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ANTHROPOMETRY FOR RESPIRATOR SIZING

**U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Health Services and Mental Health Administration
National Institute for Occupational Safety and Health**

ANTHROPOMETRY FOR RESPIRATOR SIZING

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Webb Associates of
Yellow Springs, Ohio

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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<p>From this study the following conclusions may be drawn: 1. An adequate source of head and face anthropometry measured on civilian industrial workers does not exist. 2. A broad and useful body of head and face anthropometric data is available for various U. S. military samples. This data can be used in the design and sizing of respirators for civilian industrial workers with a considerable degree of confidence. 3. The anthropometric data available from the U. S. Air Force 1967 survey and the U. S. Air Force Women's survey of 1968 are judged to be the most satisfactory of the military data for portraying the civilian working population. 4. Differences in head and face size among racial and ethnic subgroups are of little practical significance in respirator design. 5. The assumption that the female face is, for face piece design purposes, a small male face has not been adequately validated. 6. The regression equation method for sizing appears to offer some distinct advantages over the direct computation method. 7. A variety of sequential sampling procedures are available for testing masks for compliance with the desired standards.</p>			
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FOREWORD

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Mr. Marvin Thordson and Mr. Stewart Lauterbach were responsible for preparation of the tables and graphs in the report and Mrs. Jane Seese edited and typed the manuscript.

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INTRODUCTION

Respirators designed to afford dust protection undoubtedly go far back in the history of man. As early as Roman times there was concern about the effects of dust and fumes in lead mines and refineries. By the 19th century, dust respirators were relatively common but no real study of the problems of respirator design had been undertaken and as a consequence the efficiency of these devices was relatively poor.

For over 100 years canister respirators have been in use in industry and agriculture. It was not until poison gas was used in World War I, however, that intensive research and development was conducted in their design. From the initial crude emergency devices issued as stop-gap measures early in the war were evolved a series of efficient canister respirators that reduced the devastation of poison gas warfare. The war related research vastly improved concepts in respirator design, in methods of fabrication and assembly and established some standardization in tests and inspection.

While industrial and agricultural respirator design has benefited immeasurably from the research conducted by the military establishments, much remains to be done. The research described in this report was undertaken to fill some of the gaps in our understanding of the proper sizing and design of commercial respirators and relate to three separate but interrelated tasks described in the following sections.

SECTION I

Task 1. Assist in the preparation of anthropometric specifications which will describe the head and face of United States male and female workers.

Our initial activity under this task was to compile the available sources of anthropometric data for United States male and female workers. The data were then examined to determine their appropriateness for use in establishing anthropometric specifications of the head and face.

The majority of the anthropometric data are from four primary sources: a) growth surveys; b) anthropometric surveys of students; c) health and occupational surveys; and d) military anthropometric surveys.

(a) The anthropometric data from the various growth surveys are of very limited value for our particular purpose. In general, these data are obtained from intensive longitudinal studies of small regional samples and do not include comprehensive measurements of the head and face. The studies are quite naturally concentrated on the early growth years with little usable anthropometric data for the post adolescent ages being gathered.

(b) A number of anthropometric studies have been made of various student populations. Those made on college students are typically oriented toward entering freshmen (17-19 years of age), include a relatively few body

dimensions and are in most instances a generation or so out of date. Even were extensive data available for the student population, it would necessarily be marginally useful to us due to the young age of the samples and the probable selective nature of the college population.

(c) The anthropometry of occupational groups, particularly those groups that are drawn from industrial or consumer populations, would be most useful. It is unfortunate that the relatively few studies of this nature conducted in the United States consider a very limited number of body dimensions and these are usually very specifically related to work space layout. None of the studies examined included any head and face measures that would be representative, in even suggestive form, of the broad civilian working populations.

Damon and McFarland (1955), for example, have surveyed the anthropometric data available for occupational groups and concluded that "occupational anthropometry has been somewhat neglected despite its relevance . . ." Certainly such research in the United States lags far behind that accomplished by researchers in Europe. In their report Damon and McFarland gave anthropometric data on some 272 regular truck bus drivers, and 103 champion truck drivers as part of the research being conducted on highway transportation safety. Of the 40 some

dimensions measured on this occupational group, only one, head circumference, is a measure of primary interest to us.

Previous research by Garn and Gertler (1950) investigated the difference in physique between research workers and general factory workers in the same plant. Again we find the emphasis in this research is on gross physical size and physique with little or no attention being given to metric description of the head and face.

Snow and Snyder (1965) conducted an anthropometric survey of 684 air traffic controllers to obtain design data for layout of work spaces. Of the 75 dimensions included in this survey, only three (head circumference, bitracion-minimum frontal arc and bitracion-submandibular arc) were measures of the head and face.

The most recent and extensive research of occupational anthropometry was that of Stoudt and his co-workers in their study, Static and Dynamic Measurements of Motor Vehicle Drivers (1970). The study was undertaken to provide descriptive data to be used "to ensure automobile drivers and passengers adequate spatial accommodations in their vehicles including clearance around their bodies, access to points of optimum vision from the vehicle, access to controls, and comfortable, fatigue-preventing seats." As expected, the study concentrated on those parameters which are critical to work space and driving with no head or face dimensions being included.

Occupational anthropometry has not been widely undertaken in the United States and those studies that have been conducted were rather specific in nature. It is not surprising, therefore, that this particular source of anthropometry is of such limited value in our particular problem.

Broad anthropometric surveys of United States adult civilians have never been accomplished. An anthropometric survey of adult women was conducted by the U. S. Department of Agriculture in 1939-1940 and included some fifty-nine anthropometric variables measured on 14,698 women who ranged in age from 18 to 69 years. The emphasis in the survey was to provide data for use in improving the fit of women's garments and patterns. As might be expected, there were no dimensions of the head and face measured in the survey.

The most recent anthropometry of U. S. civilians is that obtained during the Health Examination Survey conducted during the period October 1959 - December 1962. In this survey some 6,672 sample persons (civilian adults living outside institutions) ranging in age from 18 to 79 years were examined from a nationwide probability sample of 7,710 persons. The anthropometric findings from this survey have been reported (Stoudt, et al. 1965, 1970) and, while current and undoubtedly representative, are of limited use for our purposes. The survey included age and sex distributions for the following variables:

a) weight, b) height, c) sitting height (erect), d) sitting height (normal), e) knee height, f) popliteal height, g) elbow-rest height, h) thigh clearance height, i) buttock-knee length, j) buttock-popliteal length, k) elbow-to-elbow breadth, l) seat breadth, m) triceps skinfold, n) infra-scapular skinfold, o) right arm girth, p) chest girth, q) waist girth and r) biacromial diameter. It is unfortunate that the selection of dimensions for this survey was primarily for purposes of work space layout and nutritional assessment and are not relevant for sizing and design of personal protective equipment.

(d) The remaining source of anthropometric data is surveys of military populations. This source of data is particularly rich and current since each of the United States military services has completed a major anthropometric survey of its members within the last seven years.

A listing of a number of post World War II anthropometric surveys of military personnel is compiled in table form below (Table 1).

While not all U. S. military anthropometry is included here, an attempt was made to list the major sources of such data. The surveys listed include not only data from each service, both male and female, but in a fashion are samples from different segments of the population. The 1946 Army sample, for example, was a composite group of Army men and had

TABLE 1

MAJOR ANTHROPOMETRIC SURVEYS OF U. S. MILITARY POPULATIONS*

DATE OF SURVEY AND SAMPLE	SAMPLE SIZE	NUMBER OF MEASURED VARIABLES	NUMBER OF HEAD & FACE VARIABLES	AGE OF SAMPLE \bar{X} (SD)
1946 ARMY MEN	>25,000	65	11	~ 24
1946 ARMY WOMEN	> 8,500	50	9	26.6(5.4)
1950 AIR FORCE FLIERS	> 4,000	132	33	27.4(4.2)
1953 AIR FORCE WOMEN	841	63	6	19.8(2.7)
1953 AIR FORCE BASICS	> 3,000	60	6	18.9(1.9)
1964 NAVY FLIERS	1,549	97	32	~ 28
1965 AIR FORCE MALES	3,869	156	42	22.7(6.5)
1966 ARMY MALES	6,682	70	12	22.2(4.6)
1966 NAVY MALES	4,095	70	12	19.9(1.5)
1966 MARINE MALES	2,008	70	12	20.9(2.9)
1967 AIR FORCE FLIERS	2,420	188	46	30.0(6.3)
1968 AIR FORCE WOMEN	1,905	137	27	22.9(6.5)
1970 ARMY FLIERS	1,482	85	15	26.2(5.5)

* Post WW II

in common only that they were being processed for discharge out of the Army at one of several separation centers. The 1946 Army women's sample similarly was composed of nurses, WAC officers and enlisted women, etc. who were being separated from active duty at the end of World War II. The very heavy manpower demands made by the services during World War II necessitated the relaxing of physical standards normally maintained by the military establishments so that the 1946 U. S. Army male and female samples were in all probability broadly representative in body size of their age groups in the civilian working population at the time of the survey. The 1967 Air Force fliers sample, however, is composed largely of rated fliers; that is, officers on flying duty. This sample is characterized by individuals drawn from the upper socio-economic levels of our society with a relatively high educational level and are in better than average physical condition. Similar selection criteria are characteristic of the 1950 Air Force fliers and 1964 Navy fliers samples and to a lesser degree the 1970 Army fliers sample. The latter sample is primarily composed of officers and warrant officer helicopter pilots and warrant officer candidates undergoing helicopter flight training.

The 1965 U. S. Air Force sample is predominantly but not exclusively composed of airmen undergoing basic training. The 1966 Army, Navy and Marine samples are also predominantly recruits measured during basic training.

In Appendix A are summarized the anthropometric data for head and face measurements from these military surveys. The chart includes the mean and standard deviation (centimeters) for each head and face variable from each of these military surveys. The variables of age (years), height (centimeters) and weight (pounds) are also listed for each sample at the bottom of each column.

The 1967 U. S. Air Force survey is listed to the left as it was the most complete in terms of the number of variables considered. The other surveys were searched for variables which could be considered comparable to the USAF 1967 dimensions and these were then listed for comparison. In one case, a variable of some interest to us (nasal root breadth) was not measured in the USAF 1967 survey but was measured previously and this was then included in the final listing of variables. The comparability of the listing was determined by comparison of the measurement descriptions from the various surveys. As a number of the surveys listed here have not been published, we have worked from the notes made available to us by the principal investigator in charge of the survey. Some inconsistencies may still exist in these data; that is, measures from different surveys that are listed as comparable may not be equated (due to differences in interpretation of anthropometric landmarks and the like. It is of considerable interest to note, however, that when well established landmarks are used for a particular measurement (e.g. tragion), differences among the various surveys become quite small.

In these military surveys, we find a wealth of head and face anthropometric data immediately available for use. The question that remains, therefore, is determining if these data can be used to adequately characterize the head and face size of U. S. civilian workers. Were data for even a few head and face dimensions available of a representative civilian sample, it would be possible to make direct comparisons between the civilian and military for comparability. As no such data appear to exist, we must use an indirect technique to evaluate the appropriateness of utilizing the military anthropometry as design data for civilian workers.

The civilian body size data obtained during the 1960-1962 Health Survey is probably fairly representative for the U. S. civilian population. We can, therefore, use the general body measures of height and weight as a comparison with the various military samples (Table 2). Height and weight are not unrealistic measures for such a comparison as they do define gross body size. In addition, there is a relatively high relationship of stature with other measures of body linearity and of weight with measures of body circumference, breadth, depth and volume. (For a detailed discussion of the practical use of these relationships, see McConville, Alexander and Velsey, 1963.) From this it would appear that the USAF 1967 sample was slightly taller (≈ 2 cm) than a comparable age group of civilians and some two pounds heavier.*

* The weight of the civilian population does include light clothing below the waist which would add a little over two pounds to the mean values for the male sample and somewhat less than two pounds to the mean values for the female sample.

TABLE 2

Comparison of Body Size of Various U. S. Civilian and USAF Samples

Sample	N	Age	Stature		Weight		Sit Ht		Head Circ	
			\bar{X}	SD	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD
Health Survey ¹	411	18-24	174.5(6.9)*		160(24.2)*		90.9(3.8)*			
"	675	25-34	175.5(7.1)*		171(28.1)*		91.4(3.6)*			
"	703	35-44	174.0(6.9)*		172(26.8)*		91.2(3.5)*			
"	547	45-54	173.2(6.9)*		172(27.3)*		90.7(3.5)*			
"	418	55-64	171.2(7.2)*		156(28.1)*		89.4(3.8)*			
Truck Drivers ²	269	35(8.2)	173.6(6.6)		167(27.9)		92.0(3.2)		56.8(1.6)	
Champion Drivers ²	103	34(6.1)	175.3(6.1)		167(27.4)		93.1(3.0)		57.0(2.0)	
Civilian Drivers ³	509	38(12.6)	177.5(7.1)		180(29.6)		---		---	
USAF 1967	2420	30(6.3)	177.3(6.2)		173.6(21.4)		93.2(3.2)		57.5(1.4)	
WOMEN										
Health Survey ¹	534	18-24	162.1(6.6)*		129(20.7)*		85.3(3.3)*			
"	746	25-30	161.8(5.9)*		136(25.8)*		85.6(3.4)*			
"	784	35-44	161.3(6.1)*		144(27.7)*		85.6(3.4)*			
"	705	45-54	159.8(6.2)*		147(30.1)*		84.8(3.5)*			
"	443	55-64	158.5(6.1)*		152(30.1)*		83.8(3.6)*			
Civilian Drivers ³	524	32.5(14.2)	161.3(7.4)		132.6(25.7)		---		---	
WAF 1968	1905	22.9(6.5)	162.1(6.0)		127.3(16.6)		85.6(3.2)		54.9(1.6)	

* Standard Deviation approximated from percentile values of Sex.

¹ Stouidt, H.W., et al., 1965. Weight, Height and Selected Body Dimensions of Adults: United States - 1960-1962. Nat'l Center for Health Statistics, Series 11, Number 8, Washington, D.C.² Damon, Albert and R.A. McFarland, 1955. "The Physique of Bus and Truck Drivers: With A Review of Occupational Anthropology." Am. J. Phys. Anthropology, ns 13, 4:711-742.³ Stouidt, H.W., et al., 1970. Static and Dynamic Measurements of Motor Vehicle Drivers. Harvard School of Public Health, Boston, Mass.

The WAF 1968 sample was of approximately the same stature as a comparable age group of civilian women but some two pounds lighter.

The most marked difference between the civilian and USAF data is in the standard deviation for weight and to a lesser degree for stature. This would indicate that the distribution of values for the civilian samples is much broader than in the military populations. This is not unexpected as the military services do maintain limits on body size for individuals inducted into the services. It should be remembered, however, that the Health Survey data include "civilian adults living outside institutes" and as a consequence contain individuals who may not, due to health or physical size, be normally included as members of the work force especially in areas of work where personal protective gear such as respirators are required.

One additional factor should be pointed out and that is the relative agreement in values for height and weight from the 5th to the 95th percentiles (the range for which sizing programs are usually developed) between the civilian and military samples. This correspondence is illustrated in Table 3:

TABLE 3

Comparison of Body Size of Various
U. S. Civilian and USAF Samples ..
5th & 95th Percentile Values

<u>MALE</u>	<u>Age</u>	<u>Weight (lbs)</u>		<u>Stature (cm)</u>	
		<u>5th</u>	<u>95th</u>	<u>5th</u>	<u>95th</u>
Health Survey	18-24	124	214	163.3	183.9
	25-34	129	223	163.6	184.7
	35-44	134	219	163.1	182.1
	45-54	131	219	162.6	182.1
	55-64	123	213	159.8	180.3
USAF 1967	30.0(6.3)*	140	211	167.4	187.7
<u>FEMALE</u>					
Health Survey	18-24	99	170	152.4	172.5
	25-34	102	191	151.6	170.9
	35-44	109	204	151.4	170.7
	45-54	106	205	150.1	170.7
	55-64	112	211	148.3	169.2
WAF 1968	22.9(6.5)*	102	156	152.4	172.2

* \bar{x} (SD)

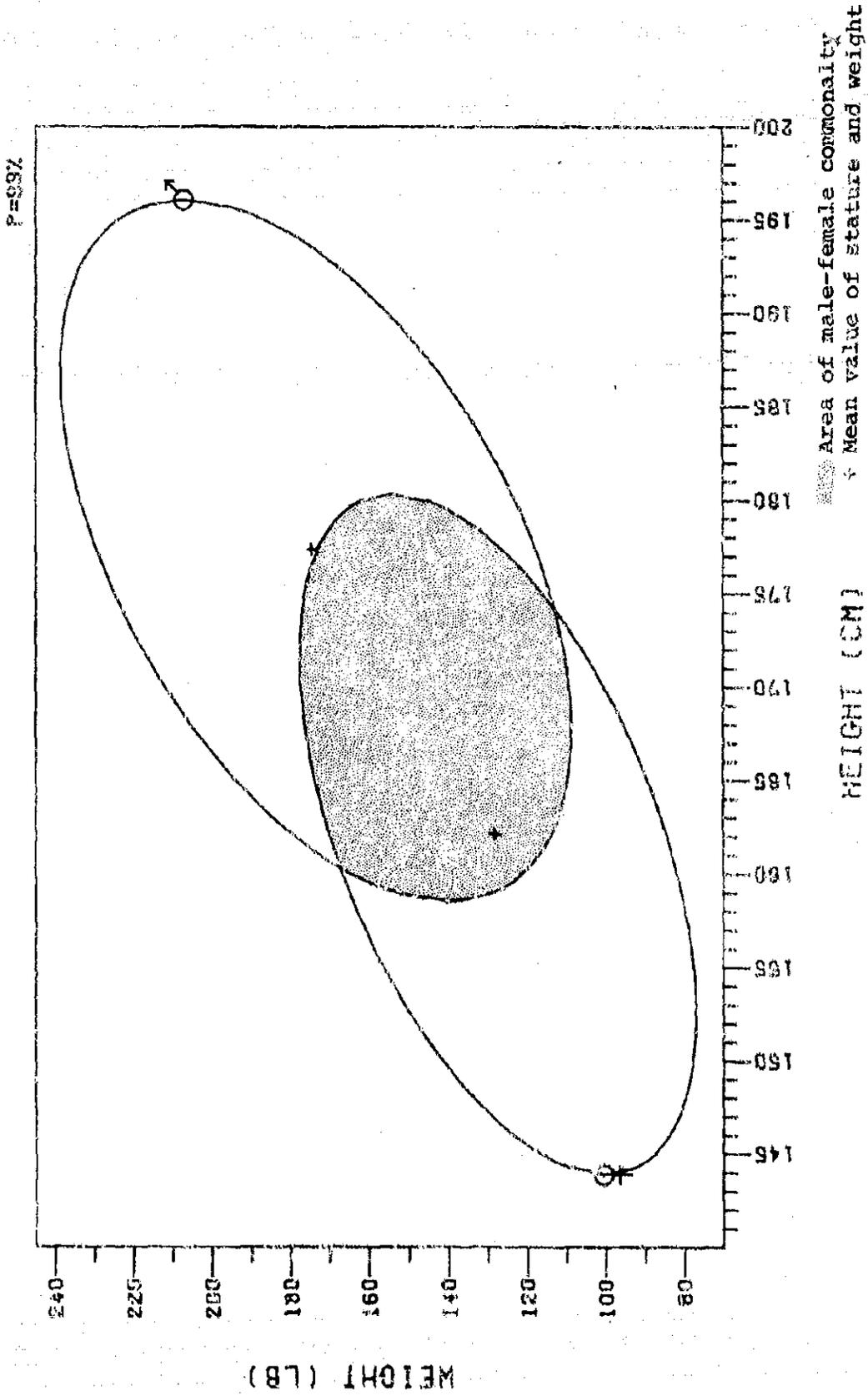
The largest discrepancies in Table 3 appear to be those associated with weight and primarily in that the military data do not adequately cover either the lower end of the male weight distribution or the upper end of the female weight distribution. These discrepancies are not as serious as they may appear, however, if we can assume that personal protective equipment design programs for industrial workers will be for the total working population and will not normally be unique to one or the other sex. If this assumption is reasonable, then the lower end of the male weight distribution not covered by the male military series falls well within the upper end of the weight distribution of the female military series. By the same token, the upper end of the female weight distribution not covered by the female military series falls well within the lower distribution of the male military series. The ellipses in Figure 1 illustrate the degree of commonality of the male and female military data for the dimensions of height and weight.

In terms of gross body size the military data, as represented by the most current of the Air Force male and female samples, approximated reasonably well the gross body size of the civilian population.

Even were these measures of gross body size to show greater differences than in Table 3, this would not necessarily rule out the use of the military head and face data for civilian design problems. The primary selection for military service is based

FIGURE 1

Height-Weight Bivariate Ellipse
(USAF Male - Female Data)



upon specific limits of age, general health, intelligence, stature and weight. None of these selective factors necessarily restrict the variability of the head and face in the military population. The selection factors that might reasonably be expected to restrict head and face variability are the variables of age, height, and weight. Appendix B indicates the correlation coefficients for measures of the head and face with age, stature and weight. The coefficients given are for the interrelationships determined from the USAF 1967 data but are representative of those for other military and civilian samples as well. What is immediately apparent from this listing is the generally moderate to low relationship of head and face dimensions with height, weight and age. In evaluating the meaning of these correlation coefficients, we may use the value of the correlation coefficient squared (r^2) to give an indicator of how the variables are "restricted" by the variables of age, stature and weight. Using menton-to-nasal root (face length), we see the correlations of .118, .277 and .230 respectively with age, stature and weight, which indicate that some 1% of face length variance is associated with age variance, some 8% with stature variance, and some 5% with weight variance. From this we may conclude that existing military standards for age, weight and stature do not necessarily restrict the dimensions of head and face size because of the demonstrable moderate to low relationship of the selection criteria with the dimensions of the head and face.

For these reasons we believe that the military head and face anthropometric data can be used with good confidence in the establishing of design criteria for the civilian working population with no adjustments of the military data being necessary. From the military data, we would select the Air Force 1967 male and the 1968 female head and face anthropometric data as most appropriate for use. This selection is based upon a number of factors which include the currency of the data, the number of variables measured, the age and the gross body size of these samples.

Comparisons of male and female head and face data for establishing size and design criteria of personal protective equipment has not, to our knowledge, been previously made. It is, therefore, of some interest to examine the available data with this purpose in mind.

The data listed in Appendix A can be used to determine the magnitude of the difference in the dimensions of the head and face between male and female samples. The most complete set of comparable data is that from the USAF 1967 male and the Air Force Women 1968 surveys. While there were significantly fewer dimensions measured in the women's survey than in the men's survey, there are sufficient data tabulated for some meaningful comparisons. The most obvious difference in the comparison of head and face mean values is the generally smaller values for each female dimension. The dimension menton-to-nasal root depression (face length) for the females is only 88% of the male average

value and the dimension of bizygomatic breadth (face breadth) for women approximately 91% of the male mean value. In general we find in this comparison that the female face appears to be dimensionally smaller but not significantly different in proportionality. The small differences in head and face proportions that do appear to exist are of possible minor significance for design purposes.

In Appendix C are given a series of bivariate ellipses for selected head and face dimensions with the male and female data plotted in the same graph. Each pair of ellipses is shown on three consecutive graphs with probability samples of 90%, 95% and 99% being illustrated. The graphs for face breadth and face length, for example, illustrate the slight difference in proportionality between the male and female data through the difference in orientation of the major and minor axes of the two ellipses. These graphs, in addition, demonstrate the degree of coincidence and uniqueness of the male and female head and face data. We might initially conclude from these data that female users of personal protective equipment could be accommodated by the smaller of the devices made for male users supplemented with one or more items designed for the lower end of the female size distribution.

