how much per week?
16. Do you use any kind of medication regularly?
17. Have you noticed any marked weight changes during the last year?
18. Do you wear dentures?
19. Are you out in the cold much of the time (as in winter sports)?
20. Do you take part in any regular athletic program?
21. Have you been a student for at least six months?

APPENDIX VI

STATISTICAL TESTS

Difference-of-Means Test

Values:

N = Sample Size

$\bar{X}$ = Individual Value

$x = (X-\bar{X})$

s = Sample Standard Deviation or $\sqrt{\frac{\Sigma x^2}{N-1}}$

s^2 = Sample Variance

$$F = \frac{s^2 \text{ of Larger Sample}}{s^2 \text{ of Smaller Sample}}$$

$$s_{X_1-X_2} = \sqrt{\frac{N_1 s^2_1 + N_2 s^2_2}{N_1+N_2-2}} \qquad \sqrt{\frac{N_1+N_2}{N_1 N_2}}$$

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{\bar{X}_1 - \bar{X}_2}}$$

1. $s_1 = s_2 = s$, Normal Populations
2. Independent Random Samples
3. When $H_0, \bar{X}_1 = \bar{X}_2$

Procedure:

1. Calculate the values.
2. Verify that $s_1 = s_2 = s$. The F-table with degrees of freedom of N_1-1 and N_2-2 at the chosen level will show a higher F than the calculated one if there is no significant difference.
3. Set the significance level using one tail of the curve if direction is predicted, or two otherwise.
4. Find the t-value. The higher the value, the more different are the two means. If the calculated t-values are greater than those given in the probability table, the null hypothesis [H_0] can be rejected.

From Snedecor 1956:96, and Blalock 1960:170-175.

Stepwise Correlation-Regression Test

Information on the computer regression program may be had at the University of Michigan Computing Center, Ann Arbor; its features employed in this work have already been discussed. The correlation coefficients were tested for significance by the following methods.

1. Significance tables for use with simple linear correlation coefficients (r) may be found in Snedecor 1956: 174, or Fisher 1928:209.

2. Significance of the multiple correlation coefficients (R) was handled by an analysis-of-variance test, where

$$F = \frac{R^2}{1-R^2} \frac{N-K-1}{K}$$

and where N is the number of data sets (i.e., the number of individuals, no matter how many data there are for each one), and K is the number of independent variables.

Degrees of freedom I (one) is equal to K which increases with each step, and degrees of freedom II (two) is equal to N-K-1. See Blalock 1960:354.