The question of ethnic variability in head and face size has never been satisfactorily answered despite the many investigators who have studied this problem. The availability of the relatively large military samples with, in many instances, broad

distribution provided the opportunity to compare the facial dimensions of some racial and ethnic subgroups extent in the United States population. The first comparison is Caucasian and Negro facial data drawn from the 1965 USAF male survey* and the 1968 USAF women's survey. This comparison is shown in Appendix D. The first table of this appendix (D-1) is a comparison of Negro and Caucasian head and face data with the samples being matched on the basis of age. The head and face measurement differences which approached the 5% level have been highlighted. In the following table (D-2) are similar data for females. In this instance the data were not from matched samples, with the Negro subgroup being approximately 10% that of the Caucasian group. Again, the differences in head and face measurements which approach the 5% level have been highlighted. Following these tables are a series of graphs (D3-D13) in which the male data showing the largest differences have been plotted as frequency distributions. In the majority of instances, the distribution of values for the two groups overlap to the point where design criteria based upon either of the subgroups would largely accommodate members of the other group. In a few instances, for example, nasal breadth (D-7) and lip-to-lip distance (D-12), the designers should be aware of the differences between the groups and adjust his design accordingly to accommodate the wider range of variability.

* The USAF 1965 survey sample is used for this comparison because it contains a broader racial and ethnic composition than does the USAF 1967 survey sample.

Additional racial-ethnic comparisons were attempted but were not fully satisfactory. In most military surveys racial or ethnic designation other than for the primary races of Caucasian, Negro or Oriental has normally not been obtained. In addition, members of racial or ethnic groups when they can be identified often occur so infrequently as to preclude obtaining a sample of sufficient size for effective comparison. The data from the USAF 1965 male survey have been used in an attempt to isolate additional ethnic subgroups. In seeking to isolate a Spanish-American subgroup, all subjects in this survey with a Spanish form of surname were sorted into a single group. This group was then classified as to birthplace. If the subject was born in Mexico or if one or both of his parents were born in Mexico, then the subject was classified as Spanish-American. A similar criteria of selection was used to establish the Puerto-Rican subgroup. This is admittedly a somewhat weak method for establishing such subgroups but is at present the only reasonable one available to us. The results of this comparison are included in Tables D-14 and D-15. It will be seen that mean differences for head and face dimensions among the racial and ethnic groups is relatively slight when evaluated in terms of the variability within any one group. For this reason we tentatively conclude that, for design purposes of head and face personal protective equipment, we may work with the total group data. The conclusion is tentatively stated due to the small sample size of the subgroups used in this comparison.

SECTION II

Task 2. Prepare sample respirator sizing programs.

The primary purpose of dividing men into a series of size categories is to obtain groups of men who are more or less alike in a number of dimensions. The more alike the group of men are in body size, the more satisfactorily they will be fitted by a single-size article, and the less the adjustability or tolerance the designer must provide.

The initial procedure in establishing any sizing system is to decide on a range of sizes based, usually, on one or more critical or key dimensions involved in a particular garment. For example, in ready-to-wear clothing, shirts are usually sized on neck circumference and sleeve length. Clothing based upon these dimensions therefore "fits" an individual in these dimensions but otherwise it fits him only to the degree to which he conforms to the manufacturer's standards used as the guide for the other dimensions that go into the garment.

In practice, this system works reasonably well for the loosely-fitting garments which make up the bulk of an individual's wardrobe. In the development of personal protective equipment, however, this approach may prove inadequate and may require extensive modification of the item to prevent compromising the functions for which it is designed. One solution to the problem of poor "fit" could be the sizing of a garment on the basis of all

of its most critical dimensions. A dress shirt, for example, sized on the basis of neck circumference and sleeve length, may require five sleeve lengths for each neck size. If five neck sizes are also required, then a total of 25 shirt sizes are required in order to adequately fit the variability in body size of the using population. If the shirt must, through necessity, also fit the chest and waist girth as well as the neck circumference and sleeve length, the number of sizes increases radically. If only four chest sizes and also four waist sizes are required, then the total number of sizes might become five times five times four time four, or a total of 400 sizes to clothe a given population. Such a solution is economically unfeasible. It may be noted, however, that 69 shirt sizes are indicated as being available in a recent mail order catalog for a single type of dress shirt and this garment is sized solely on neck circumference and sleeve length.

Control of the variability within a size category can be accomplished either directly or indirectly. The direct approach is illustrated by the sizing of dress shirts in which the key or controlling dimensions are an integral measure of the item being designed. The indirect approach uses the control achieved by the use of key dimensions which are not a part of the item being designed but are highly correlated with the sizing dimensions involved in the item. An example of this is the USAF height-weight sizing system for flying garments, neither of which are directly

used in the design of such garments. They can be used as key dimensions, however, because they are highly correlated with other measures of body lengths, breadths and girths that must be controlled in the sizing of the garments.

In selecting key dimensions for a complex sizing program, the final choice will of necessity be based on how well the key dimensions control the variability of the other dimensions that are of importance in the fit of the item. The amount of indirect control of certain key dimensions must always be balanced against the amount of direct control afforded by making the key dimensions those which are the most critical in terms of fit. Before such judgments can be made properly, it is necessary to determine the degree of control which will be obtained by the use of various combinations of key dimensions.

Appendix E is an intercorrelation matrix for the head and face variables measured in the USAF 1967 survey. The data from this survey are used because of the large number of head and face dimensions measured and the intercorrelations tabulated are typical of those generally found for the head and face. It is immediately apparent from this table that the arcs correlate highest with arcs, the length with lengths, and the breadths with breadths. It is also apparent that there is a negligible degree of relationship between one class (length or breadth) of variable and another. As Churchill and Truett have pointed out (1957),

"The proportion of small values among the head and face correlations is probably greater than would be found for any other major group of body dimensions. ...Truly, the dimensions of the head and face are, in the main, little related to each other."

Because of the low correlation among the head and facial dimensions, a key dimension for sizing of respirators is not readily apparent. In a successful sizing program for oral-nasal oxygen masks, the USAF used face length and lip length as the key dimensions. They selected three lengths for face pieces (short, regular, long) with each length having two widths (narrow, wide) yielding a six-size program. After extensive fit-tests in the field, the wide masks were found to be unnecessary and only the regular wide was retained because of the large number of subjects (16%) who required it as their indicated size.

If two facial variables are used as key dimensions, we might wish to select a length and breadth. If we use face length and face breadth, for example, we would reduce facial variability in any one size because of the relationship of the lengths with face length and breadths with face breadth. In Appendix F is illustrated a bivariate frequency table of face length and face breadth using data from the 1967 USAF and 1968 WAF surveys. The data from the two sources have been combined in a single bivariate table in order to illustrate the degree of uniqueness and overlap of the male and female data. In a particular bivariate cell, for example

that for individuals who have a face length of from 113.5 - 115.5 mm* and a face breadth of from 133.5 to 135.5 mm, we find the notation 14/22. This would indicate that 14 females and 22 males have facial lengths and breadths within these limits. The number to the left of the slash always enumerates subjects from the female sample, with the number to the right always being from the male sample. Note that considerable degree of overlap does occur in the center of the table.

For illustrative purposes, the variable of face length (menton-nasal root length) is used as a key or sizing dimension. In Appendix G are given sizing programs for males and females using USAF 1967 and WAF 1968 data. The sizing programs consist of five different sizing systems as shown in Table 4.

The data presented in the tables of Appendix G are relatively self-explanatory and will be discussed only briefly. The units of measure are: age in years, weight in pounds, and the remainder of the variables in millimeters. The information on the sheet includes the size system, the method of computation (direct or regression), the number of individuals falling within the sizing category and the percentage of subjects within the sizing system and the population for that particular sizing category. The tabular data given include the variable names, the within-size standard deviation, and the mean value for each of the sizes.

* The values given for each row and column are midpoint values for an interval; that is, the value 114.5 for face length designates the 2 mm interval of 113.5 mm - 115.5 mm.

TABLE 4

Illustrative Face Length Sizing Programs

2 Size System

<u>Face Lengths</u>	<u>Female</u>	<u>Male</u>
Size 1	9.05-10.55 cm	10.55-12.05
Size 2	10.55-12.05	12.05-13.55

3 Size System

<u>Face Lengths</u>	<u>Female</u>	<u>Male</u>
Size 1	8.95-10.15 cm	10.15-11.35
Size 2	10.15-11.35	11.35-12.55
Size 3	11.35-12.55	12.55-13.75

4 Size System

<u>Face Lengths</u>	<u>Female</u>	<u>Male</u>
Size 1	8.55- 9.45 cm	10.35-11.25
Size 2	9.45-10.35	11.25-12.15
Size 3	10.35-11.25	13.15-13.05
Size 4	11.25-12.15	13.05-13.95

5 Size System

<u>Face Lengths</u>	<u>Female</u>	<u>Male</u>
Size 1	8.95- 9.65 cm	10.35-11.05
Size 2	9.65-10.35	11.05-11.75
Size 3	10.35-11.05	11.75-12.45
Size 4	11.05-11.75	12.45-13.15
Size 5	11.75-12.40	13.15-13.85

6 Size System

<u>Face Lengths</u>	<u>Female</u>	<u>Male</u>
Size 1	9.05- 9.65 cm	10.25-10.85
Size 2	9.65-10.25	10.85-11.45
Size 3	10.25-10.85	11.45-12.05
Size 4	10.85-11.45	12.05-12.65
Size 5	11.45-12.05	12.65-13.25
Size 6	12.05-12.65	13.25-13.85

The tables giving the results of the direct computations contain those values obtained as the mean and pooled standard deviation for all the subjects within a particular sizing category for each head and face variable. The results obtained using the regression equation method are somewhat more involved as to the method of computation. Referring to the two-size system, male data, we can compare the results obtained for the two methods for variable 35, menton-nasal root depression or face length, our key dimension. The sizing category is identical in either method but the mean values differ 115.72 mm and 125.06 mm for sizes 1 and 2 by the direct method and 113.00 mm and 128.00 mm by the regression method. The former is, of course, the actual mean for the subjects that fall within the limits of the sizing category. The latter values are established as the midpoint of the interval for that sizing category. The reasoning used in the regression method is that in actual practice the subjects are never distributed equally throughout the sizing interval but tend to cluster toward one or another end of the sizing interval. The effectiveness of the sizing procedure is, therefore, reduced by the unequal weighting of the sample distribution within each category. By placing the key dimension at the center of the sizing interval, the effects of the uneven sample distribution are reduced. The values for all the remaining variables using this sizing procedure are then established using a series of regression equations which predict the variable values from the

value of the predictor or key dimension, in this case face length midpoint.

The advantage of the regression equation method is believed to be that it provides better sizing coverage for the ends of the total sample distribution and establishes more even increments of sizing from one category to the next.

It will be noted that the various sizing systems outlined above were designed to provide one or more overlapping size categories of male and female data. This has not to our knowledge been attempted previously and gives us the opportunity to evaluate the degree of difference in a size category between a male and female series for similar variables. If we examine the data obtained by the direct computation method, for example, in the two size system with the sizing category 105.5 - 120.5 mm, we find that the data for the female sample is significantly smaller in value than that from the male sample for almost all dimensions. Part of the difference might be explained on the basis that while the two samples are drawn from the same sizing category of face length the distributions within the category differ for the male and female sample. If we look at the value of the key dimension, face length, we find the difference to be some 5.2 mm less for the female sample than for the male sample. This result would appear to confirm the difference in distribution of the two samples within the sizing category with the females unevenly weighted toward the lower end and the males toward the upper end of the cell.

Turning to the results obtained from that regression equation method which is in part designed to alleviate the unevenness of sample distribution, we find that significant differences between the sizing category means still exist despite the equating of the key dimension of face length at 113.0 mm. These findings suggest that our earlier assumption that the female face, in terms of respirator design and sizing, can be treated as a small male face is open to serious re-evaluation. Due to time limitations, it has not been possible to test and resolve this question.

The sample sizing program included here (Appendix G) is primarily illustrative but could be used for a specific purpose of sizing quarter or half face pieces. For sizing of full face pieces, it would probably be more desirable to go to a sizing system based on two key dimensions, such as face length and face breadth. Sizing of other types of head and face personal protective equipment would require consideration of other key variables selected on the basis of their capability to reduce variability within a sizing category.

SECTION III

Task 3. Selection of fit test samples.

The final step in the design of a mask is, in a very real sense, an evaluation of how well the mask performs the task for which it is intended. To carry out such an evaluation, it is necessary to test the effectiveness of the mask under realistic conditions while being worn by members of a properly selected test sample.

The design of test procedures is beyond the scope of this report, but clearly the test protocol must be one which will provide results having both high reliability (reproducibility) and high validity (relevance), and our discussion of sampling plans assumes a test protocol with these properties will be used. It is important to note that the test protocol and the sampling plan interrelate in their determination of the overall precision of the evaluation procedure. Thus, for example, it may well be possible to decrease the size of the test sample needed to provide a given level of accuracy by increasing the amount of testing performed on each member of the sample and vice versa. Ideally, the choice of sampling plans and test procedures should be made on the basis of choosing the combination which gives the greatest expected accuracy for a fixed input of time and money or, equivalently, a fixed level of accuracy with a minimum cost.

Our primary concern here will be twofold: to note some of the factors worthy of consideration in the selection of a sampling plan, and to outline a variety of such plans. These plans are intended primarily to illustrate the wealth of possible approaches that can be used. The choice of sampling plan for any particular test program should be made on the basis of the specifics of that program.

Among the factors that provide a basis for choosing a sampling plan are these:

First, the desire to obtain an accurate evaluation of how well the mask will perform. Prediction of precisely how well a mask will serve its intended purpose when it is worn by any member of the user-population cannot be made with complete accuracy by testing a sample. Fortunately, however, such accuracy is not likely to be necessary or even of real importance. What will be needed is rather the information that is required to answer the simpler and more pertinent question:

Is it reasonable to suppose the mask will - in general - provide the required level of protection?

The answer to this question may be quite clear. If, for example, when the mask is tested on a small but well selected sample, the contamination level for every subject was less than half the permitted level the answer would undoubtedly be positive. If, on the other hand, the contamination level was well above the

standard level for every man tested who had a long-narrow face, the answer would be negative, at least for men with faces of this type. Usually, however, one would expect results which will be less clear cut, and the test evaluation procedures should be chosen which will treat these cases as well as the more clear cut ones.

The terms 'reasonable' and 'in general', as we have used them here, not only need to be defined but presumably will require a variety of definitions depending on such factors as the planned use of the masks. Thus, for example, the testing of masks designed for use in a radioactive dust environment would surely call for quite stringent definitions of these terms. The term 'in general' should, in all instances, be interpreted as including satisfactory performance when the mask is worn by men with any normally shaped face.

Second, the desire to limit the testing to the smallest sample which will provide data adequate for making a judgment. This goal of minimum testing should be envisioned not in terms of a fixed size sample for each mask, but in terms of the totality of tests required for evaluating a group of masks. The test evaluation should be designed so that superior masks are accepted and inferior ones are rejected on the basis of relatively little testing, and so that the greater share of the available effort is reserved for evaluating those masks whose quality is not clear cut.

Third, the desire to keep the overall assessment of the test as mathematically simple as is practical while at the same time

making effective use of the information developed by these tests. Among the reasons for stressing the desirability of simplicity of the test procedures for use in the immediate future is that an optimum choice among the more complex procedures can only be made on the basis of experience in the testing of masks which we have still to gain.

And, finally, the desire to develop a procedure which, while based solidly on scientific principles, will be accepted by the non-scientists as being both reasonable and relevant.

It may be useful to review several of the ways in which the results of the evaluation of a single mask on a single subject can be stated and used. The two basic methods are these:

(a) *Pass-fail*. Clearly, the simplest procedure is to characterize the mask's performance as having passed or having failed the test. The weakness of this method is that it ignores presumably pertinent data: if the mask failed, how badly, or, if it passed, by how wide a margin?

(b) *Actual amount of contamination (weight or percents) allowed by the mask*. A variety of methods for analyzing data of this type are available. Such analyses can use all information available from the tests, but their use may add more to the complexity of the analysis than to the accuracy of the results.

Other methods of classing the results will fall somewhere between these methods, both in the degree of detail of the data utilized and in complexity of the analysis. Two methods seem worthy of mention:

(a) *the use of multiple pass-levels or multiple fail-levels.* If in a particular test situation, for example, the acceptable level of contamination is 2%, the results for an individual test might be specified as P+, P, F, and F- on the basis of a scheme such as the following:

P+, less than 1%; P, 1 to 2%; F, 2 to 3%;
F-, more than 3%

The use of such multiple classification points would not necessarily change the criterion for acceptance, i.e., the 2% contamination level, but the resulting information would be used in judging the probability that the mask meets this criterion. One way in which this might be done is outlined below.

(b) *the use of the amount of contamination beyond the accepted level which a mask allows.* If this method is used, the outcome of an individual test would be recorded either,

- i) the mask passed, or
- ii) E, the amount (in weight or percentage points) by which the contamination exceeded the standard.

The final judgment on the mask might then be based on the sum of the E-values for a total sample.

Still other methods can, of course, be devised.

The most important criterion in the selection of a test sample - or samples - is that the total range* of face shapes be included. For facial masks, fit presumably is related most importantly to face width and face length. Since there is little relationship between these measurements, men with faces which are short and wide and men with faces which are long and narrow occur almost as frequently as men with short-narrow faces and those with long-wide faces. All of these width-length combinations must be represented in a test sample.

Perhaps surprisingly, the criterion that the sample accurately reflect the user population with respect to the proportion of men in each size and shape category is neither necessary nor important. If such a sample includes enough men with the less common face shapes to provide a satisfactory test of how well the mask works for faces of these shapes, it will contain far more men with the most typically shaped faces than are necessary. The size of the subsample which is needed to determine, to a fixed level of probability, how well a mask will fit men with long-narrow faces is exactly the same size as that needed to answer the same question for men with medium-length, medium-width faces, even though there

* These remarks apply equally to a mask designed to cover the entire range and to one designed to cover only a restricted, specified range. In the latter case, all references to the range and to terms such as short, long, narrow, and wide, are relative to the item's specified range.

may be 5 or 10 times as many men with faces of the latter shape as of the former. One could even argue that it is not necessary to test any men with medium-medium faces because if a mask fits all the other face shapes, it will surely fit this one. It may be that after we have acquired substantial experience in testing masks, there may be value in exploring this argument. One might argue on the other hand, that since more men with 'medium-medium' faces than men with 'long-narrows' will use the mask, the question of fit for the former group should be evaluated with greater accuracy than is necessary for the same question as it applies to the second group.

For optimum efficiency, a sampling plan should be both flexible and rigid. It should be rigid in the sense that the basis for making any decision is clearly spelled out in advance. It should be flexible in that it contains a number of decision points at which the next step or steps in the plan are determined on the basis of the data then available. The purpose of using a flexible plan is that - for a given level of accuracy - the average amount of testing can be reduced, or, equivalently, that greater accuracy can be obtained with a fixed average amount of testing. A flexible plan makes this possible by stopping the testing whenever the results are clear. For both the clearly acceptable and the clearly unacceptable mask, this stopping point will usually come after a relative small number of tests, making it practical to do considerably more testing on those masks of intermediate quality.

The fact that the testing of a mask on an individual subject is a rather lengthy process coupled with the simplicity of the data analyses which we are proposing make it practical to analyze the test results at the conclusion of each individual test. Thus we can design the data analysis so that at any point in the testing we make one of the four following decisions on the basis of our test plan and the results obtained up to that point:

- (a) accept the mask and discontinue testing
- (b) reject the mask and discontinue testing
- (c) continue testing as originally planned
- (d) modify the test scheme and continue testing*

Obviously, not all alternatives are available at each point; for example, neither of the first two decisions would ever be made until a minimum number of tests had been completed.

In many types of industrial testing, sequential testing plans result in testing which require, on the average, about half the maximum sample size. Only actual experience can tell what the relationship between the average and the maximum sample sizes will be for the mask testing. In some of our illustrations in this section, we speak of a maximum test sample of about 60. This figure was chosen primarily in order to have a specific number to use, but was judged a reasonable figure on the basis of two

* An example of the use of such a decision would be a testing plan which calls for additional testing of men of a particular shape face whenever the mask performs unsatisfactorily for one or more men with this shape face. The details of when and how such modifications are to be made must be specified in the original testing plan.

assumptions - first, that on the average about 30 men can be tested for each mask, and second, that the procedures we suggest will require testing, on the average, of only about half the total sample.

Rejection of a mask can logically be made at any point after a minimum number of tests have been made. A testing plan might specify that a mask will be rejected if it fails in more than a specified number of tests for a sample of given size. Perhaps, for example, a mask will be judged unsatisfactory if it fails 7 or more times when tested on a panel of 64 men. Clearly, testing such a mask can be discontinued as soon as the 7th failure is observed - even (or especially) if it occurs on the 7th test. A similar argument can often be made when some other criterion for rejection is used, such as the total contamination permitted on all tests. Once the maximum that would be permitted for the entire test panel has been exceeded, testing can stop.

Early acceptance of a mask presents somewhat different problems than those for early rejection. A mask might be rejected solely because it does not provide protection to men with a particular shape face, but it can be accepted only if it provides protection to men of all shape faces. Hence, in several of the illustrative sampling plans which follow this discussion, we specify dividing the total sample into subsamples, each of which covers the desired range of face sizes. Early acceptance of a mask could, in these plans, take place only at the end of testing a subsample.

Two approaches to early acceptance seem reasonable for this testing. One approach calls for setting proportionally higher criteria for acceptance at the end of each subsample testing. If, for example, a mask is to be accepted if there are no more than 6 failures for a sample of 64, an acceptance scheme such as the following might be set up:

after 1st subsample (N=16):	accept if no failures (0%)
" 2nd " (N=32):	" " only 1 fails (3%)
" 3rd " (N=48):	" " " 3 fail (6%)
" 4th " (N=64):	" " " 6 fail (9%)

This approach is largely limited to those situations in which a mask will be accepted even though it fails more than a minute proportion of the individual tests.

The second approach is that of using the multiple-pass-levels described earlier. Thus, for a simple example, if a mask is to be accepted if the contamination level does not exceed 1% for more than 2 subjects out of a panel of 64, the mask might be accepted:

if in the 1st subsample (N=16) the contamination level did not exceed 0.25% for more than 2 subjects, or

if in the combined first two subsamples (N=32) the contamination level did not exceed 0.50% for more than 2 subjects, or

if in the combined first three subsamples (N=48) the contamination level did not exceed 0.75% for more than 2 subjects, or, finally,

if in the total sample (N=64) the contamination level did not exceed 1.00% for more than 2 subjects.

The determination of the levels suggested here as bases for early acceptance require somewhat sophisticated statistical support, but we need be concerned at this point only with the fact that such support is available.

The following sampling plans are listed only as illustrations of the sort of plans that are possible and of some of the ways in which the plans can be flexible.

Plan A.

	S	M	L
W	1	2	1
M	2	4	2
N	1	2	4

Sixteen subjects are selected in nine categories (S=short, L=long, N=narrow, W=wide, M=medium) as indicated in the diagram to the left and are tested.

Prior to the testing, values of P and P+ (as described above) are established. Also, the maximum allowable number of failures in a sample of 64, F_{max} , is set.

At the end of testing these 16 subjects, three decisions are possible:

- a) contamination level for all 16 was P+.
Decision: accept mask and discontinue testing.
- b) contamination level was above P for more than F_{max} subjects.
Decision: reject mask and discontinue testing.
- c) results intermediate to these two.
Decision: proceed to the next step.

Next step = draw and test a second sample as above.

Again, three decisions are possible:

- a) contamination level was P or better for all 32, and was P+ for at least half of the sample.
Decision: accept mask and discontinue testing.
- b) and c) same as before.

If no decision is reached at this point, an additional 32 subjects are selected and are tested, one by one. Testing stops whenever either the total number of failures exceeds F_{max} (reject) or the total number of satisfactory tests equals $(64 - F_{max}) + 1$ (accept).

Plan B.

	S	M	L
W	3	3	3
M	3	3	3
N	3	3	3

Twenty-seven subjects are selected in nine categories as indicated in the diagram to the left, and are tested. If the mask performs sat-

isfactorily for all 27, it is accepted. If the mask fails for 3 or more subjects, or, for 2 of those in any one category, it is rejected. If it failed for a single individual in one or two categories, 3 additional subjects in this category or each of these categories are selected and tested. If all pass, the mask is accepted.

Plan C.

A maximum value for the sum of the excessive contamination, E_{max} , based on a sample of 64 is established; the mask is to be rejected if 4 or more tests are unsatisfactory or if E_{max} is exceeded.

First a sample of 16 subjects is selected as in Plan A, and is tested. If the contamination level exceeds the standard for any test, the excess, E , is computed. These values are summed to give ΣE .

The decision scheme is:

- a) If ΣE ever exceeds E_{\max} , reject the mask. (Since E_{\max} is the largest amount acceptable for a sample of 64, if ΣE exceeds E_{\max} after only a few tests, the decision to reject at this point is still logically based on a sample of 64. Were testing to continue, there would be no way that the results could change.)
- b) if all 16 tests are satisfactory, accept the mask and discontinue testing.
- c) otherwise, draw a second sample of 16 and test. After these tests:
accept if 31 have passed and ΣE is still less than E_{\max} .
- d) if no decision has been reached, draw on third panel of 16 and continue testing. At this point,
accept if 46 have passed and ΣE remains less than E_{\max} .
- e) if, again, no decision has been reached based on the first 3 panels, draw and test a fourth panel,
if at least 61 have passed and ΣE is less than E_{\max} ,
otherwise, reject it.

A decision as to the sampling plan which will be best for the testing of any particular type of mask probably should be made in the initial stages of the testing program jointly by NIOSH staff and the contractor's statistician, and should take into account the reliability of the test protocol, the level of compliance with the specified standard required for acceptance, the resources available for carrying out the testing, and the specifics of the subject pool.

CONCLUSIONS

From this study the following conclusions may be drawn:

1. An adequate source of head and face anthropometry measured on civilian industrial workers does not exist.
2. A broad and useful body of head and face anthropometric data is available for various U. S. military samples. This data can be used in the design and sizing of respirators for civilian industrial workers with a considerable degree of confidence.
3. The anthropometric data available from the U. S. Air Force 1967 survey and the U. S. Air Force Women's survey of 1968 are judged to be the most satisfactory of the military data for portraying the civilian working population.
4. Some differences in head and face size do exist among racial and ethnic subgroups. In general, the differences that have been noted are of little practical significance in respirator design as the variability within a group is so broad that effective design for this range of variability largely accommodates the variability for other groups as well. This conclusion is tentative due to the small sample size of some of the racial and ethnic subgroups used in the comparison

and due to the comparisons being made on the basis of head and face size alone rather than both size and shape.

5. The assumption that the female face is, for face piece design purposes, a small male face has not been adequately validated. This would appear to be a significant point for further analysis.
6. The regression equation method for sizing appears to offer some distinct advantages over the direct computation method. The very low interrelationship of head and face dimensions does present a distinct handicap to be overcome whichever method of analysis is used.
7. A variety of sequential sampling procedures are available for testing masks for compliance with the desired standards. Such sampling procedures hold promise of substantially reducing the total amount of testing required to achieve a given level of accuracy.

BIBLIOGRAPHY

Unpublished Sources

U. S. Air Force Anthropometric Survey - 1965.
Anthropology Branch, Aerospace Medical Research
Laboratory, Wright-Patterson Air Force Base, Ohio.

U. S. Air Force Anthropometric Survey - 1967.
Anthropology Branch, Aerospace Medical Research
Laboratory, Wright-Patterson Air Force Base, Ohio.

U. S. Marine Corps Anthropometric Survey - 1966.
Clothing and Personal Life Support Laboratory,
U. S. Army Natick Laboratories, Natick, Mass.

U. S. Navy Anthropometric Survey - 1966. Clothing
and Personal Life Support Laboratory, U. S. Army
Natick Laboratories, Natick, Mass.

Alexander, M., and Hertzberg, H. T. E., 1957, A Comfort Evaluation of a Form-Fitting High Altitude Helmet, WADC Technical Report 56-404, Wright-Patterson Air Force Base, Ohio.

Alexander, M., and Laubach, L. L., 1968, Anthropometry of the Human Ear, AMRL-TR-67-203, Wright-Patterson Air Force Base, Ohio.

Chemical Warfare Service, 1945, Chemical Warfare Service Anthropometric Data on Faces and Heads, Pamphlet No. MTT 1, U. S. Army, Edgewood Arsenal, Md.

Churchill, E., and Daniels, G. S., 1953, Nomographs of Head Measurements, WADC Technical Report 53-14, Wright-Patterson Air Force Base, Ohio.

Churchill, E., McConville, J. T., Laubach, L. L., and White, R. M., 1972, Anthropometry of U. S. Army Aviators - 1970, Report 72-52-CE, U. S. Army Natick Laboratories, Natick, Mass.

Churchill, E., and Truett B., 1957, Metrical Relations Among Dimensions of the Head and Face, WADC Technical Report 56-621, Wright-Patterson Air Force Base, Ohio.

Clauser, C. E., Tucker, Pearl, McConville, J. T., Churchill, E., Laubach, L. L., and Reardon, Joan, 1971, Anthropometry of Air Force Women, AMRL-TR-70-5, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio.

Damon, Albert and McFarland, R. A., 1955, "The Physique of Bus and Truck Drivers: With a Review of Occupational Anthropology," American Journal of Physical Anthropology, Vol. 13,4:711-742.

Davis, C. N. (Ed.), 1962, Design and Use of Respirators, Pergamon Press Inc., New York, N. Y.

Emanuel, I., Alexander, M., and Churchill, E., 1959, Anthropometric Sizing and Fit-Test of the MC-1 Oral-Nasal Oxygen Mask, WADC Technical Report 58-505, Wright-Patterson Air Force Base, Ohio.

Garn, S. M. and Gertler, M. M., 1950, "An Association Between Type of Work and Physique in an Industrial Group," American Journal of Physical Anthropology, 8,4:387-397.

Garn, S. M., Hunt, E. E., and Maranjian, G., 1952, Forsyth Rapid Reading Faceometer and Data for Headform Design, Final Report Part II, Contract No. DA 18-108-CML-2829, Forsyth Dental Infirmary for Children, Boston, Mass.

Gifford, E. C., Provost, J. R., and Lazo, John, 1965, Anthropometry of Naval Aviators - 1964, Report NAEC-ACEL-533, U. S. Naval Engineering Center, Philadelphia, Pa.

Hertzberg, H. T. E., Daniels, G. S., and Churchill, E., 1954, Anthropometry of Flying Personnel - 1950, WADC Technical Report 52-321, Wright-Patterson Air Force Base, Ohio.

Hyatt, E. C., et al., 1963, Respiratory Protective Devices Manual, American Conference of Industrial Hygienists, Braun and Brumfield, Inc., Ann Arbor, Michigan.

McConville, J. T., Alexander, M., and Velsey, S., 1963, Anthropometric Data in Three-Dimensional Form: USAF Height-Weight Sizing Manikans, AMRL-TR-63-55, Wright-Patterson Air Force Base, Ohio.

McFadden, E. B., Raeke, J. W., and Young, J. W., 1962, An Improved Method of Determining the Efficiency of Crew and Passenger Oxygen Masks, Report 62-21, Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma.

Newman, R. W. and White, R. M., 1951, Reference Anthropometry of Army Men, Report 180, Environmental Protection Division, Quartermaster Research and Development Command, Natick, Mass.

Randall, F. E., and Damon, A., 1942, Anthropometric Facial Survey of Wilberforce University, Memorandum Report, Air Corps, Material Division.

Randall, F. E., and Damon, A., 1942, Facial Surveys of Aviation Cadets and Other Flying Personnel, EXP-M-49-695-4B, Material Center, Army Air Force.

Randall, F. E., Damon, A., Benton, R. S., and Patt, D. I., 1946, Human Body Size in Military Aircraft and Personal Equipment, Report No. 5501, Army Air Force, Air Material Command, Wright Field, Dayton, Ohio.

Randall, F. E., and Munro, E. H., 1949, Reference Anthropometry of Army Women, Report 149, Environmental Protection Section, Office of the Quartermaster General, U.S.A., Lawrence, Mass.

Siegel, B., and Schanty, F., 1955, Design Considerations in the Development of Protective Masks, American Chemical Society Report No. R-55-4, Army Chemical Center, Md.

Stoudt, H. W., Crowley, T. J., McFarland, R. A., Ryan, A., Gruber, B., and Ray, C., 1970, Static and Dynamic Measurements of Motor Vehicle Drivers, Guggenheim Center for Aerospace Health and Safety, Boston, Mass.

Stoudt, H. W., Damon, A., McFarland, R. A., and Roberts, J., 1965, Weight, Height and Selected Body Dimensions of Adults: United States 1960-1962, National Center for Health Statistics, Series 11, Number 8, Washington, D. C.

White, R. M., 1961, Anthropometry of Army Aviators, Technical Report EP-150, Quartermaster Research and Engineering Center, Natick, Mass.

White, R. M., and Churchill, E., 1972, The Body Size of Soldiers: U. S. Army Anthropometry - 1966, Report 72-51-CE, U. S. Army Natick Laboratories, Natick, Mass.

Zeigen, R. S., Alexander, M., Churchill, E., 1960, A Head Circumference Sizing System for Helmet Design, WADC Technical Report 60-631, Wright-Patterson Air Force Base, Ohio.

APPENDIX B

CORRELATION COEFFICIENTS OF AGE, STATURE AND
WEIGHT WITH HEAD AND FACE MEASUREMENTS
(1967 USAF Survey Data)

	<u>Age</u>	<u>Stature</u>	<u>Weight</u>
Head Circumference	.110	.292	.410
Sagittal Crv/Inion	-.066	.157	.129
Minimum Frontal Cv	.058	.072	.202
Bitrag-Coronal Crv	-.060	.268	.300
Bitrag-Min Frontal	.072	.263	.365
Bitrag-Subnasale	.093	.234	.468
Bitrag-Menton Crv	.172	.310	.545
Bitrag-Submandibul	.202	.274	.536
Bitrag-Inion Crvtr	.073	.166	.299
Head Length	.052	.246	.259
Max Hd Diag/Menton	-.018	.389	.386
Max Hd Diag/Inion	.155	.199	.244
Ear Breadth	.176	.151	.176
Ear Length	.370	.227	.290
Ear L Above Tragion	.127	.125	.098
Head Breadth	.124	.134	.307
Maximum Frontal Br	.031	.195	.298
Bitragion Breadth	.261	.184	.395
Bizygomatic Br	.234	.187	.452
Bigonial Breadth	.223	.100	.414
Ear-To-Ear Breadth	.154	.209	.267
Biocular Breadth	.004	.124	.191
Interpupillary Br	.068	.139	.185
Interocular Br	.020	.094	.153
Nasal Breadth	.226	.048	.191
Lip Length	.214	.092	.173
Ear Protrusion	.085	.090	.112
Subnasale-Nasal Rt	.199	.196	.119
Philtrum Length	.276	.036	.133
Lip-To-Lip Height	-.367	.063	-.063
Menton-Subnasale	-.001	.176	.171
Menton-Nasal Root	.118	.277	.230
Vertex-Glabella Rt	-.239	.095	.011
Vertex-Nasal Root	-.242	.169	.063
Vertex-Ext Canthus	-.200	.180	.099

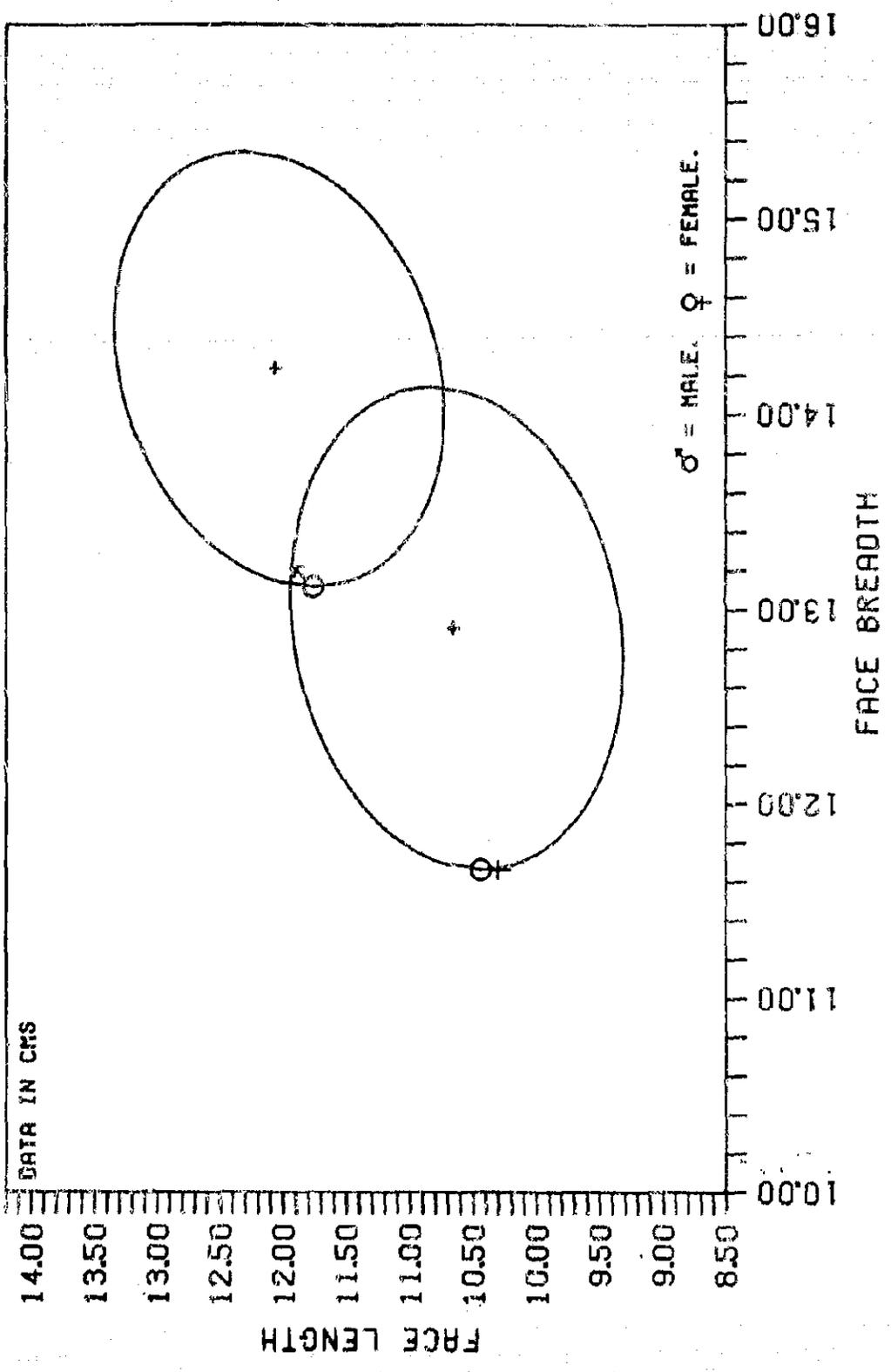
APPENDIX B (continued)

Vertex-Pronasale	-150	.182	.051
Vertex-Subnasale	-174	.222	.080
Vertex-Stomion Hgt	-148	.238	.100
Vertex-Menton Hgt	-137	.282	.168
Vertex-Tragion Hgt	-131	.196	.163
Wall-Glabella Lgth	.001	.264	.275
Wall-Nasal Root Lg	.026	.264	.273
Wall-Ext-L Canthus	.129	.174	.221
Wall-Pronasale Lgh	.146	.250	.299
Wall-Subnasale Lgh	.105	.208	.284
Wall-To-Lip Length	.098	.188	.295
Wall-To-Chin L-gth	.185	.178	.334
Wall-Tragion L-gth	.080	.080	.133

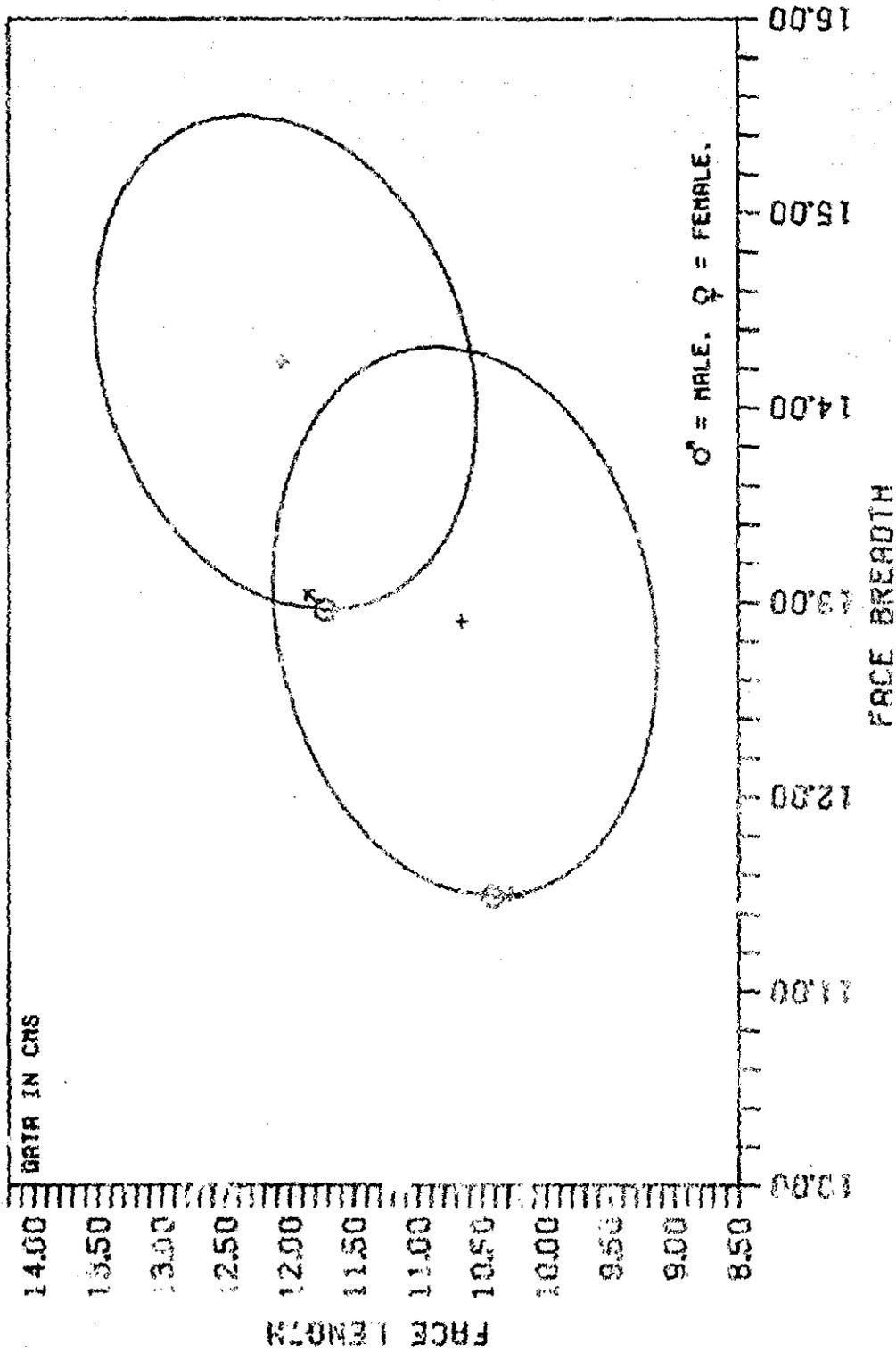
APPENDIX C

Male and Female Bivariate Tables

FACE BREADTH-FACE LENGTH ELLIPSES --- P = 90%



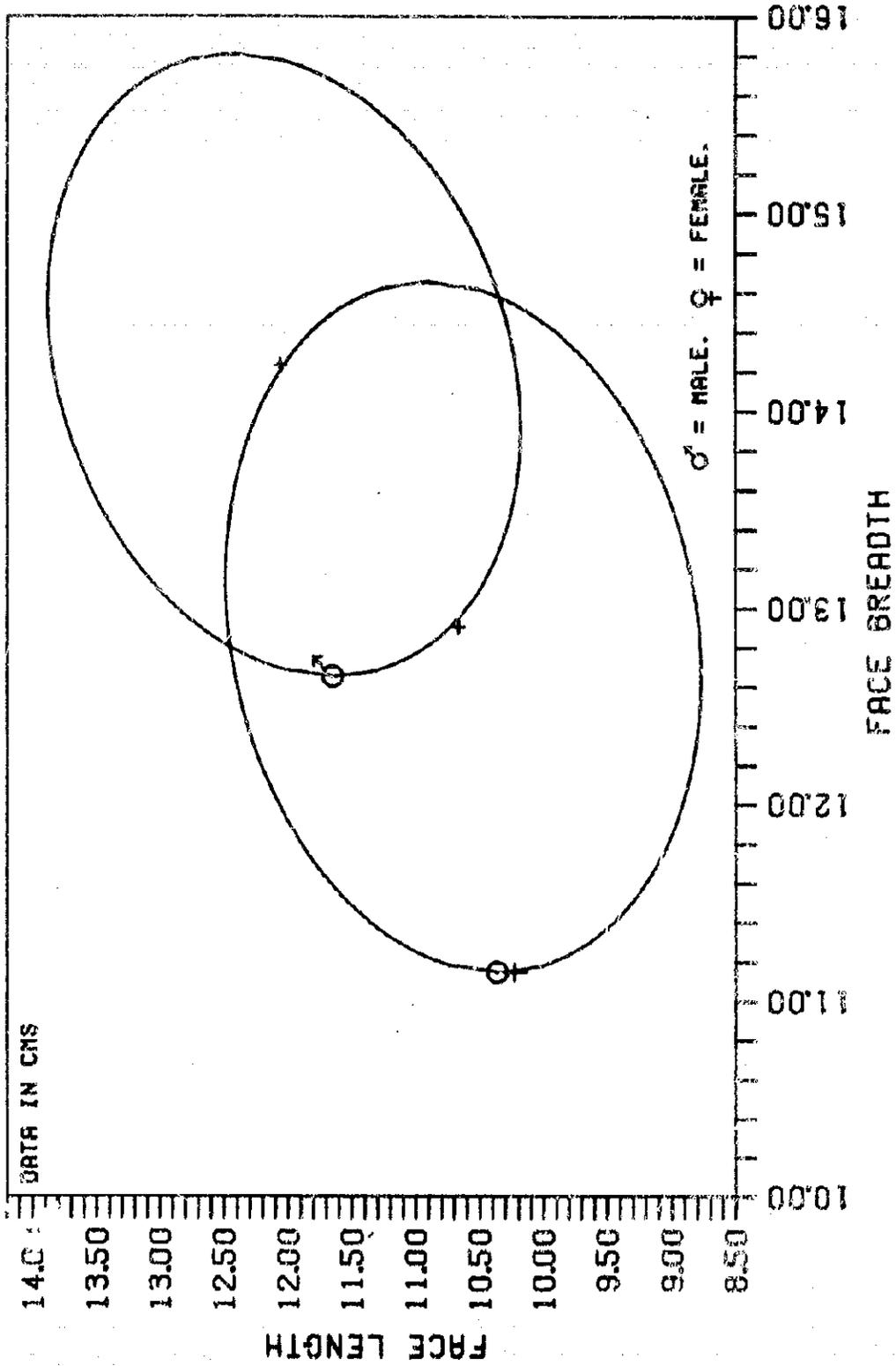
FACE BREADTH-FACE LENGTH ELLIPSES --- P = 95%