3. Further, to see whether R is significantly improved by additional steps, another F-test was employed where,

$$F = \frac{R^2_1 - R^2_2 \;/\; (K_1 - K_2)}{(1-R^2) \;/\; N-K-1.}$$

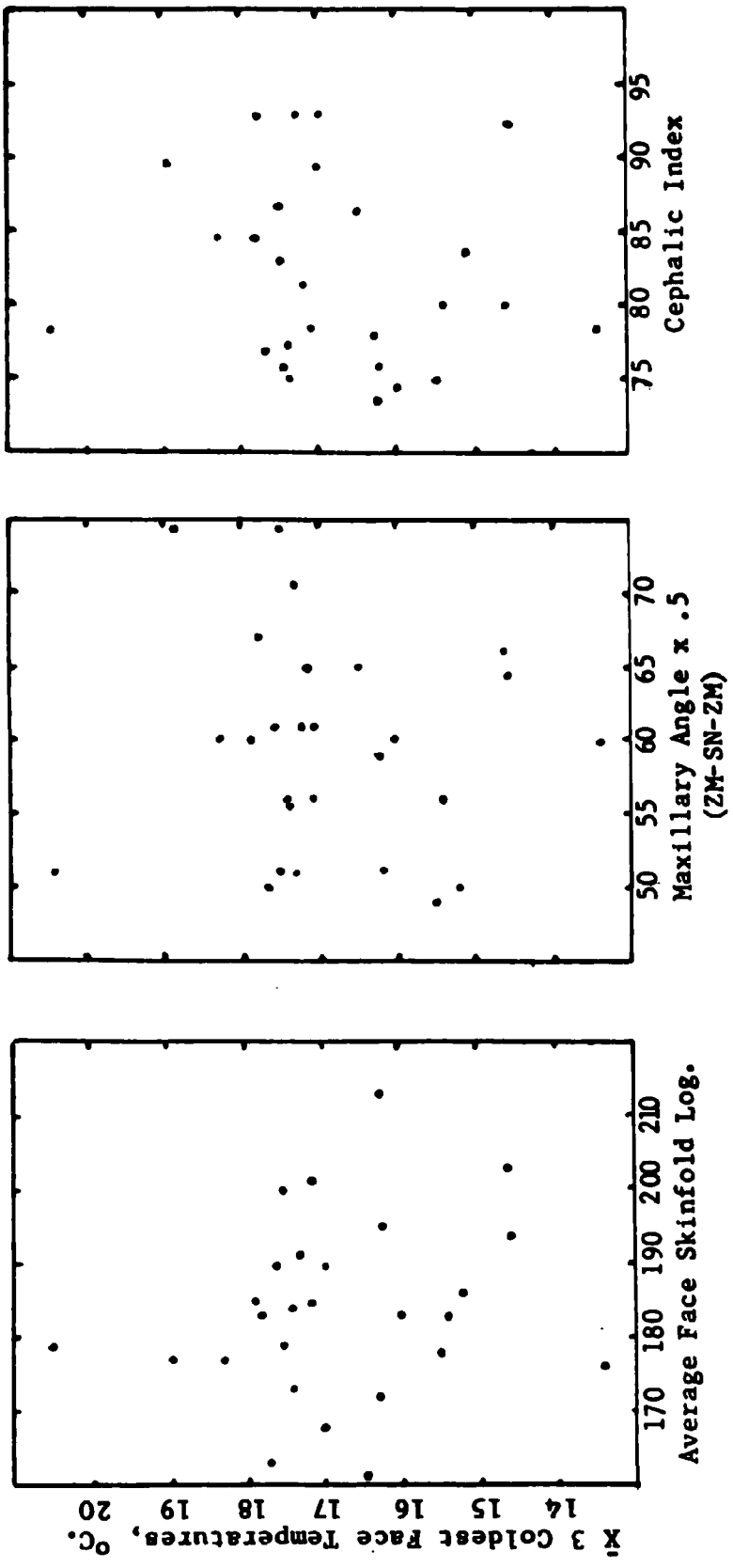
From McNemar 1962:279, and Snedecor 1956:246-249.