APPENDIX C

Male and Female Bivariate Tables

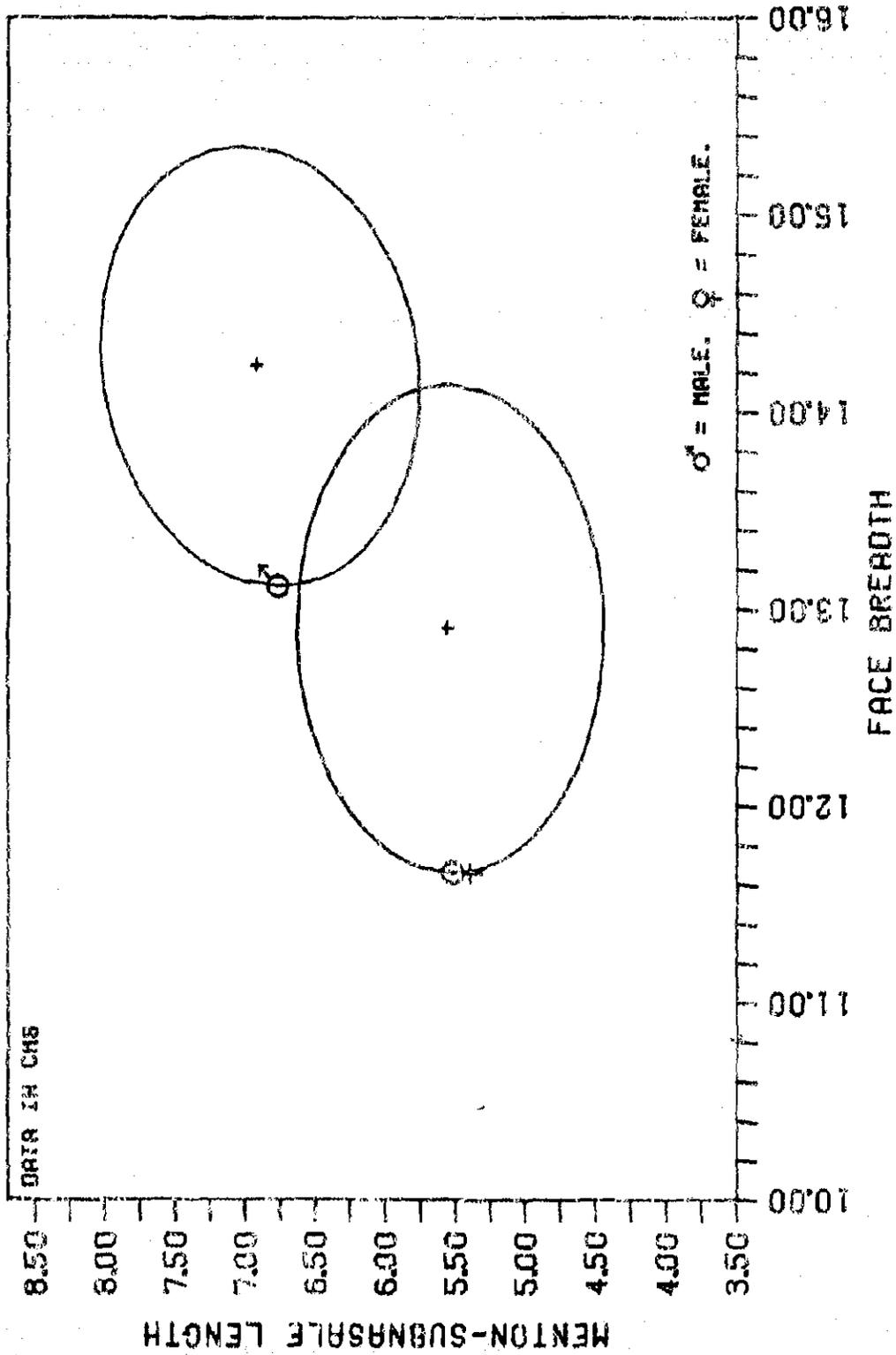
FACE BREADTH-FACE LENGTH ELLIPSES --- P = 99%



APPENDIX C

Male and Female Bivariate Tables

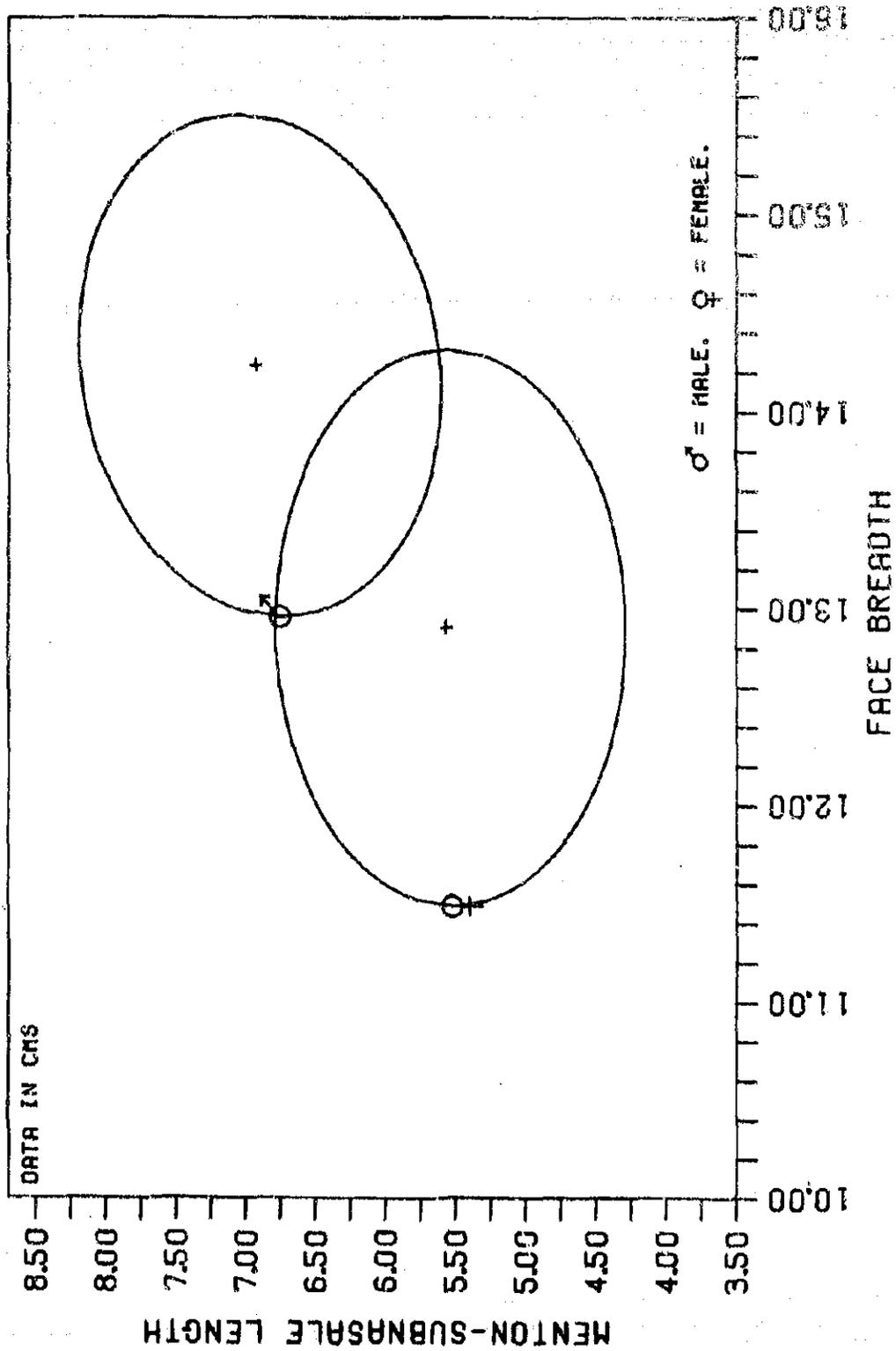
FACE BREADTH-HENTON SUBNASALE LENGTH ELLIPSES --- P = 90%



APPENDIX C

Male and Female Bivariate Tables

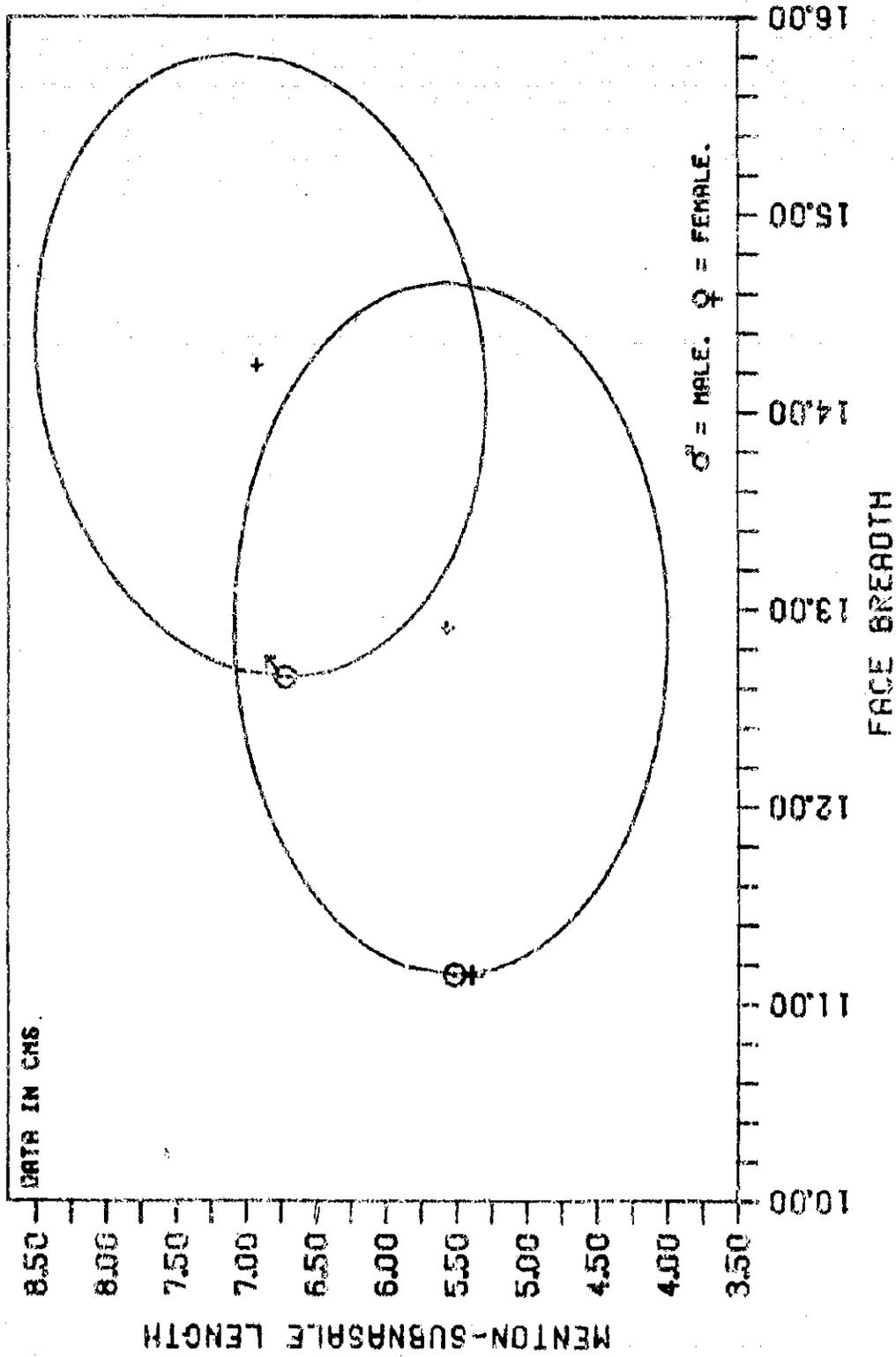
FACE BREADTH-MENTON SUBNASALE LENGTH ELLIPSES --- P = 95%



APPENDIX C

Male and Female Bivariate Tables

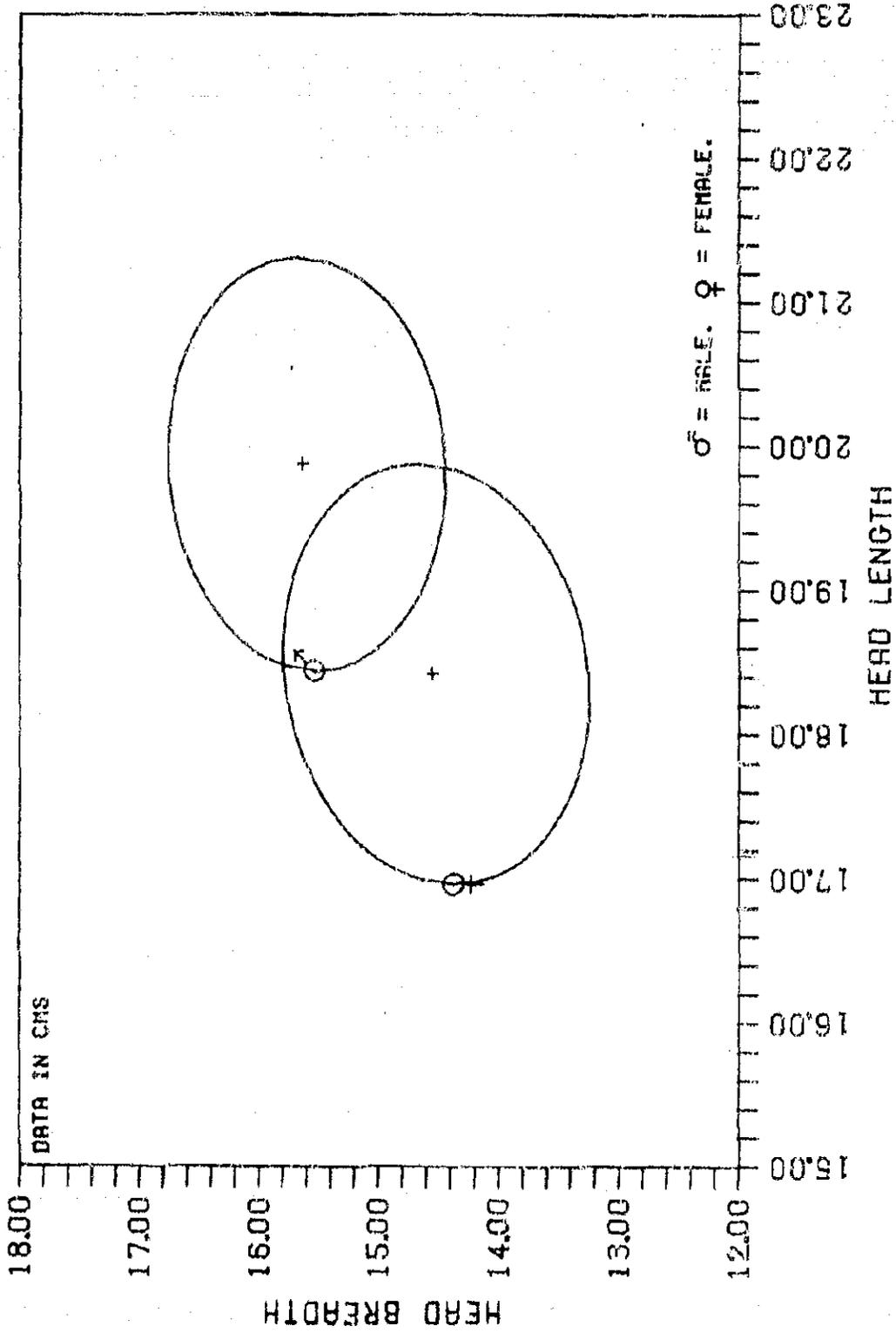
FACE BREADTH-MENTON SUBNASALE LENGTH --- P = 99%



APPENDIX C

Male and Female Bivariate Tables

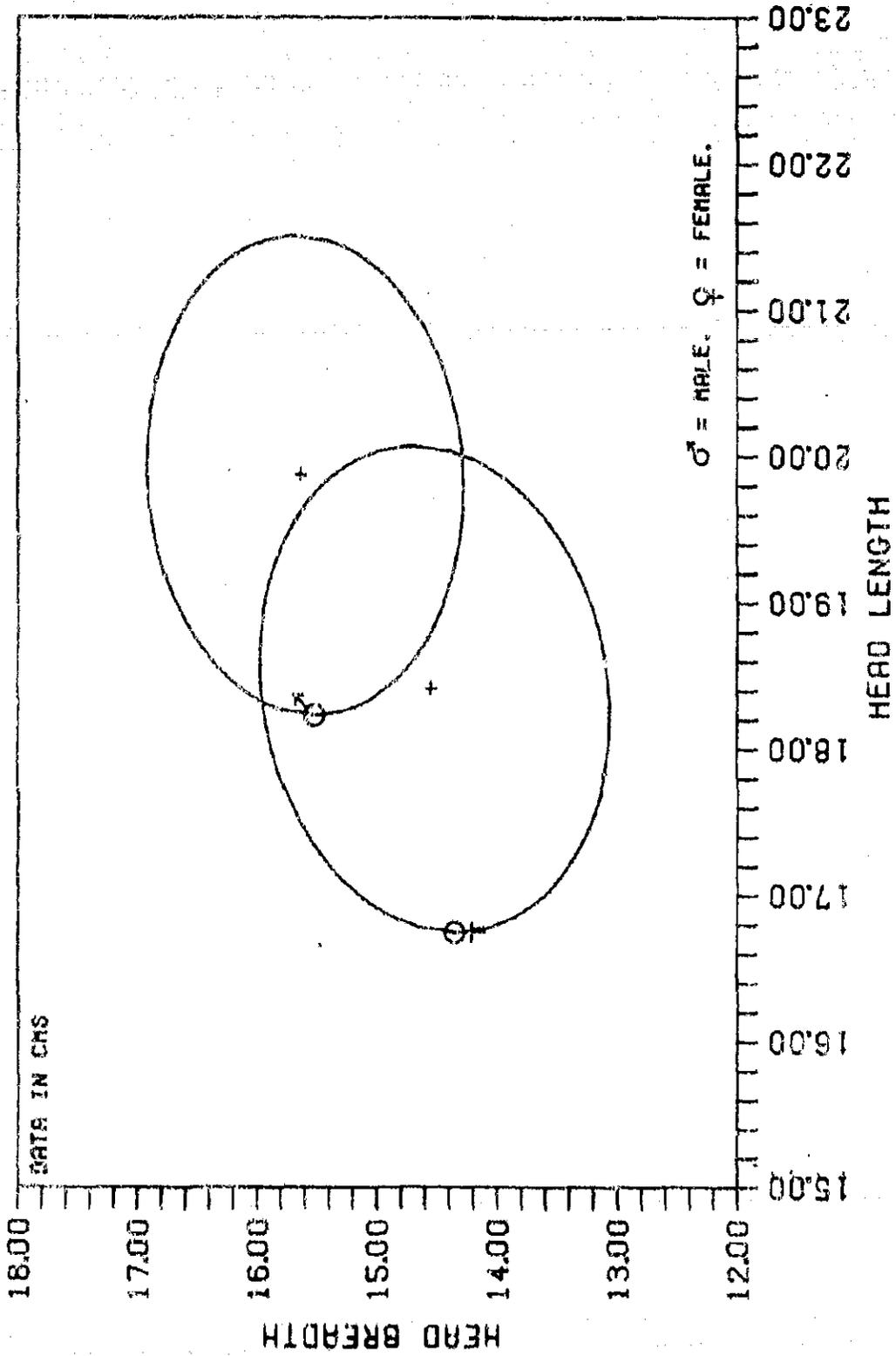
HEAD LENGTH-HEAD BREADTH --- P = 90%



APPENDIX C

Male and Female Bivariate Tables

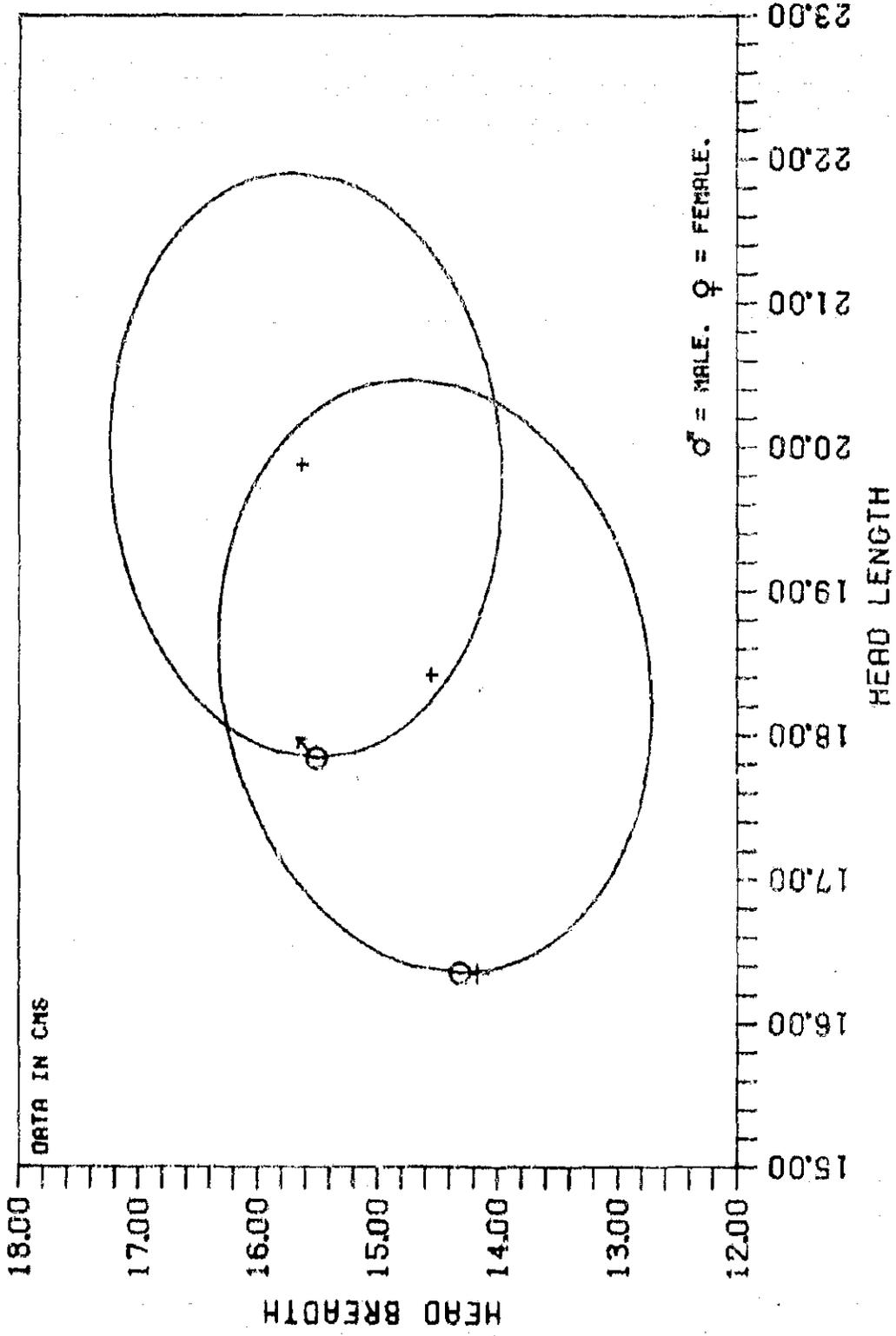
HEAD LENGTH-HEAD BREADTH ELLIPSES --- P = 95%



APPENDIX C

Male and Female Bivariate Tables

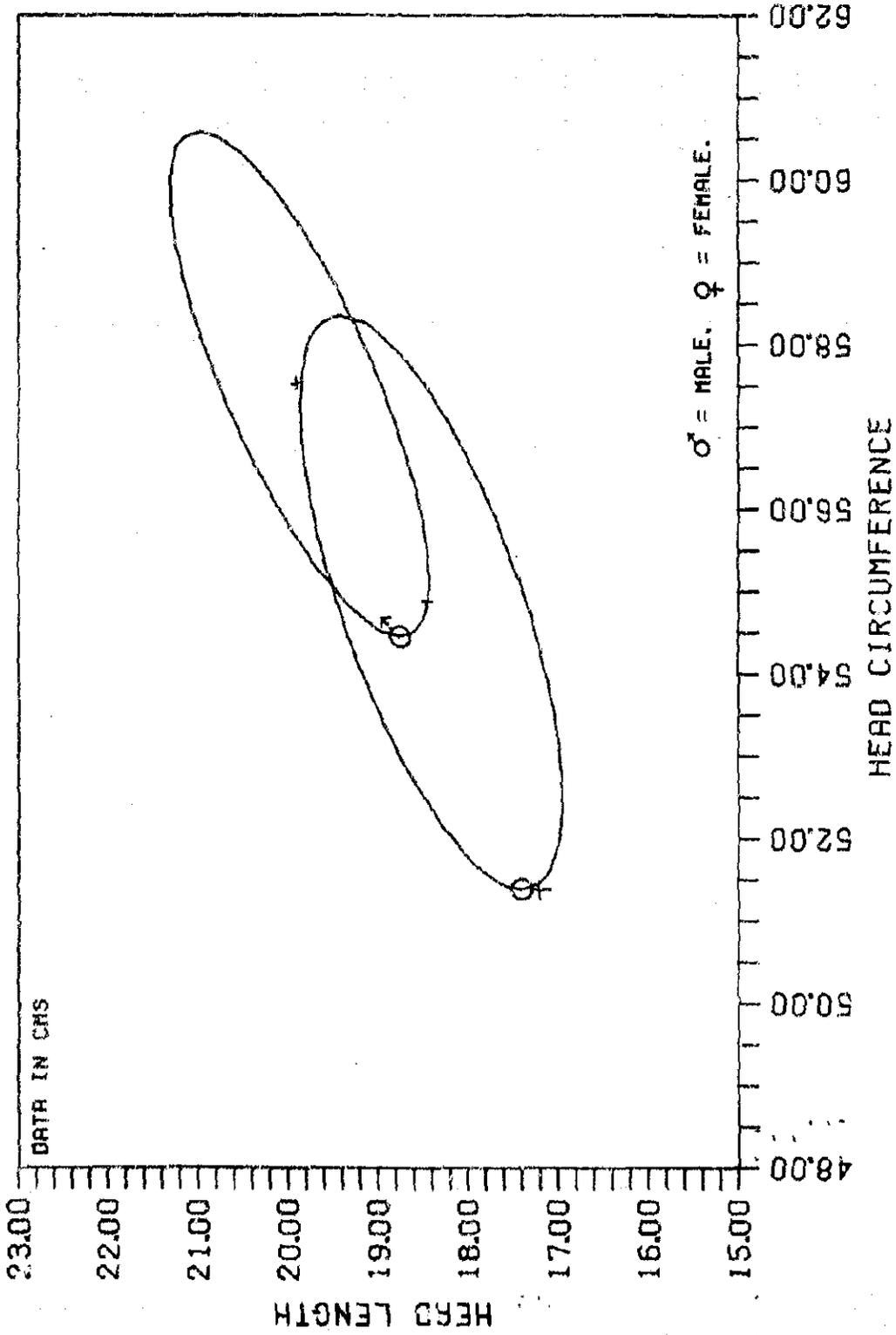
HEAD LENGTH-HEAD BREADTH ELIPSES --- P = 99%



APPENDIX C

Male and Female Bivariate Tables

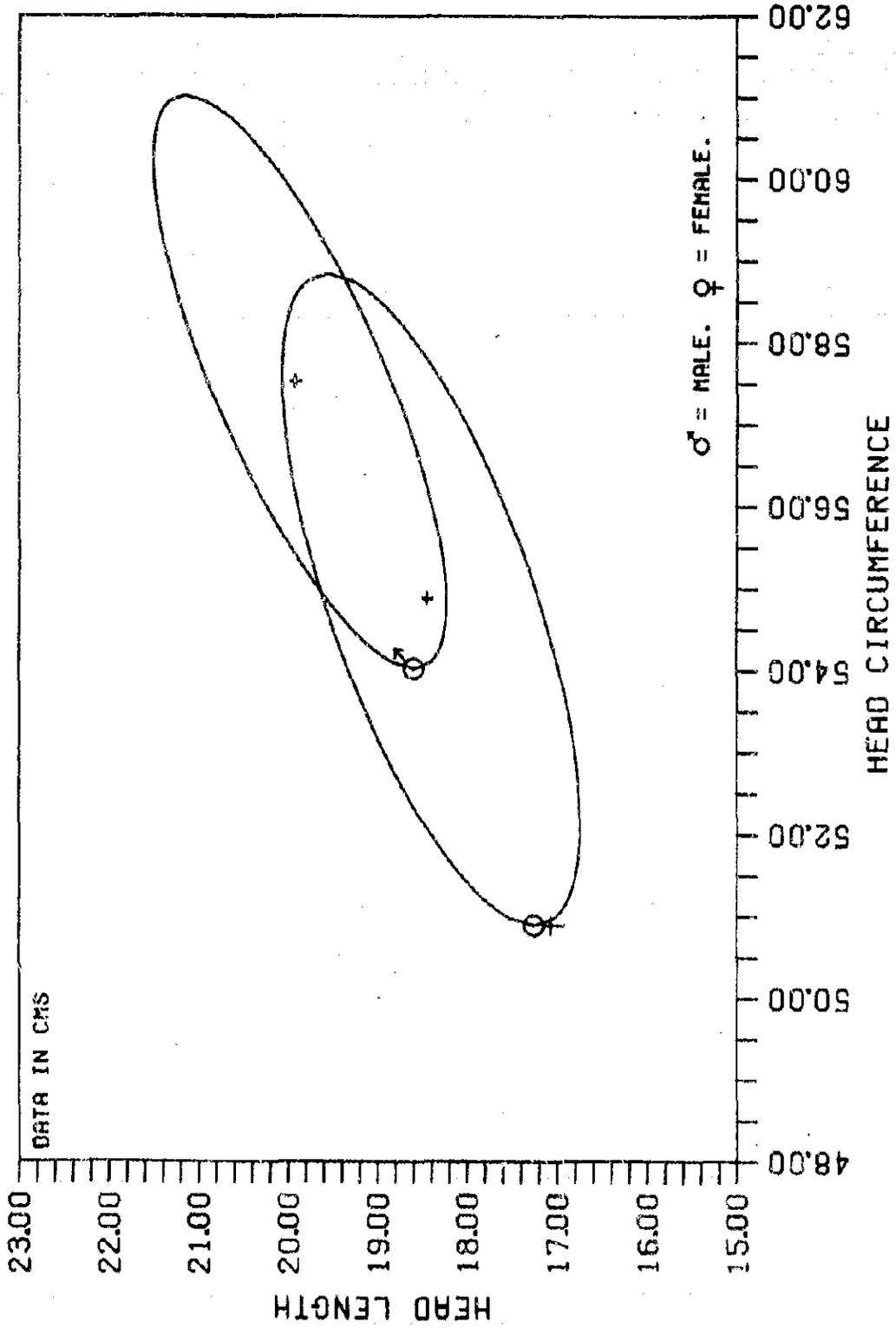
HEAD CIRCUMFERENCE-HEAD LENGTH ELLIPSES --- P = 90%



APPENDIX C

Male and Female Bivariate Tables

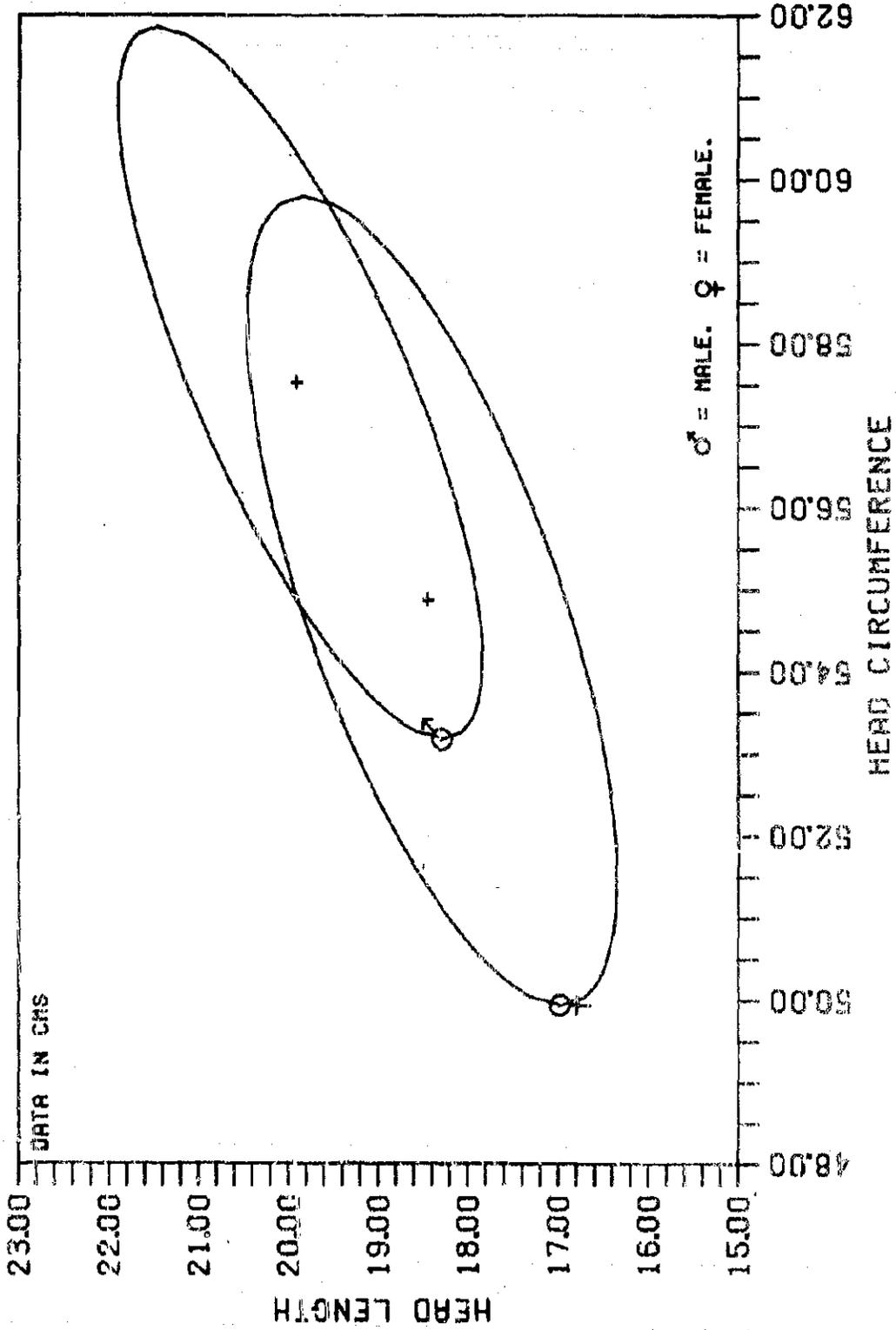
HEAD CIRCUMFERENCE-HEAD LENGTH --- P = 95%



APPENDIX C

Male and Female Bivariate Tables

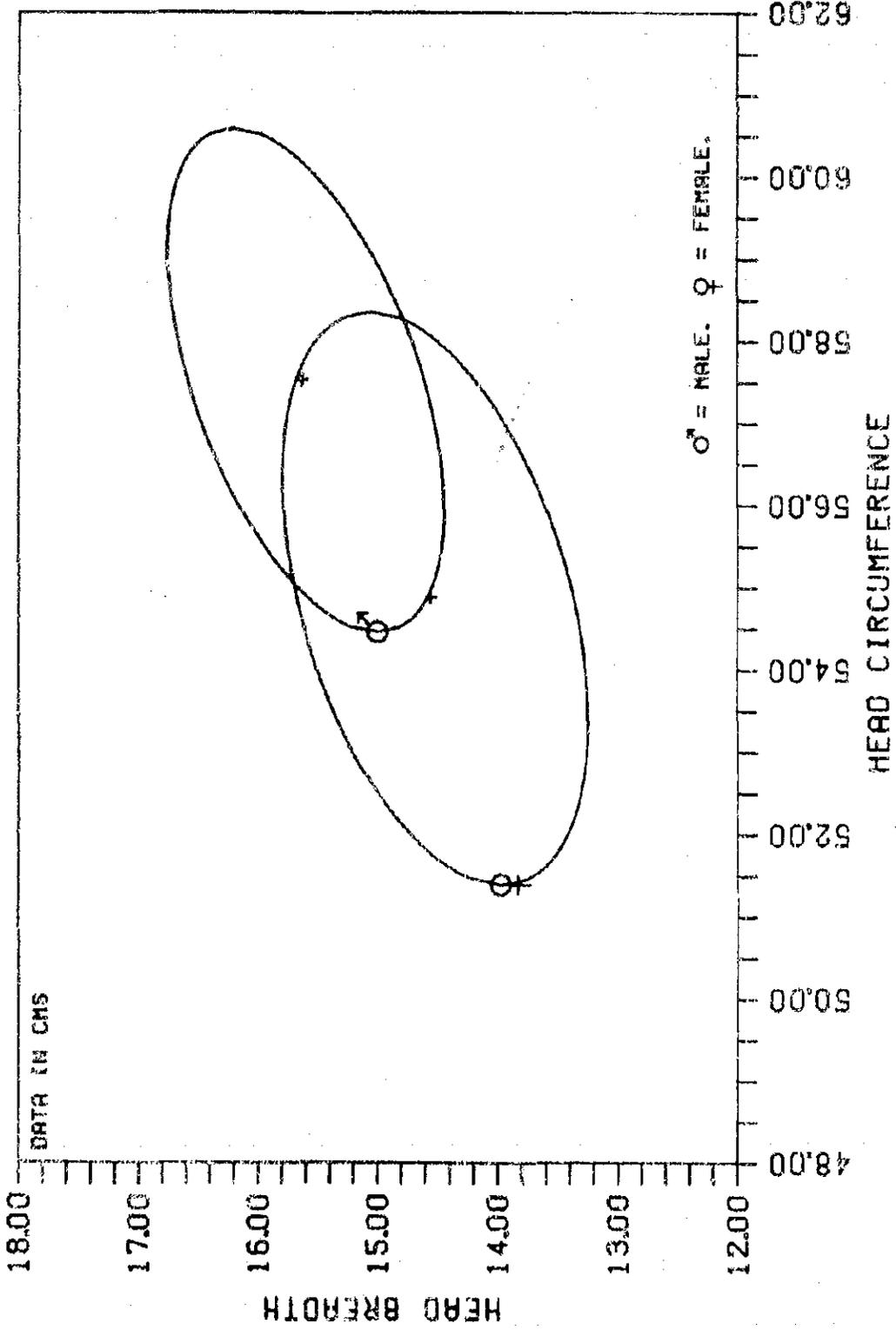
HEAD CIRCUMFERENCE-HEAD LENGTH ELLIPSES --- P = 99%



APPENDIX C

Male and Female Bivariate Tables

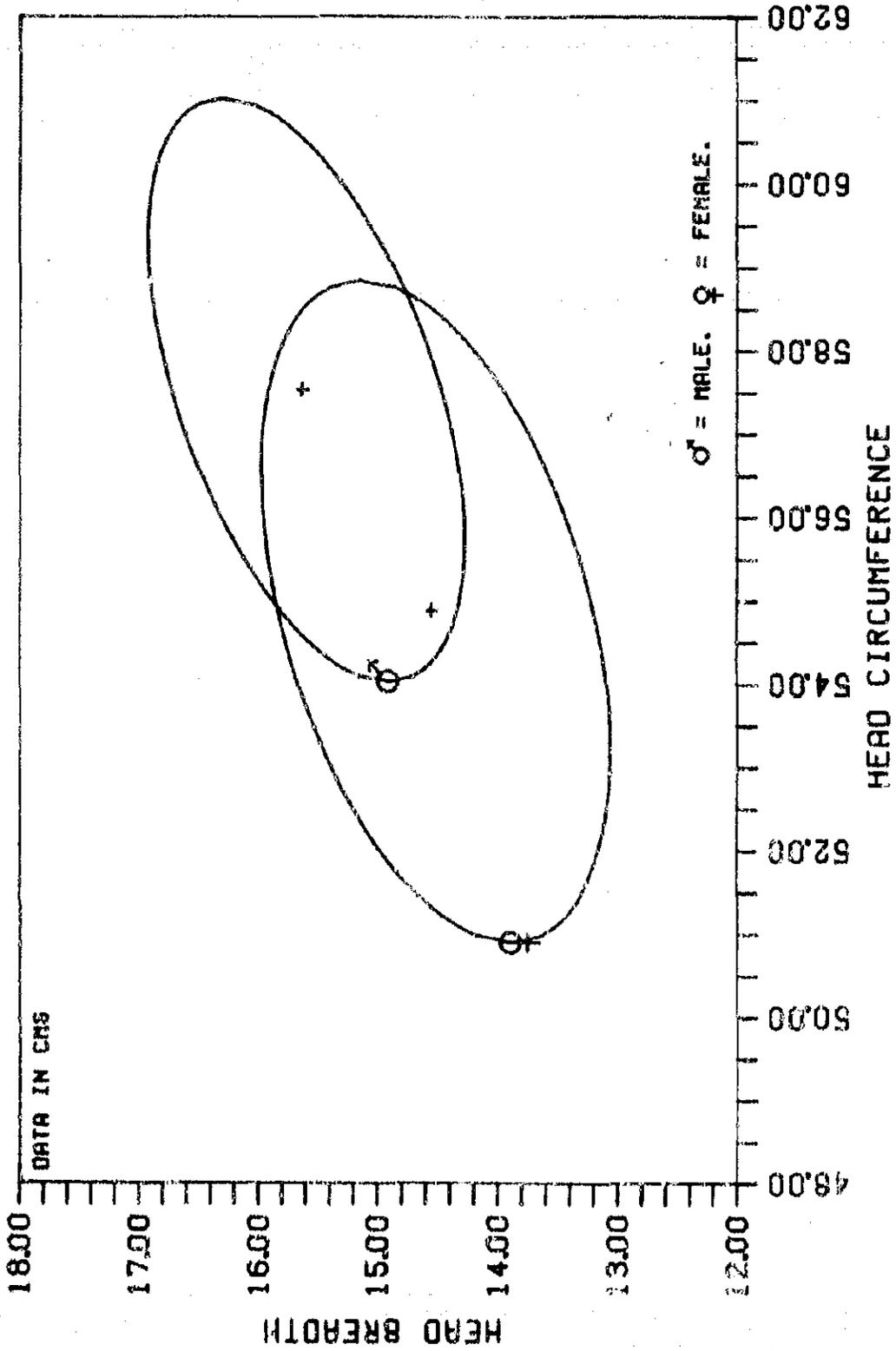
HEAD CIRCUMFERENCE-HEAD BREADTH --- P = 90%



APPENDIX C

Male and Female Bivariate Tables

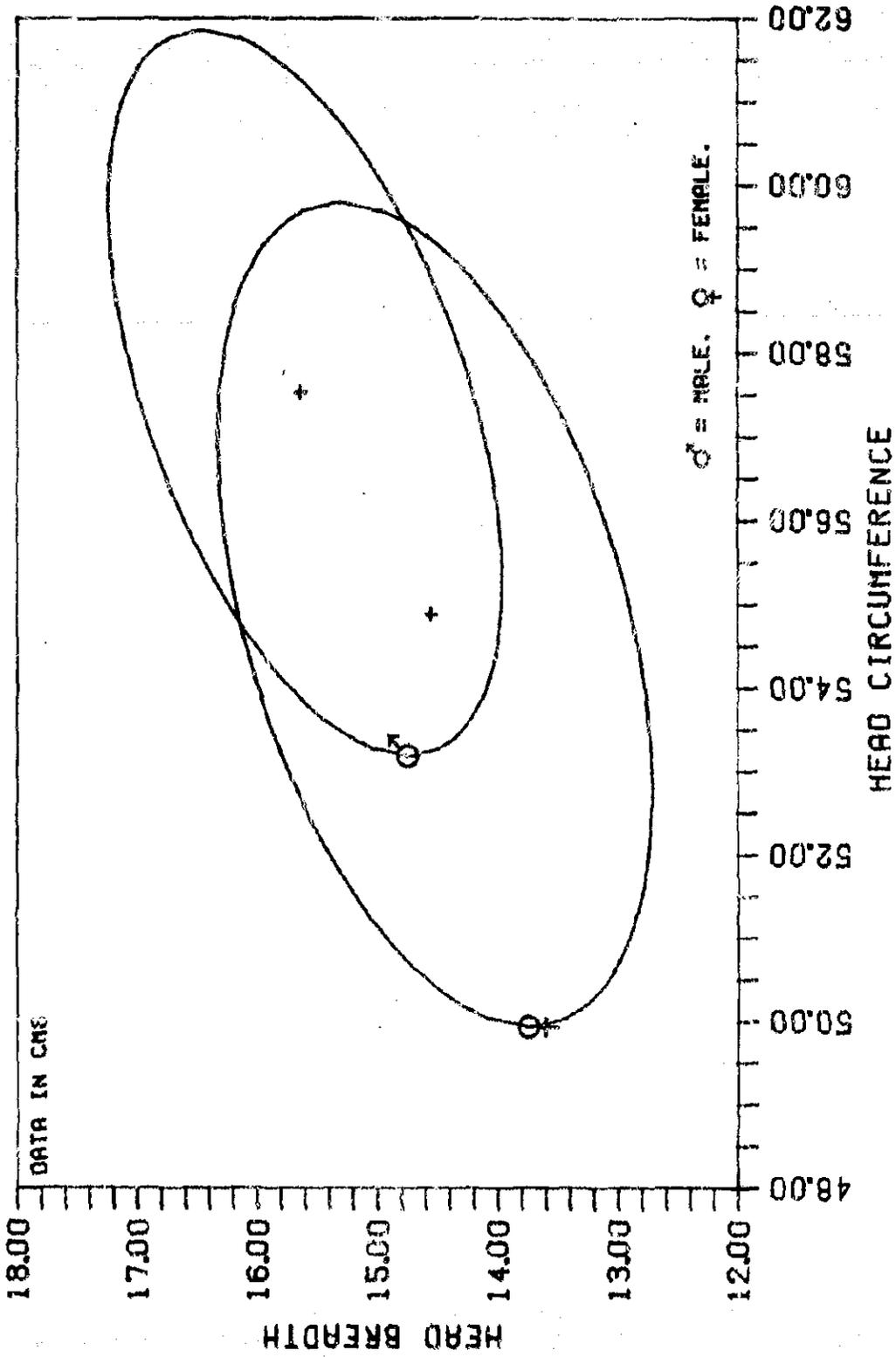
HEAD CIRCUMFERENCE--HEAD BREADTH ELLIPSES --- P = 95%



APPENDIX C

Male and Female Bivariate Tables

HEAD CIRCUMFERENCE-HEAD BREADTH ELLIPSES --- P = 99%



APPENDIX D

COMPARISON OF HEAD AND FACE MEASUREMENTS - Mean(SD)*
White and Negro (Male)