APPENDIX VII

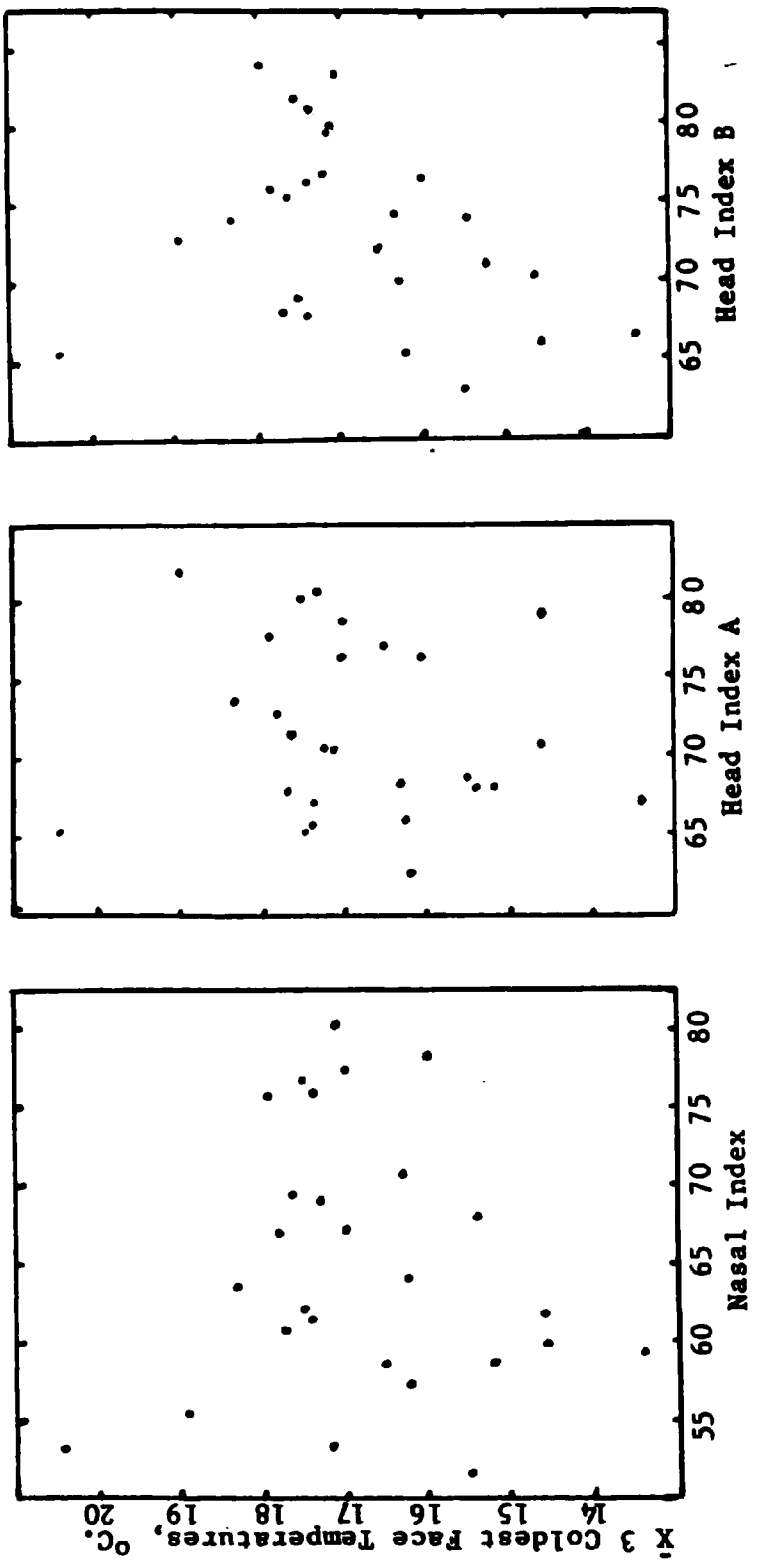
SCATTERGRAMS: MEAN, COLDEST FACIAL TEMPERATURES—MORPHOLOGY

APPENDIX VII

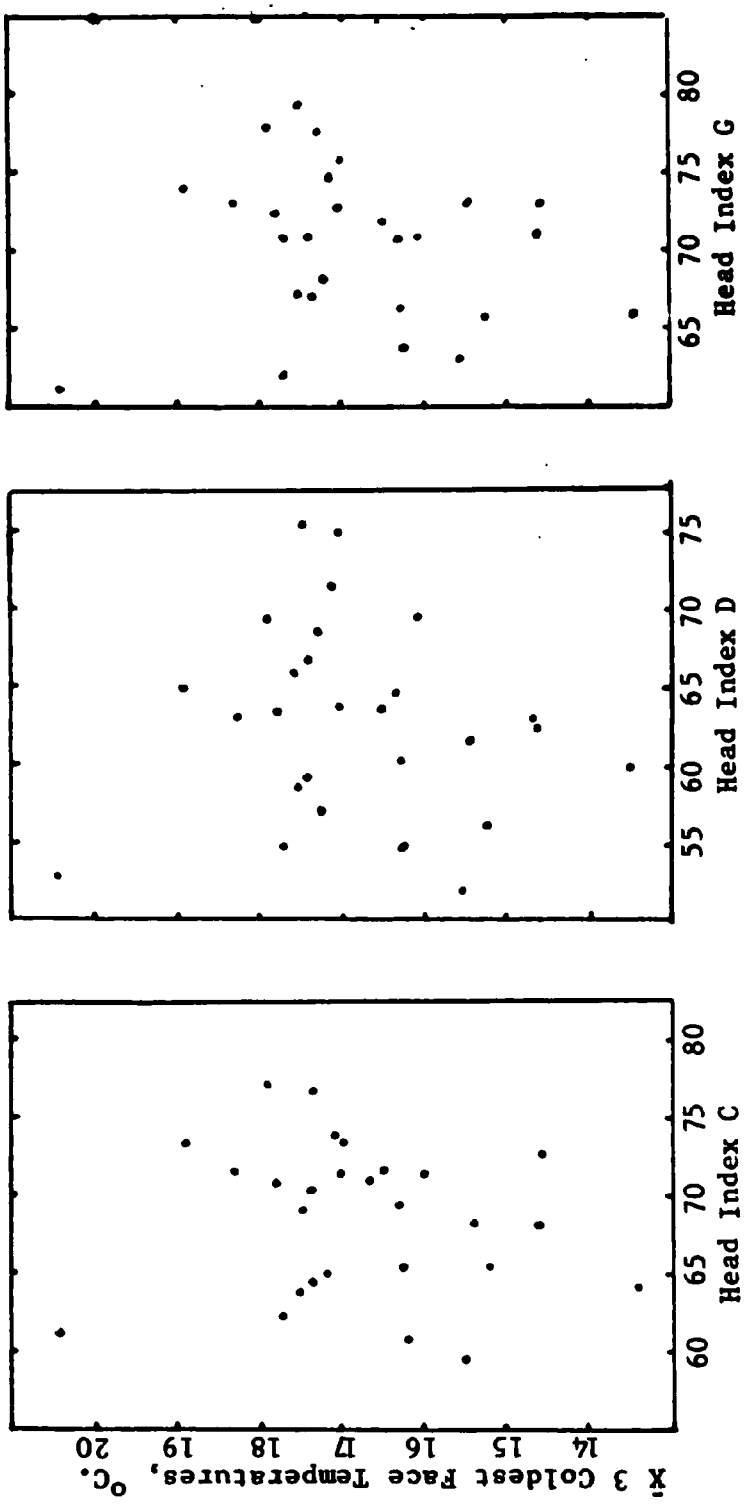
SCATTERGRAMS: MEAN, 3 COLDEST FACIAL TEMPERATURES-MORPHOLOGY



APPENDIX VII (Continued)



APPENDIX VII (Continued)



APPENDIX VIII

SITES AND MAGNITUDES OF THERMAL RESPONSE FLUCTUATION

Format: First figure = rise in degrees Centigrade; following figure in parentheses = temperature at which rise began; each expression represents a single cycle with time starting at the left and moving right. Asterisk indicates those who are also showing cycles elsewhere on the face.

Cycles at Nasal Tip						Subject
			2.0(17.0)	1.3(16.0)	1.2(15.8)	1
				2.7(17.2)	1.8(14.7)	2
					2.1(14.2)	4*
					1.5(12.3)	7*
				.9(13.5)	1.2(12.8)	9
					1.0(10.8)	10
				3.1(11.3)	1.2(11.6)	14
2.1(23.6)	1.3(23.1)	1.8(18.3)	2.1(14.9)	1.0(13.7)	2.7(12.8)	15*