Matched Sample: Age	White	Negro	ΔW-N	%N/W
				n = 343
Head Circ	55.77 (1.64)	56.17 (1.59)	-.40	100.72
Sagittal Arc	37.59 (1.41)	37.55 (1.53)	.04	99.89
Min Frontal Arc	11.90 (0.87)	11.89 (0.83)	-.09	100.76
Bit-Coronal Arc	34.77 (1.30)	34.61 (1.31)	.16	99.54
Bit-Min Front Arc	30.28 (1.12)	30.45 (1.10)	-.17	100.56
Bit-Subnasal Arc	28.30 (1.07)	29.09 (1.10)	-.79	102.79
Bit-Menton Arc	30.87 (1.37)	31.55 (1.35)	-.68	102.50
Bit-Submandibular	28.63 (1.46)	28.79 (1.49)	-.16	100.56
Bit-Posterior Arc	24.93 (1.23)	24.84 (1.12)	.09	99.64
Head Length	19.53 (0.72)	19.78 (0.69)	-.25	101.28
Nasal Root Breadth	1.73 (0.23)	1.99 (0.29)	-.21	111.80
Ear Breadth	3.46 (0.33)	3.44 (0.32)	.02	99.42
Ear Length	6.25 (0.39)	5.97 (0.41)	.28	95.52
Ear Lth above Tragon	2.81 (0.29)	2.70 (0.31)	.11	96.09
Head Breadth	15.24 (0.59)	15.08 (0.54)	.06	99.60
Max Frontal Br	11.42 (0.49)	11.52 (0.51)	-.11	100.96
Bitragion Br	13.53 (0.61)	13.56 (0.56)	.07	99.49
Bizygomatic Br	13.84 (0.57)	13.86 (0.52)	-.02	100.14
Bigonial Br	10.61 (0.50)	10.50 (0.51)	.11	98.96
Ear to Ear Br	18.39 (0.92)	17.52 (0.80)	.87	95.27
Biocular Br	9.17 (0.46)	9.69 (0.46)	-.52	105.67
Interpupillary Br	6.09 (0.36)	6.45 (0.38)	-.36	105.91
Interocular Br	3.12 (0.24)	3.34 (0.29)	-.22	107.05
Nose Breadth	3.24 (0.24)	4.06 (0.34)	-.82	125.30
Nose Protrusion	2.29 (0.27)	2.07 (0.25)	.22	90.39
Lip Length	4.68 (0.37)	5.09 (0.43)	-.41	108.76
Ear Protrusion	2.13 (0.38)	1.90 (0.32)	.23	89.20
Subnasale-Nasal Rt Lth	5.07 (0.36)	5.00 (0.36)	.07	98.62
Philtrum	1.40 (0.25)	1.50 (0.24)	-.10	107.14
Lip to Lip Length	1.80 (0.29)	2.53 (0.36)	-.73	140.56
Menton-Subnasale Lth	6.99 (0.53)	7.52 (0.61)	-.53	107.58
Menton-Nasal Rt Lth	11.91 (0.64)	12.24 (0.69)	-.33	102.77
Glabella-Vertex	9.32 (0.76)	9.21 (0.81)	.11	98.82
Nasal Rt-Vertex	10.95 (0.72)	11.02 (0.78)	-.07	100.64
X-Canthus-Vertex	11.64 (0.63)	11.64 (0.67)	--	100.00
Pronasale-Vertex	14.91 (0.83)	14.78 (0.88)	.13	99.13
Subnasale-Vertex	-----	-----	---	----
Stomion-Vertex	18.24 (0.79)	18.49 (0.90)	-.25	101.37
Menton-Vertex	22.73 (0.90)	23.15 (0.99)	-.42	101.85
Tragon-Vertex	13.22 (0.57)	13.03 (0.60)	.19	98.56
Glabella to Wall	19.76 (0.72)	20.01 (0.68)	-.25	101.27
Nasal Rt to Wall	19.53 (0.72)	19.68 (0.67)	-.15	100.77
X-Canthus to Wall	17.01 (0.70)	17.38 (0.68)	-.37	102.18
Pronasale to Wall	21.81 (0.81)	22.02 (0.74)	-.21	100.96
Subnasale to Wall	-----	-----	---	----
Lip Prom to Wall	-----	-----	---	----
Chin Prom to Wall	-----	-----	---	----
Tragon to Wall	9.55 (0.61)	9.73 (0.62)	-.18	101.88
Age	19.07 (1.11)	19.07 (1.11)	--	100.00
Height	175.17 (6.86)	175.05 (6.57)	.12	99.93
Weight	150.1 (2.99)	150.8 (2.02)	-.7	100.47

APPENDIX D

COMPARISON OF HEAD AND FACE MEASUREMENTS - Mean(SD) *
White and Negro (Female)

	White n=1347	Negro n=131	ΔW-N	%N/W
Head Circ	54.73 (1.60)	55.83 (1.53)	-1.10	102.01
Sagittal Arc	34.64 (1.41)	34.91 (1.21)	-.27	100.49
Min Frontal Arc				
Bit-Coronal Arc	33.83 (1.38)	34.67 (1.32)	-.16	102.48
Bit-Min Front Arc				
Bit-Subnasal Arc				
Bit-Menton Arc				
Bit-Submandibular				
Bit-Posterior Arc				
Head Length	18.35 (0.68)	18.66 (0.70)	-.31	101.69
Nasal Root Breadth				
Ear Breadth	2.96 (0.33)	3.08 (0.32)	-.12	104.05
Ear Length	5.19 (0.43)	5.25 (0.45)	-.06	101.16
Ear Lth above Tragon				
Head Breadth	14.45 (0.56)	14.37 (0.60)	.08	99.45
Max Frontal Br				
Bitragon Br	12.82 (0.48)	12.84 (0.45)	-.02	100.16
Bizygomatic Br	12.87 (0.57)	12.96 (0.48)	-.09	100.70
Bigonial Br	10.14 (0.55)	10.22 (0.64)	-.08	100.79
Ear to Ear Br	15.76 (0.96)	15.56 (0.92)	.20	98.73
Biocular Br	9.65 (0.49)	10.05 (0.44)	-.40	104.15
Interpupillary Br				
Interocular Br				
Nose Breadth	3.19 (0.34)	3.77 (0.32)	-.58	118.18
Nose Protrusion				
Lip Length	4.36 (0.43)	4.85 (0.38)	-.49	111.24
Ear Protrusion				
Subnasale-Nasal Rt L	4.49 (0.39)	4.43 (0.39)	.06	98.66
Philtrum				
Lip to Lip Length				
Menton-Subnasale L	5.53 (0.50)	5.85 (0.52)	-.32	105.79
Menton-Nasal Rt L	10.56 (0.59)	10.70 (0.61)	-.14	101.33
Glabella-Vertex				
Nasal Rt-Vertex				
X-Canthus-Vertex	11.72 (0.91)	12.25 (1.04)	-.53	104.52
Pronasale-Vertex	14.66 (1.14)	15.15 (1.23)	-.49	103.24
Subnasale-Vertex	15.84 (1.08)	16.32 (1.20)	-.48	103.03
Stomion-Vertex	17.76 (1.11)	18.44 (1.23)	-.68	103.83
Menton-Vertex	21.84 (1.12)	22.56 (1.12)	-.72	103.30
Tragon-Vertex	12.68 (0.76)	12.91 (0.77)	-.23	101.81
Glabella to Wall				
Nasal Rt to Wall				
X-Canthus to Wall	16.31 (0.98)	17.05 (1.03)	-.74	104.54
Pronasale to Wall	21.13 (0.95)	21.76 (0.96)	-.63	102.98
Subnasale to Wall	19.64 (0.98)	20.50 (0.98)	-.86	104.38
Lip Prom to Wall	19.29 (1.07)	20.50 (1.09)	-1.21	106.27
Menton to Wall	18.19 (1.12)	18.97 (1.17)	-.78	104.29
Tragon to Wall	10.15 (0.90)	10.68 (1.00)	-.53	105.22
Age	20.37 (3.63)	20.85 (3.93)	-.48	102.36
Height	161.86 (5.88)	161.30 (5.79)	.56	99.65
Weight	125.65(15.40)	124.14(15.74)	1.51	98.80

* In Centimeters

Age in years. wt. in pounds

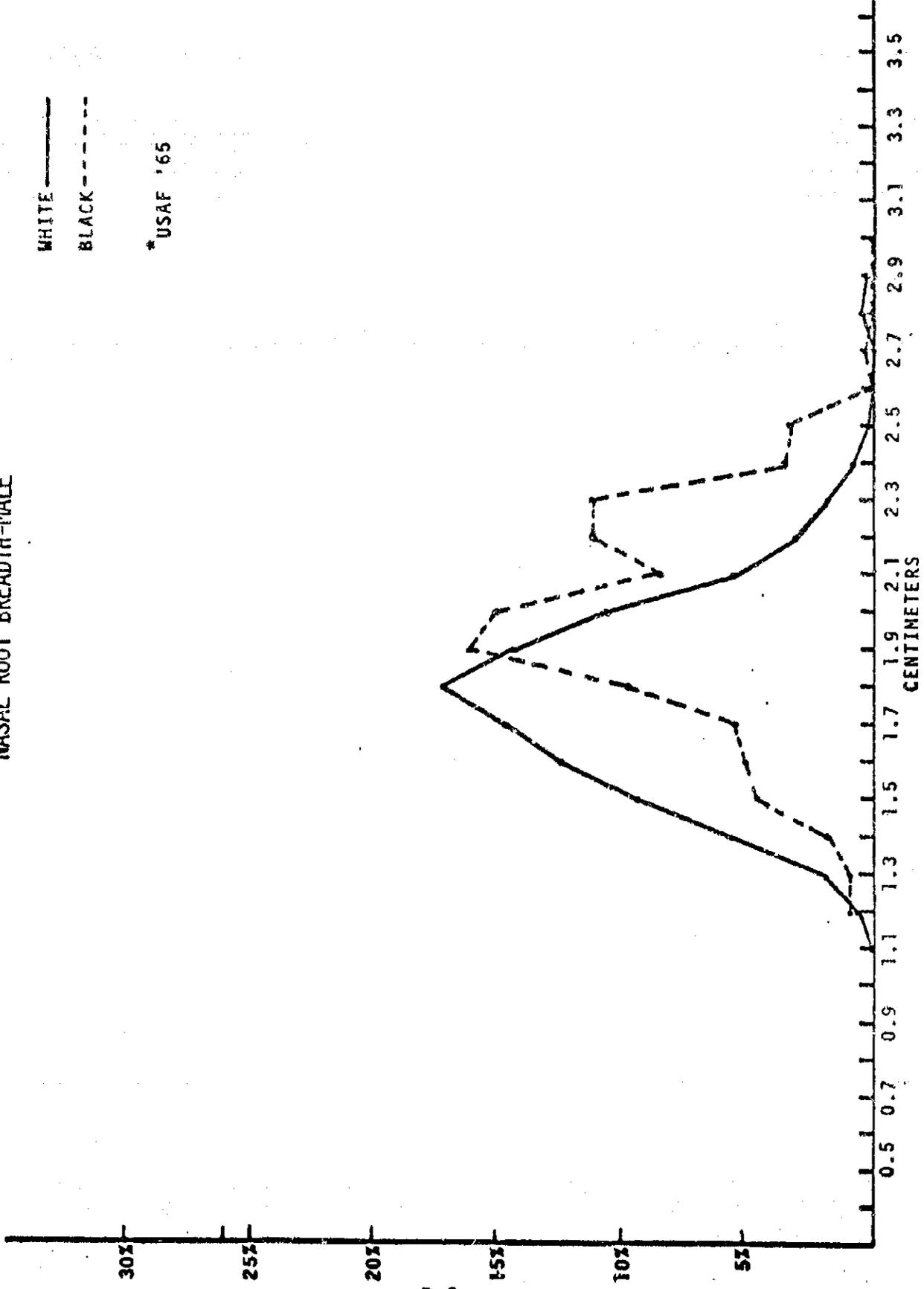
APPENDIX D

NASAL ROOT BREADTH-MALE*

WHITE ———

BLACK - - - - -

* USAF '65

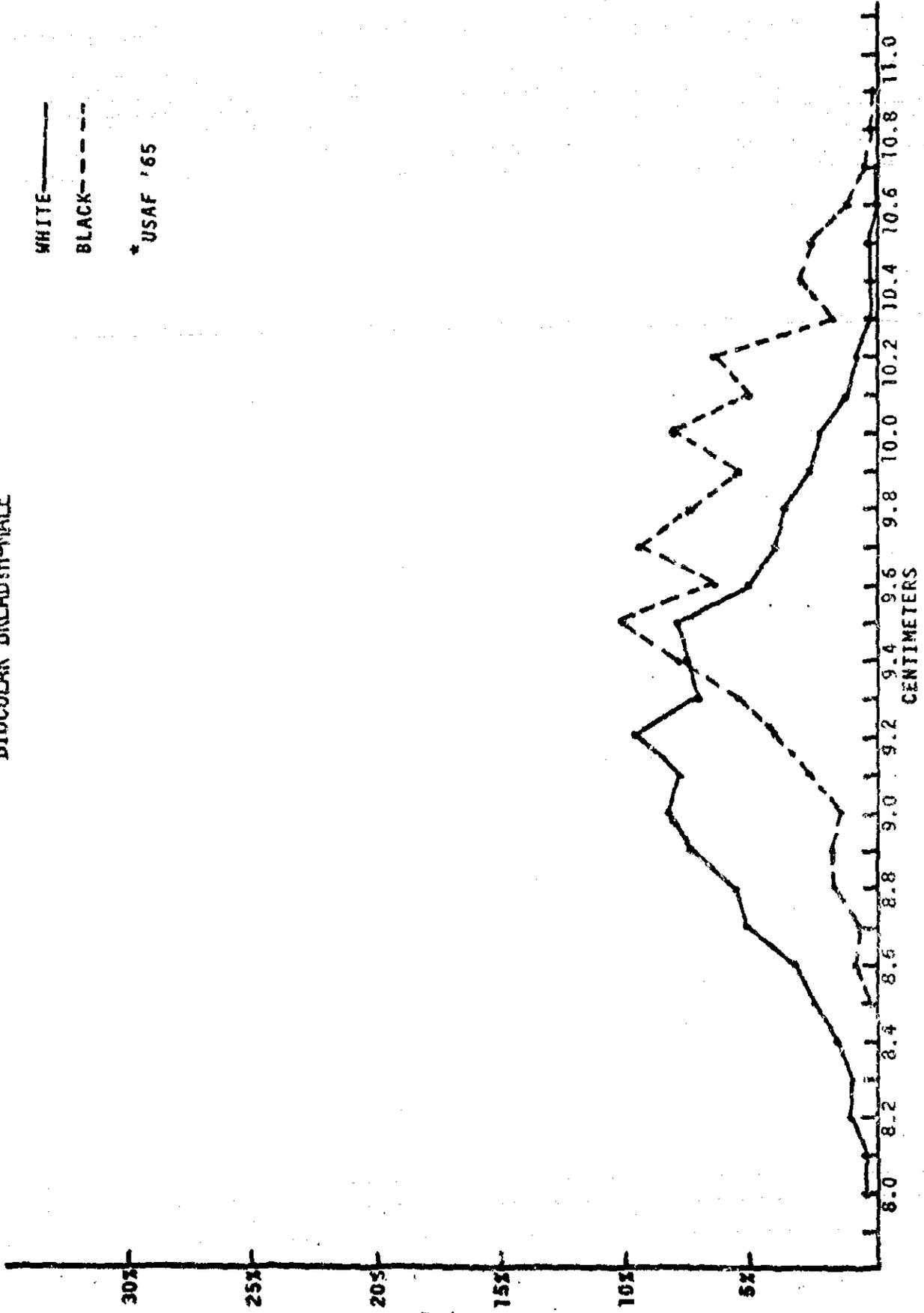


Appendix D
BIOCULAR BREADTH-MALE*

WHITE ———

BLACK - - - -

* USAF '65



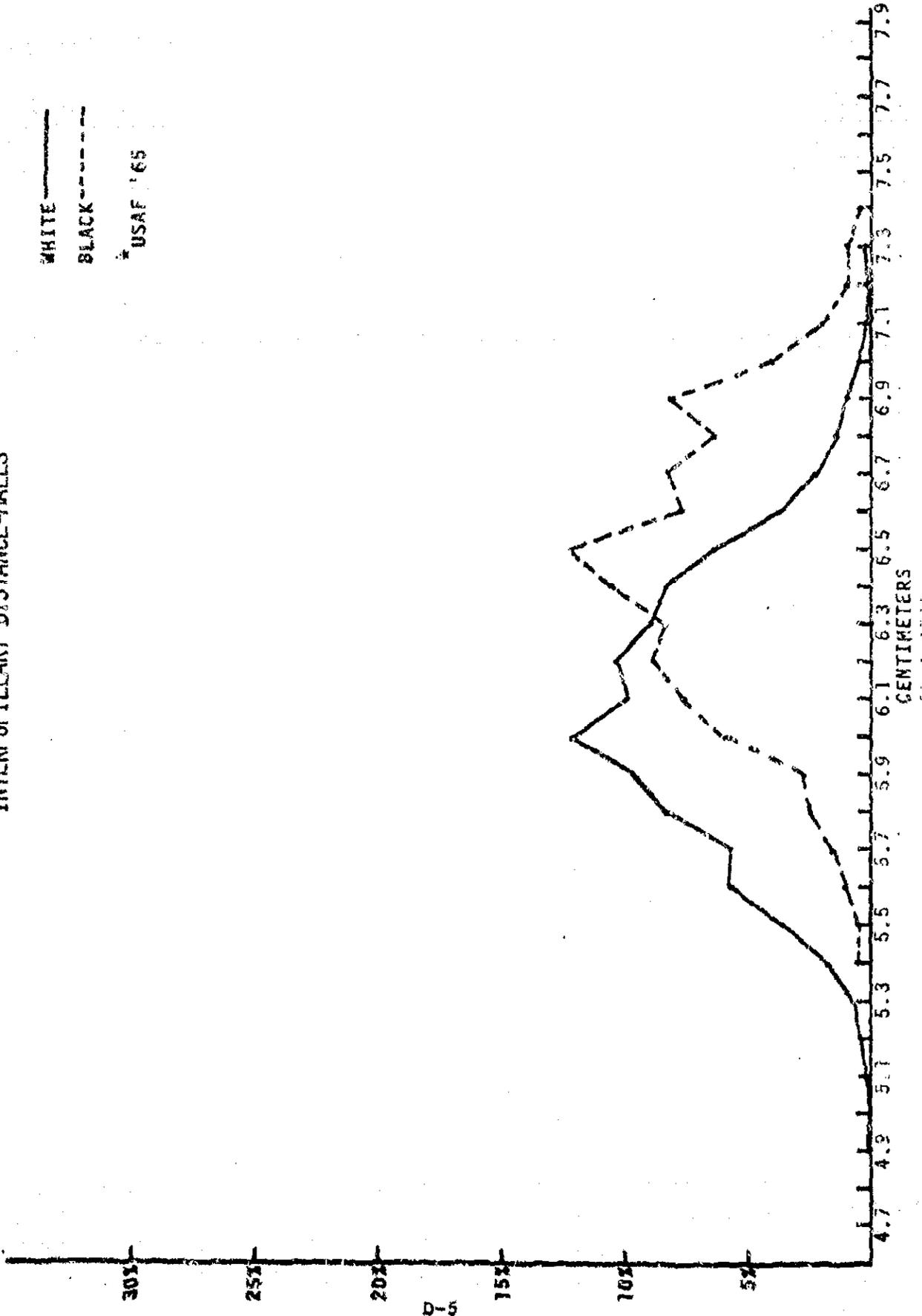
APPENDIX D

INTERPUPILLARY DISTANCE-MALES*

WHITE ———

BLACK - - - - -

* USAF '65

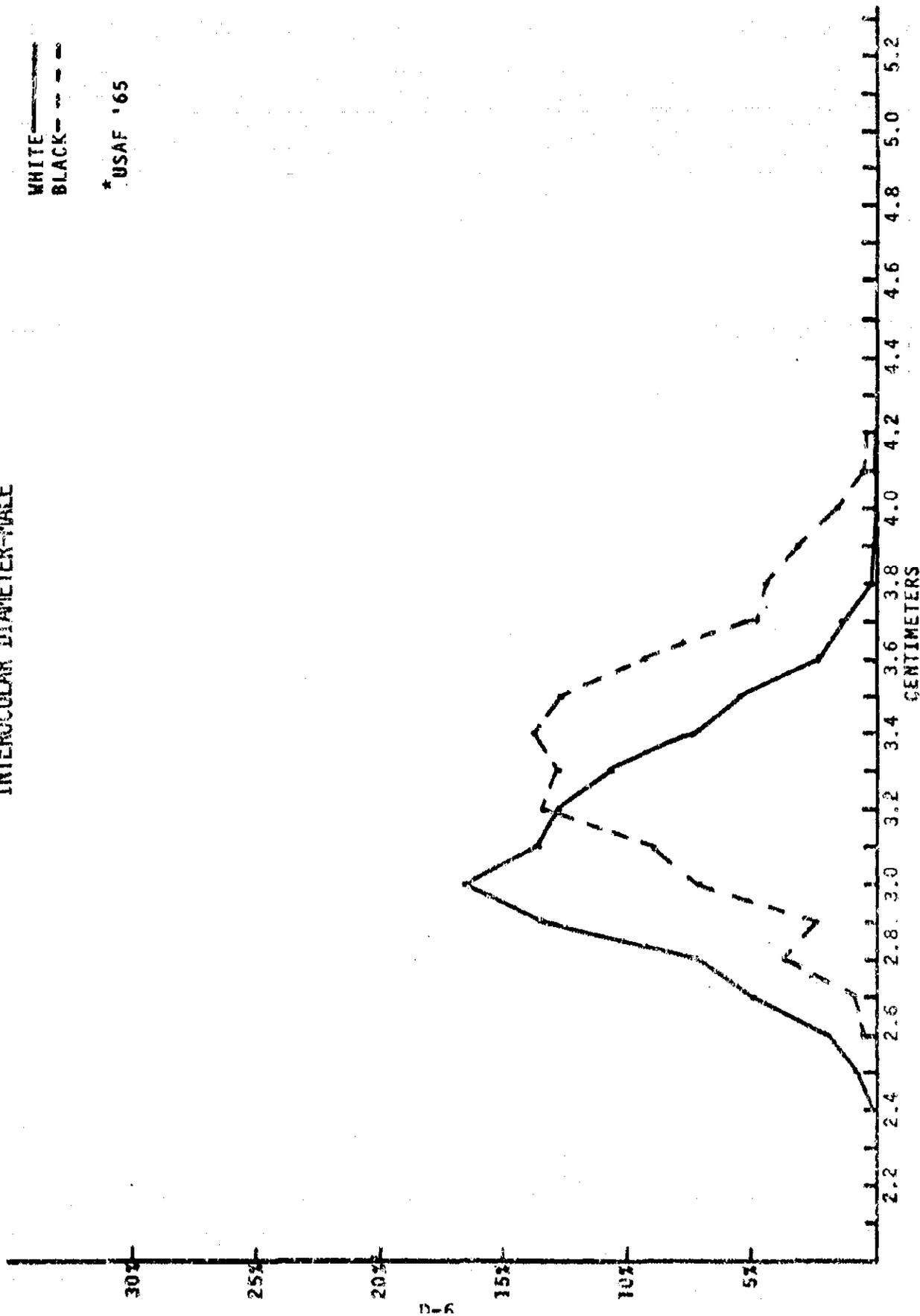


APPENDIX D

INTEROCULAR DIAMETER-MALE*

WHITE ———
BLACK - - -

* USAF '65

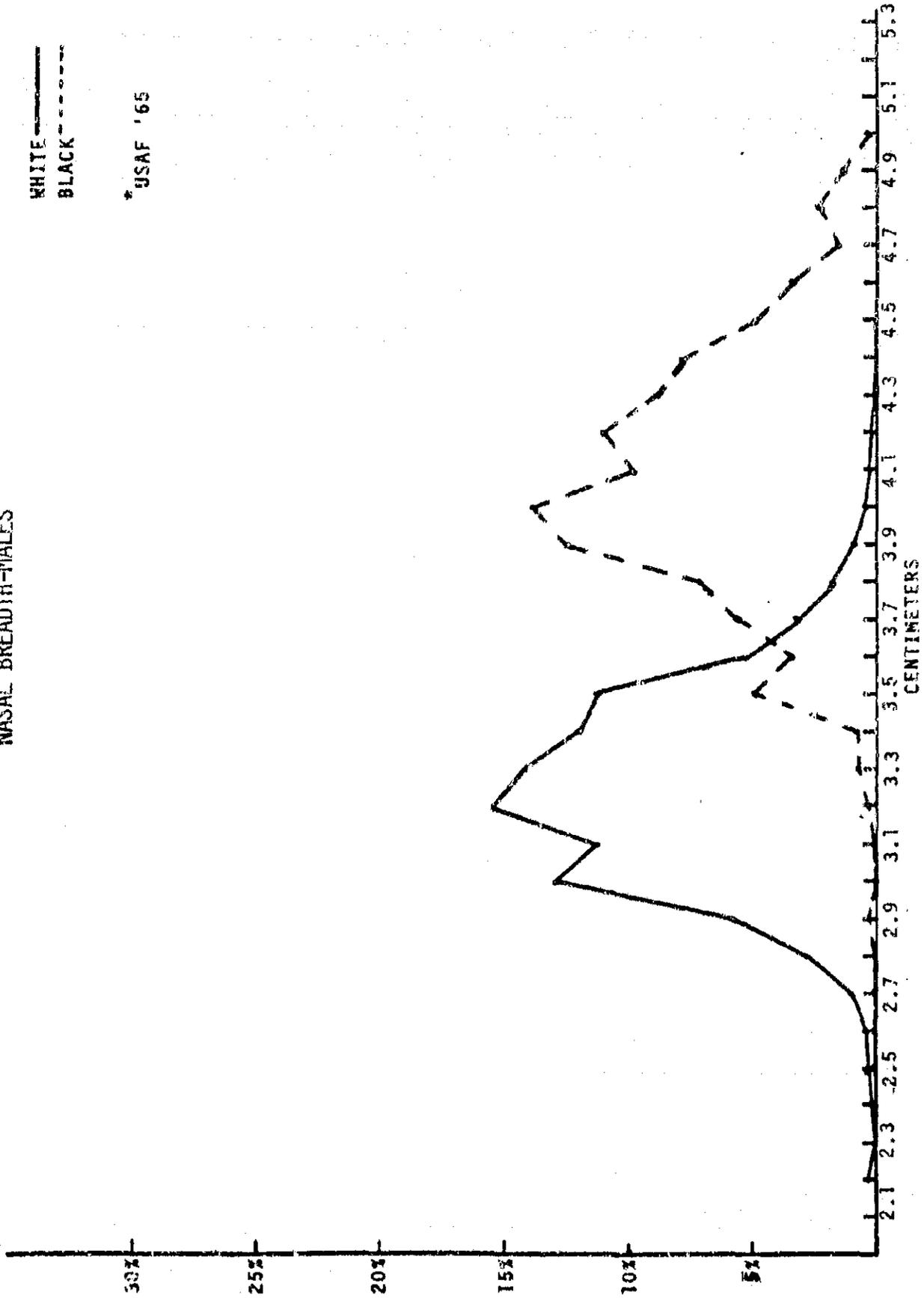


APPENDIX D

NASAL BREADTH-MALES*

WHITE ———
BLACK - - - -

* USAF '65



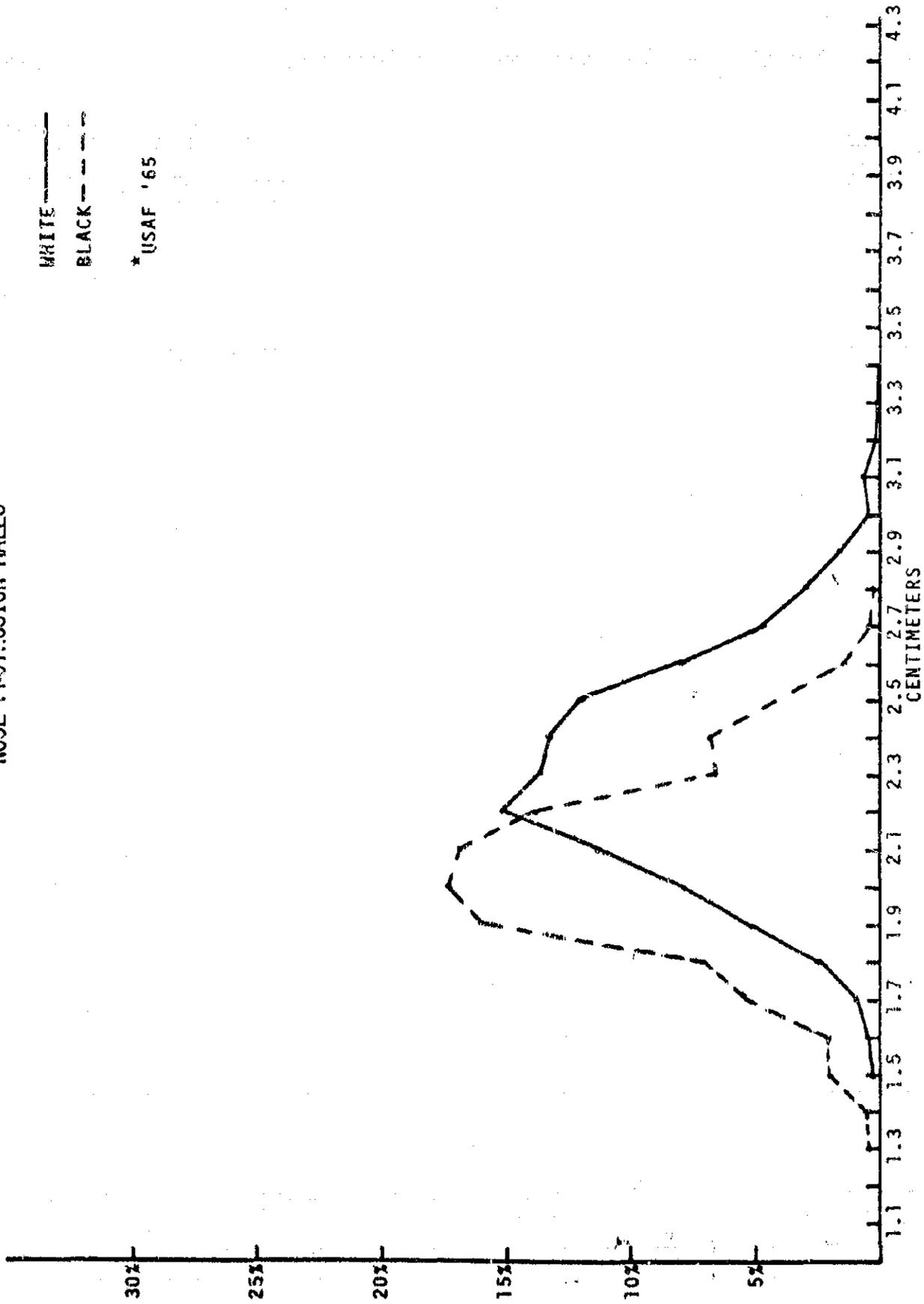
APPENDIX D

NOSE PROTRUSION-MALES*

WHITE -----

BLACK - - - - -

* USAF '65

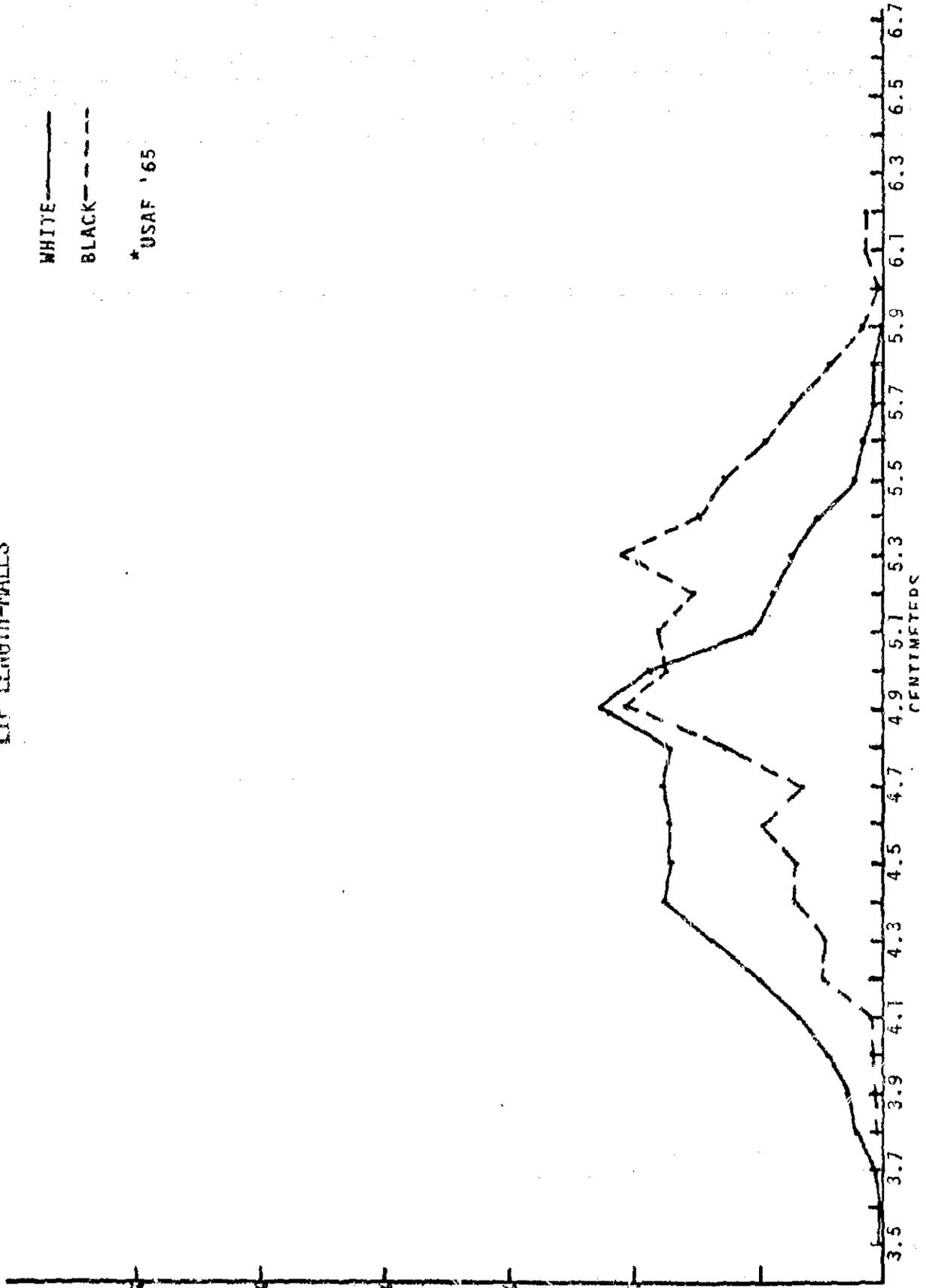


APPENDIX D

LIP LENGTH-MALES*

WHITE ———
BLACK - - - -

* USAF '65



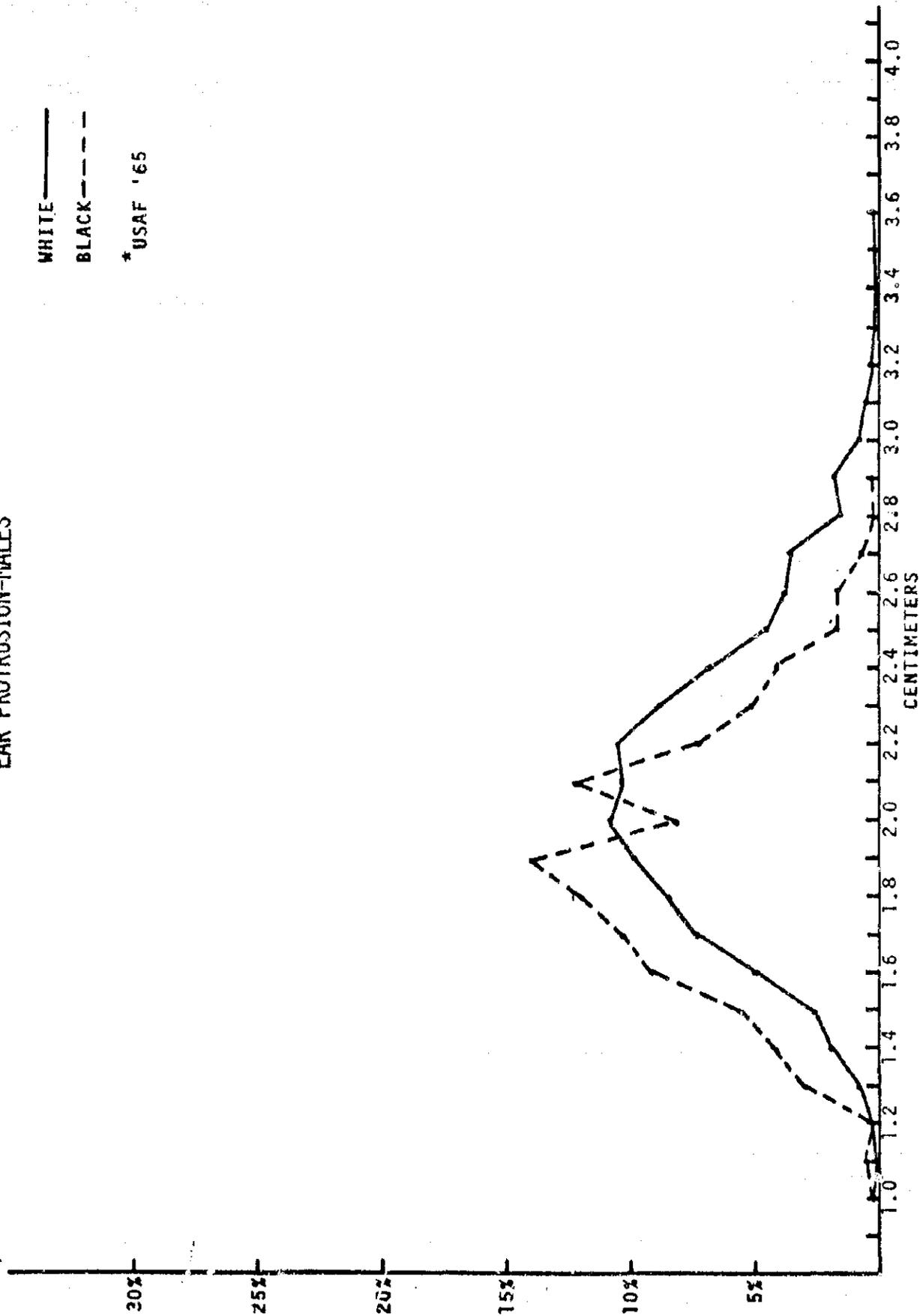
APPENDIX D

EAR PROTRUSION-MALES*

WHITE ———

BLACK - - - -

* USAF '65

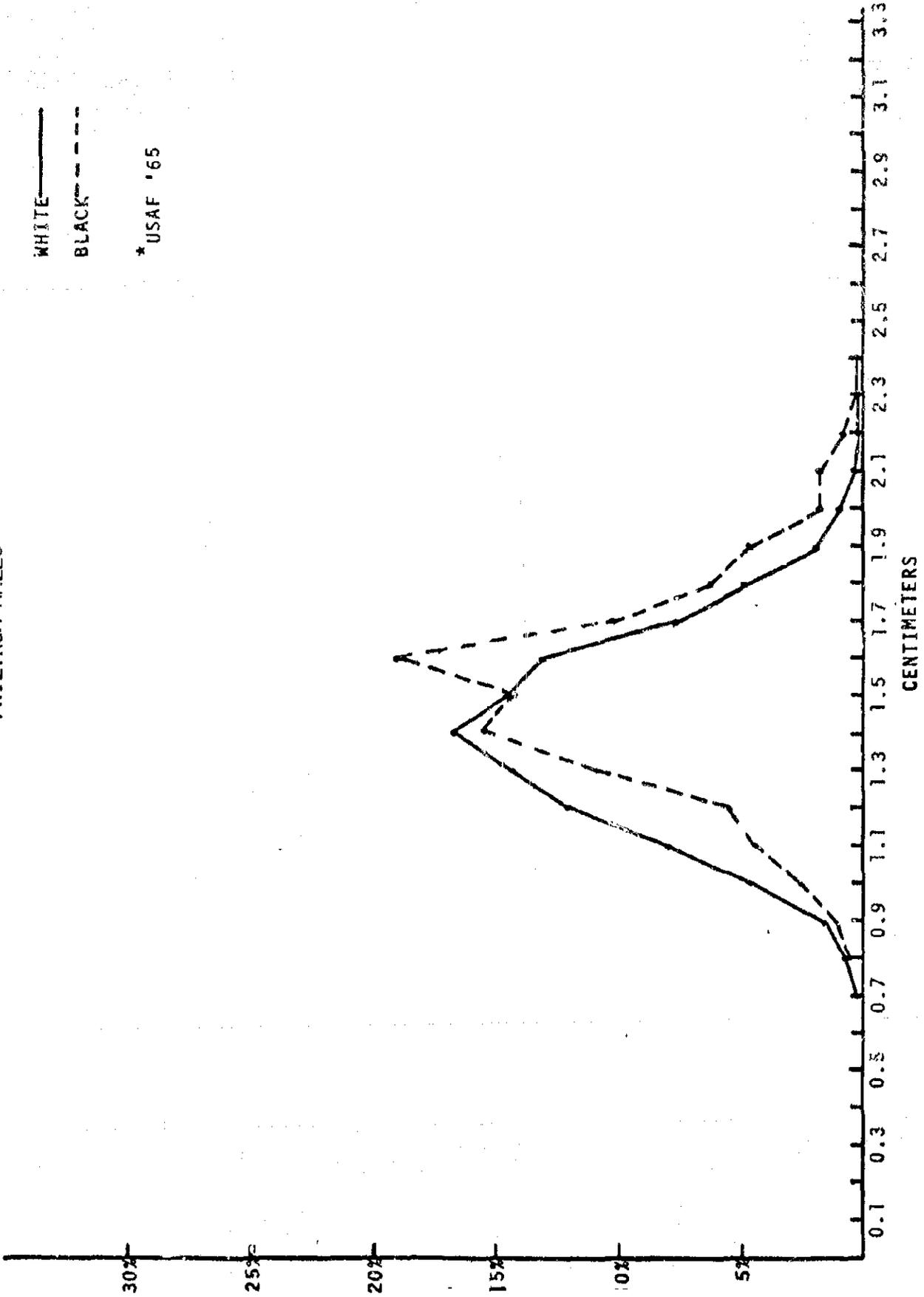


APPENDIX D
PHILTRUM-MALES*

WHITE ———

BLACK - - - -

* USAF '65



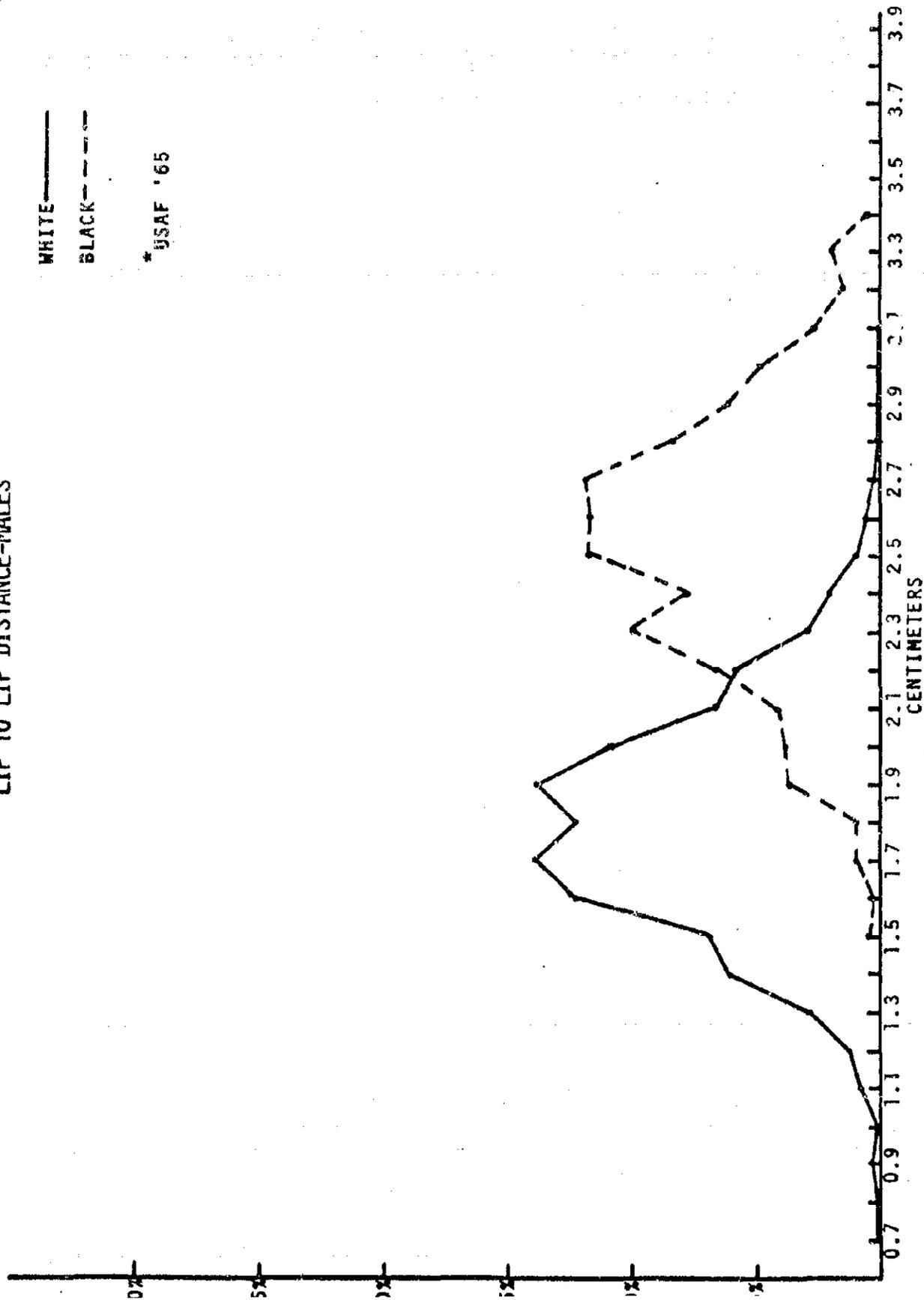
APPENDIX D

LIP TO LIP DISTANCE-MALES*

WHITE ———

BLACK - - - -

* USAF '65



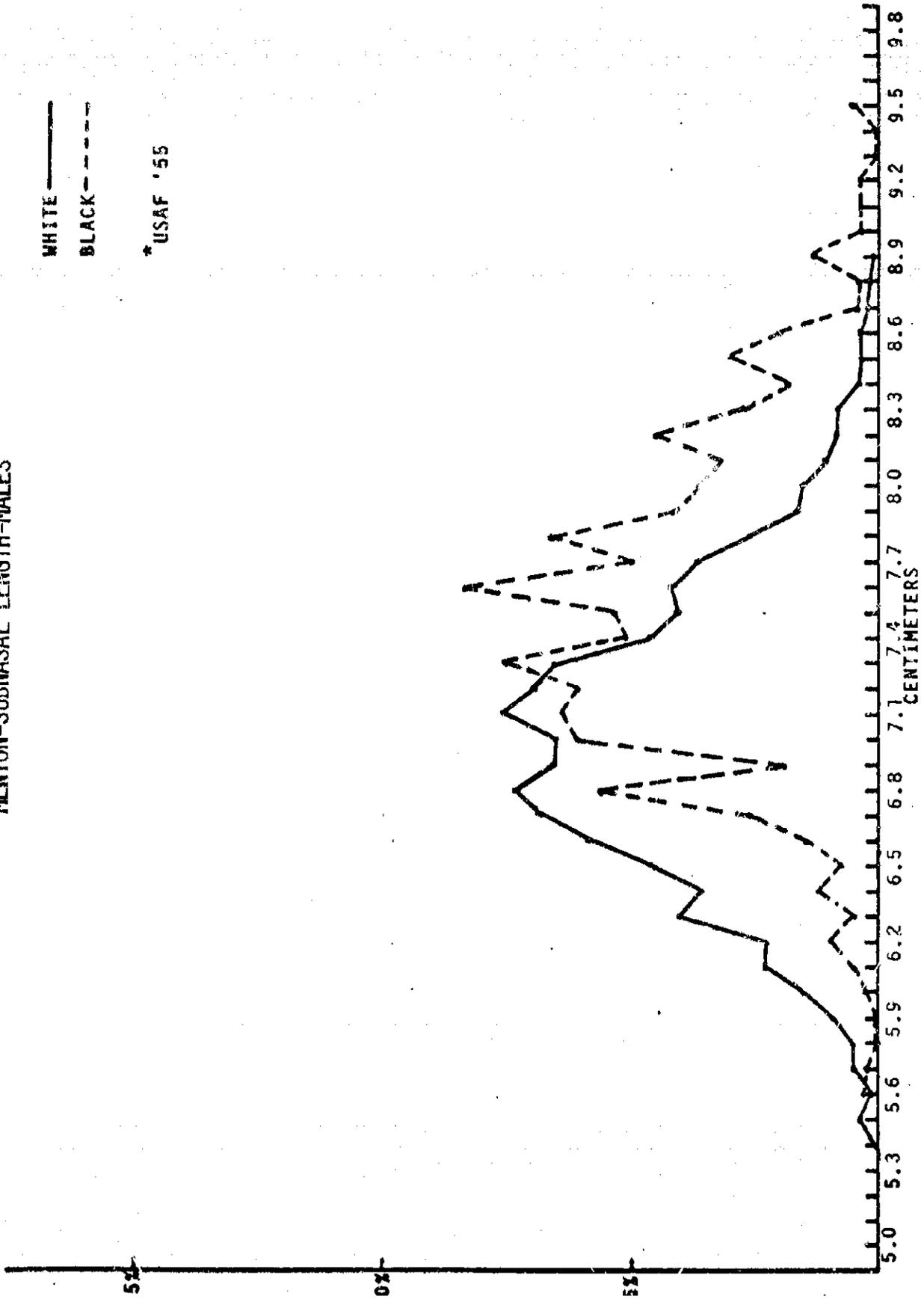
APPENDIX D

MENTON-SUBNASAL LENGTH-MALES*

WHITE ———

BLACK - - - -

* USAF '55



APPENDIX D

COMPARISON OF HEAD AND FACE MEASUREMENTS - Mean (SD)^{*}
- Ethnic Subgroups Drawn from 1965 USAF Data -