			1.3(17.8)	.9(18.0)	.9(15.1)	17
			1.6(19.9)	1.5(18.2)	1.4(15.0)	19
				3.9(16.6)	5.0(10.3)	20*
					1.6(14.3)	21
					.9(11.5)	22
					1.0(14.8)	23*
	1.1(15.8)	2.1(16.0)	3.0(14.2)	2.9(14.2)	2.7(13.2)	24*
				2.0(10.0)	1.3(10.8)	26*
				2.0(18.3)	.9(16.4)	28
				1.7(11.6)	2.1(10.8)	29
MEANS			2.0(16.7)	2.0(14.9)	1.7(13.1)	

Cycles at Nasal Bridge				Subject
			2.1(18.1)	4*
			1.0(21.5)	11*
	.8(26.7)	.9(20.9)	1.3(18.1)	15*
		3.6(21.4)	2.6(14.3)	20*
			.9(21.6)	24*
			.9(21.2)	25
	2.4(16.4)	2.7(15.2)	3.5(14.5)	26*
MEANS		2.4(19.1)	1.7(18.4)	
Cycles at Chin				
	.9(23.5)	.8(22.8)	1.2(22.6)	7*
			1.3(18.7)	11*
			7(22.8)	23*
			1.9(25.0)	24*
MEAN			1.2(22.2)	
Cycles at Ear				
		1.0(12.8)	3.8(12.0)	6
		2.0(13.0)	2.8(11.8)	12

Note: Subjects 8, 13, 16, and 27 did not show enough fluctuation to register. Generally, a change amounting to less than .6°C was not shown here.

APPENDIX IX

FROSTBITE, SITES OF ELECTION AND DEGREE, WESTERN POPULATIONS

Author & Year	Sample	Site	%	Comments
Aryev 1939 (in Hope 1950:9)	European Soldiers	Toes & Feet Ears & Nose	96-99 -----	Frequently seen in peace but not in wartime since rarely serious enough to be evacuated
Bell et al. 1952:40	175 U.S. Marines (Korea 1950)	Fingers & Toes Feet (only) Toes (only) Fingers (only) Nose (only)	63 27 8 2 3	Little infection seen at any site
Orr & Fainer 1952:185	1,880 American Troops (Korea 1950-1951)	Feet Hands & Feet Hands Ears, Faces, Knees	86 11 2.5 .5	1st to 4th degree Never worse than 2nd degree
Schuman 1953:332 Orr 1953:573	712 Allied Troops (Korea 1951-1952)	One Hand One Foot Both Hands Both Feet One Hand, One Foot Two Hands,Two Feet One Hand, Two Feet One Foot,Two Hands One Ear Two Ears Nose	4.5 8.8 9.8 62.5 .4 8.3 2.2 .7 1.8 .7 .1	Degree: Feet / Hands / Head 1: 43.1% / 46.7% / 31.6% 2: 30.1% / 40.8% / 68.4% 3: 22.2% / 7.1% / 0 4: 4.6% / 5.4% / 0

Girgolov & Aryev, 1940 (in Hope 1950:21)	Russians (5 year period of observation)	Freezing of face and head produces hemorrhages on chin, cheek, and supra-orbital ridge area. Waxy yellow infiltrates form on nose. Ear symptoms as in limbs and little infection seen
Kiyishev 1944 (in Hope 1950:62)	Russian Soldiers (World War II)	"Involvements of the cheeks were considerably more than our figures show, but these cases seldom came to us. The cheek and nose involvements were for the most part localized, with first and second degree of frostbite predominating."

Note: The Kiyishev observations were confirmed among American troops in Korea according to a personal communication with a combat surgeon who served during the conflict.

APPENDIX X

COLD PATHOLOGY DATA, ARCTIC POPULATIONS

Reference	Sample	Comments
Ackerknecht 1948	Eskimo	Amputate their own frozen fingers (p. 920)
Brown 1927	Eskimo	Minor face and hand frostbite (p. 221)
Høygaard 1940	Eskimo	Feels their resistance to cold is due to training (as is white's) but they also have more vascular skin. No sinus infection seen (p. 65, 73-74)
Kennan 1889	Whites	Frequent 1st degree frostbite of nose and cheekbones (p. 189, 221) and eyelashes (but not eyes) often frosted (p. 231, 241)
	Koryaks	2nd and possibly 3rd degree frostbite of face (p. 218)
Moody 1955	Eskimo (Caribou)	Old male died of frostbite gangrene in leg (p. 31) Young male had to have hand amputated due to frostbite gangrene (p. 78) Various other unspecified frostbite cases (p. 205)
Rabinowitch 1936	Eskimo (Baffin Is.)	Male developed gangrene of frozen foot, but healed spontaneously after auto-amputation (p. 497)
Rawson 1951	Eskimo (E. Arctic)	Frostbite of wrists and knees - the latter being a real problem, but frostbite of face is so common as to be ignored (p. 589)

Rodahl 1953	Eskimo	Pathologies of practical importance are frostbite, snow blindness and malignant cellulitis (p. 98) "The Eskimos do get frostbite. It is true that they do not develop frostbite so quickly as do most whites, but this is due to a number of factors, of which the Eskimo's extreme care in preventing it is of greatest importance." (p. 99). Reports several individuals frostbitten, two Eskimos freezing ears, nose, and hands. A case of spontaneous healing after a case of 2nd degree (?) frostbite (pp. 100-101)
Shackelton 1938	Whites	Frostbite on nose, cheek, fingertips, and toes - not serious (p. 161) Three different instances of facial frostbite (pp. 169, 199, & 283)
	Eskimo	Frostbite of nose and cheek (p. 205) 2nd degree frostbite of cheeks - fatigued and hungry (p. 240)
Stefansson 1922	Eskimo	Observed considerable facial frostbite which he considered not to be racial but rather individual (p. 75) "He was always each year the first to freeze his face and kept freezing it continually all winter. Of course a frozen cheek or nose is no more serious than a sunburn, if you thaw it out promptly with your warm hand as soon as it begins to freeze," (p. 76) Froze cheek, chin, and nose on hunt Frostbite prevention by good equipment and clothing

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