	(Male)				
	n=343 Caucasian	n=343 Negro	n=69 Spanish- American	n=16 Puerto Rican	n=7 Oriental
Head Circ	55.77 (1.64)	56.17 (1.59)	55.34 (1.63)	55.02 (0.66)	55.66 (1.59)
Sagittal Arc	37.59 (1.41)	37.95 (1.53)	37.27 (1.47)	36.53 (1.12)	38.13 (2.08)
Min Frontal Arc	11.80 (0.87)	11.89 (0.83)	11.64 (0.82)	11.66 (0.86)	11.96 (1.07)
Bit-Coronal Arc	34.77 (1.30)	34.61 (1.31)	35.00 (1.35)	34.75 (1.18)	35.53 (1.32)
Bit-Min Frontal Arc	30.28 (1.12)	30.45 (1.10)	30.29 (1.26)	30.18 (0.67)	30.79 (0.86)
Bit-Subnasale Arc	28.30 (1.07)	29.09 (1.10)	28.57 (1.38)	28.21 (0.72)	29.27 (1.12)
Bit-Menton Arc	30.87 (1.37)	31.55 (1.35)	31.26 (1.59)	30.57 (1.42)	31.47 (0.98)
Bit-Submandibular Arc	28.63 (1.46)	28.79 (1.49)	29.03 (1.53)	28.23 (1.38)	29.10 (0.43)
Bit-Posterior Arc	24.93 (1.23)	24.84 (1.12)	24.89 (1.29)	24.48 (0.70)	25.27 (0.23)
Head Length	19.53 (0.72)	18.78 (0.69)	19.13 (0.73)	19.03 (0.56)	19.17 (0.78)
Max Head Dia (Menton)	24.95 (0.87)	25.36 (0.80)	25.01 (0.82)	24.70 (0.55)	25.34 (0.87)
Max Head Dia (Nuch)	19.13 (0.79)	19.23 (0.70)	19.13 (0.79)	18.92 (0.54)	19.27 (0.81)
Ear Length	6.25 (0.39)	5.97 (0.41)	6.41 (0.41)	6.00 (0.33)	6.44 (0.37)
Ear Length above Tragon	2.81 (0.29)	2.70 (0.31)	2.93 (0.32)	2.71 (0.24)	2.76 (0.23)
Ear Breadth	3.46 (0.33)	3.44 (0.32)	3.57 (0.32)	3.28 (0.34)	3.44 (0.28)
Ear Protrusion	2.13 (0.30)	1.90 (0.32)	2.16 (0.39)	2.12 (0.24)	2.27 (0.43)
Head Breadth	15.14 (0.59)	15.08 (0.54)	15.28 (0.58)	15.28 (0.44)	15.69 (0.50)
Biauricular Breadth	18.39 (0.92)	17.52 (0.80)	18.51 (0.88)	18.45 (0.80)	19.24 (0.76)
Bitragon Breadth	13.63 (0.62)	13.55 (0.56)	13.83 (0.55)	13.67 (0.50)	14.21 (0.31)
Biszomatic Breadth	13.84 (0.57)	13.86 (0.52)	14.07 (0.49)	13.99 (0.49)	14.47 (0.28)
Max Frontal Dia	11.41 (0.49)	11.52 (0.51)	11.51 (0.47)	11.38 (0.41)	11.54 (0.53)
Bigonial Dia	10.61 (0.50)	10.50 (0.51)	10.81 (0.59)	10.53 (0.38)	11.07 (0.48)
Biocular Dia	9.17 (0.46)	9.69 (0.46)	9.34 (0.49)	9.34 (0.33)	9.63 (0.44)
Interpupillary Dia	6.09 (0.36)	6.45 (0.38)	6.07 (0.33)	6.17 (0.24)	6.46 (0.24)
Interocular Dia	3.12 (0.24)	3.34 (0.29)	3.17 (0.28)	3.13 (0.15)	3.40 (0.14)
Nasal Root Breadth	1.78 (0.23)	1.99 (0.29)	1.82 (0.29)	1.74 (0.26)	1.91 (0.10)
Nasal Breadth	3.24 (0.24)	4.06 (0.34)	3.48 (0.35)	3.38 (0.27)	3.59 (0.16)
Nose Protrusion	2.29 (0.27)	2.07 (0.25)	2.18 (0.29)	2.15 (0.27)	2.09 (0.22)
Philtrum Length	1.40 (0.25)	1.50 (0.24)	1.43 (0.22)	1.47 (0.25)	1.46 (0.15)
Lip-to-Lip Dist	1.80 (0.29)	2.53 (0.36)	1.86 (0.30)	1.99 (0.22)	2.01 (0.23)
Lip Length	4.68 (0.37)	5.09 (0.43)	4.80 (0.39)	4.62 (0.42)	4.97 (0.43)
Lip Length Smiling	5.48 (0.58)	5.86 (0.65)	5.71 (0.62)	5.58 (0.77)	5.97 (0.69)
Menton-Subnasale Length	6.99 (0.53)	7.52 (0.61)	7.04 (0.58)	7.16 (0.57)	7.13 (0.46)
Menton-Nasal Root Dep	11.91 (0.64)	12.24 (0.69)	12.02 (0.69)	12.02 (0.68)	11.87 (0.56)
Subnasale-NRD	5.07 (0.36)	5.00 (0.36)	5.20 (0.37)	5.05 (0.33)	4.91 (0.18)
Vertex-Glabella Height	9.32 (0.76)	9.21 (0.81)	9.17 (0.63)	9.01 (0.50)	9.46 (0.75)
Vertex-NRD Height	10.95 (0.72)	11.02 (0.78)	10.76 (0.68)	10.79 (0.64)	11.47 (0.80)
Vertex Ext Canthus Ht	11.64 (0.63)	11.64 (0.67)	11.51 (0.57)	11.45 (0.53)	12.00 (0.71)
Vertex Pronasale Ht	14.91 (0.83)	14.78 (0.88)	14.92 (0.70)	14.72 (0.55)	15.19 (0.95)
Vertex-Stomion Height	18.24 (0.79)	18.49 (0.90)	18.31 (0.70)	18.06 (0.91)	18.73 (0.87)
Vertex-Menton Height	22.73 (0.90)	23.15 (0.99)	22.75 (0.83)	22.58 (0.74)	23.17 (1.11)
Vertex-Tragon Height	13.22 (0.57)	13.03 (0.60)	13.14 (0.59)	13.13 (0.49)	13.69 (0.62)
Wall-Glabella Dist	19.76 (0.72)	20.01 (0.79)	19.42 (0.75)	19.29 (0.58)	19.38 (0.80)
Wall-NRD Dist	19.53 (0.72)	19.60 (0.67)	19.24 (0.76)	19.09 (0.59)	19.11 (0.80)
Wall-Ext Canthus Dist	17.01 (0.70)	17.38 (0.68)	16.85 (0.72)	16.58 (0.63)	17.16 (0.60)
Wall-Pronasale Dist	21.81 (0.81)	22.02 (0.74)	21.65 (0.82)	21.39 (0.60)	21.26 (1.11)
Wall-Stomion Dist	20.33 (0.84)	21.29 (0.81)	20.40 (0.80)	20.17 (0.66)	20.24 (0.95)
Wall-Menton Dist	18.41 (1.07)	18.58 (1.01)	18.37 (1.01)	18.14 (0.78)	17.90 (1.68)
Wall-Tragon Dist	9.55 (0.61)	9.72 (0.62)	9.27 (0.70)	9.16 (0.60)	9.01 (0.79)
Age	19.97 (1.10)	19.07 (1.11)	19.33 (1.18)	19.07 (1.24)	18.57 (0.73)
Height	175.17 (6.86)	175.05 (6.57)	170.57 (6.37)	171.99 (5.52)	170.67 (8.60)
Weight	150.10 (23.9)	150.00 (20.2)	145.67 (22.01)	141.06 (18.40)	144.00 (18.50)

^{*} In Centimeters

Age in years
Wt. in pounds

APPENDIX D

COMPARISON OF HEAD AND FACE MEASUREMENTS - 1 and 2

- Ethnic Subgroups Drawn From 1965 USAF Data -

	Negro		Span/Amer		Puerto Rican		Oriental	
	AW-M	% N/W	AW-S	% SA/W	AW-PR	% PR/W	AW-O	% O/W
Head Circ	-.40	100.72	.43	99.23	.75	98.66	.11	99.80
Sagittal Arc	.04	99.89	.32	99.15	1.06	97.18	-.54	101.44
Min-Frontal Arc	-.09	100.76	.16	98.64	.14	98.81	-.38	101.36
Bit-Coronal Arc	.16	99.54	-.23	100.66	.02	99.94	-.76	102.19
Bit-Min Front Arc	-.17	100.56	-.08	99.74	.10	99.67	-.42	101.38
Bit-Subnasale Arc	-.79	102.79	-.97	102.01	.09	99.63	-.87	103.43
Bit-Menton Arc	-.68	102.20	-.39	101.26	.30	99.03	-.60	101.94
Bit-Submandibular Arc	-.16	100.56	-.40	101.40	.40	98.60	-.47	101.64
Bit-Posterior Arc	.09	99.64	.04	99.84	.43	98.19	-.34	101.36
Head Length	-.25	101.28	.40	97.95	.50	97.44	.36	98.16
Head Max Dia (Ment)	-.41	101.64	-.06	100.24	.25	98.00	-.39	101.96
Head Max Dia (Nuch)	-.04	100.31	.06	99.89	.27	98.59	-.08	100.42
Ear Length	.28	95.52	-.16	102.56	.25	98.00	-.19	101.04
Ear Length above Tragon	.11	96.08	-.12	104.27	.10	96.44	.05	98.22
Ear Breadth	.02	95.42	-.11	103.18	.18	98.80	.02	99.42
Ear Protrusion	.23	89.20	-.03	101.41	.01	99.53	-.14	106.57
Head Breadth	.06	99.60	-.14	100.92	-.14	100.92	-.55	103.63
Biauricular Breadth	.87	95.27	-.12	100.65	-.06	100.33	-.85	104.62
Bitragon Breadth	.07	99.49	-.20	101.47	-.04	100.29	-.58	104.26
Bizygomatic Breadth	-.02	100.14	-.23	101.66	-.15	101.08	-.63	104.55
Max Frontal Dia	-.11	100.96	-.10	100.88	.03	99.74	-.13	101.39
Bigonial Dia	.11	98.96	-.20	101.89	.08	99.25	-.46	104.34
Biocular Dia	-.52	105.67	-.17	101.85	-.17	101.85	-.46	105.02
Interpupillary Dia	-.36	105.91	.02	99.67	-.08	101.31	-.37	106.08
Interocular Dia	-.22	107.05	-.05	101.60	-.01	100.32	-.28	108.97
Nasal Root Breadth	-.21	111.80	-.34	102.35	.04	97.75	-.13	107.30
Nasal Breadth	-.82	125.31	-.24	107.41	-.14	104.32	-.35	110.80
Nose Protrusion	.22	90.39	.11	95.20	.14	93.49	.20	91.27
Philtrum Length	-.10	107.14	-.03	102.14	-.07	105.00	-.06	104.29
Lip-to-Lip Dist	-.73	140.56	-.16	108.89	-.19	110.55	-.21	111.67
Lip Length	-.41	108.76	-.12	102.56	.06	98.72	-.29	106.20
Lip Length Smiling	-.38	106.93	-.23	104.20	-.10	101.82	-.49	108.94
Menton-Subnasale Lgth	-.53	107.58	-.05	100.72	-.17	102.43	-.13	102.00
Menton-Nasal Root Dep	-.33	102.77	-.11	100.92	-.11	100.92	.04	99.66
Subnasale-Nasal Root Dep	.07	98.62	-.13	102.56	.02	99.61	.16	96.84
Vertex-Glabella Height	.11	98.82	.15	98.39	.31	96.67	-.04	103.65
Vertex-NRD Height	-.07	100.64	.19	98.26	.17	98.45	-.52	104.75
Vertex-Ext Canthus Hgt	-.00	100.00	.11	99.05	.19	98.37	-.36	103.09
Vertex-Pronasale Height	.13	99.13	-.01	100.07	.19	98.73	-.28	101.88
Vertex-Stomion Height	-.25	101.37	-.07	100.34	.18	99.01	-.40	102.53
Vertex-Menton Height	-.42	101.85	-.02	100.09	.15	99.34	-.44	101.94
Vertex-Tragon Height	.19	98.56	.08	99.39	.09	99.32	-.47	103.56
Wall-Glabella Dist	-.25	101.27	.14	98.28	.47	97.62	.37	98.13
Wall-NRD Dist	-.15	100.77	.29	98.51	.44	97.75	.42	97.85
Wall-Ext Canthus Dist	-.37	102.18	.16	99.06	.42	97.53	-.15	100.88
Wall-Pronasale Dist	-.21	100.96	.16	99.27	.42	98.07	.55	97.48
Wall-Stomion Dist	-.96	104.72	-.07	100.34	.16	99.21	.09	99.56
Wall-Menton Dist	-.17	100.92	.04	99.78	.22	98.75	.51	97.23
Wall-Tragon Dist	-.10	101.88	.20	97.07	.39	95.92	.52	94.55
Age	---	100.00	-.26	101.33	---	100.00	.50	97.39
Height	.13	99.93	4.60	97.37	3.18	98.18	4.50	97.43
Weight	-.70	100.47	4.43	97.05	9.04	93.98	6.10	95.94

* In Centimeters

Age in years

Wt. in pounds

APPENDIX B

Intercorrelation Matrix - Dimensions
of the Head and Face*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1 HEAD CIRCUMFERENCE																									
2 SAGITTAL CHV/TRION	.470																								
3 MENTUM-FRONTAL CV	.180																								
4 MENTUM-FRONTAL CV	.279	.180																							
5 VERTX-FRONTAL CV	.562	.241																							
6 VERTX-FRONTAL CV	.667	.225	.451																						
7 VERTX-FRONTAL CV	.487	.265	.335																						
8 VERTX-FRONTAL CV	.481	.186	.274																						
9 VERTX-FRONTAL CV	.363	.148	.237	.123																					
10 HEAD HEIGHT	.775	.427	.359	.255	.488	.370	.354	.331	.410																
11 MAX HD DLNG/MENTUM	.586	.450	.225	.159	.388	.395	.587	.389	.278	.552															
12 MAX HD DLNG/INION	.486	.000	.163	.243	.335	.261	.267	.123	.403	.588	.385														
13 EAR BREADTH	.158	.068	.676	.621	.677	.200	.226	.215	.082	.111	.116	.070													
14 EAR LENGTH	.215	.006	.102	.653	.194	.247	.314	.289	.251	.163	.200	.212	.413												
15 EAR L ARVE TRAGION	.123	.044	.023	.027	.089	.126	.144	.046	.087	.127	.096	.135	.404	.486											
16 HEAD BREADTH	.523	.176	.231	.567	.427	.300	.271	.258	.206	.059	.243	.035	.116	.131	.031										
17 MAXIMUM FRONTAL BR	.386	.105	.261	.324	.544	.473	.403	.208	.118	.147	.253	.090	.063	.159	.089	.450									
18 BIPROGONIAL BREADTH	.426	.023	.233	.281	.404	.478	.469	.420	.244	.127	.213	.183	.313	.288	.146	.623	.464								
19 BIPROGONIAL BR-DTH	.468	.086	.281	.377	.568	.577	.523	.459	.233	.143	.270	.246	.133	.143	.270	.094	.661	.828							
20 BICOMIAL BREADTH	.295	.637	.170	.266	.371	.362	.378	.320	.224	.140	.188	.268	.010	.218	.098	.326	.449	.450	.548						
21 EAR-TO-EAR BREADTH	.319	.032	.098	.272	.274	.236	.238	.227	.329	.104	.185	.155	.209	.321	.192	.465	.316	.519	.492	.351					
22 BUCULAR BREADTH	.264	.374	.385	.683	.332	.402	.287	.253	.082	.122	.190	.146	.128	.065	.060	.277	.449	.226	.356	.081	.126				
23 INFRAOCCIPITAL BRD	.250	.174	.325	.151	.390	.359	.246	.211	.028	.174	.164	.045	.098	.108	.100	.264	.495	.272	.367	.215	.177	.712			
24 INTEROCULAR BR-DTH	.257	.021	.334	.171	.341	.276	.301	.143	.099	.187	.122	.153	.078	.380	.056	.211	.363	.251	.301	.168	.163	.383	.659		
25 NASAL BREADTH	.246	.304	.129	.125	.256	.324	.345	.214	.163	.195	.205	.250	.129	.218	.144	.200	.108	.151	.270	.264	.232	.152	.144	.245	.292
26 LIP LENGTH	.050	.001	.004	.030	.067	.103	.102	.112	.138	.009	.056	.023	.196	.236	.034	.071	.071	.123	.126	.009	.677	.087	.167	.175	.073
27 EAR PROTRUSION	.172	.023	.036	.095	.142	.144	.151	.119	.124	.132	.170	.280	.169	.221	.146	.110	.051	.208	.145	.027	.167	.026	.032	.083	.043
28 SUBNASALE-NASAL FT	.135	.183	.068	.016	.148	.194	.187	.228	.023	.111	.162	.039	.109	.177	.075	.096	.118	.081	.149	.027	.081	.265	.162	.038	.045
29 PHILLARUM LENGTH	.021	.019	.030	.072	.007	.050	.082	.080	.024	.035	.088	.023	.082	.108	.025	.104	.003	.145	.133	.068	.72	.006	.019	.045	.045
30 LIP-TO-LIP HEIGHT	.227	.171	.132	.178	.215	.132	.253	.201	.111	.235	.409	.110	.056	.101	.023	.071	.116	.072	.113	.003	.075	.161	.118	.085	.085
31 MENTUM-SUBNASALE	.316	.119	.152	.223	.291	.183	.327	.255	.159	.289	.479	.263	.136	.210	.094	.150	.149	.194	.207	.036	.183	.117	.114	.123	.123
32 MENTUM-NASAL WOT	.157	.375	.083	.446	.134	.034	.085	.146	.044	.124	.257	.011	.112	.078	.011	.093	.065	.114	.029	.073	.013	.081	.042	.019	.019
33 VERTX-NASAL WOT	.256	.370	.110	.398	.255	.023	.068	.057	.031	.190	.361	.071	.077	.012	.005	.175	.120	.042	.045	.091	.051	.113	.082	.033	.033
34 VERTX-EXT CANTHUS	.242	.337	.082	.447	.253	.021	.010	.077	.008	.203	.317	.083	.045	.011	.030	.139	.114	.037	.046	.088	.056	.112	.077	.000	.000
35 VERTX-FRONSALLE	.271	.348	.091	.488	.282	.054	.018	.052	.033	.224	.357	.107	.049	.019	.044	.158	.142	.020	.068	.106	.067	.113	.091	.017	.017
36 VERTX-STOMION HGT	.300	.351	.099	.497	.312	.090	.054	.009	.038	.261	.407	.138	.034	.054	.047	.154	.158	.007	.082	.110	.082	.131	.108	.033	.033
37 VERTX-STOMION HGT	.367	.376	.153	.529	.351	.127	.181	.079	.109	.322	.552	.180	.307	.079	.054	.186	.044	.127	.102	.111	.156	.129	.078	.078	.078
38 VERTX-TRAGION HGT	.375	.368	.149	.697	.357	.082	.035	.014	.096	.237	.435	.147	.045	.027	.024	.254	.141	.062	.143	.088	.121	.121	.109	.109	.109
39 VERTX-TRAGION HGT	.767	.475	.295	.273	.483	.393	.368	.236	.387	.929	.577	.537	.103	.144	.128	.070	.158	.110	.133	.134	.083	.179	.194	.181	.181
40 WALL-NASAL ROOT LG	.628	.325	.174	.160	.298	.298	.301	.238	.511	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455
41 WALL-EXT-L CANTHUS	.628	.325	.174	.160	.298	.298	.301	.238	.511	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455	.455
42 WALL-FRONSALLE LGH	.566	.274	.195	.622	.263	.454	.428	.332	.352	.736	.492	.573	.187	.322	.159	.040	.117	.176	.137	.117	.110	.112	.138	.140	.140
43 WALL-SUBNASALE LGH	.566	.274	.195	.622	.263	.454	.428	.332	.352	.736	.492	.573	.187	.322	.159	.040	.117	.176	.137	.117	.110	.112	.138	.140	.140
44 WALL-TO-LIP LENGTH	.523	.241	.198	.971	.240	.448	.460	.358	.344	.628	.463	.469	.157	.144	.113	.011	.096	.163	.116	.096	.064	.096	.120	.142	.142
45 WALL-TO-CHIN L-CHN	.448	.174	.166	.835	.198	.415	.534	.406	.295	.490	.430	.382	.172	.199	.105	.069	.110	.233	.178	.135	.108	.071	.099	.120	.120
46 WALL-TRAGION L-CHN	.417	.255	.076	.042	.040	.003	.097	.126	.379	.531	.321	.331	.074	.071	.057	.015	.070	.321	.050	.026	.046	.038	.024	.024	.024

APPENDIX E

Intercorrelation Matrix - Dimensions
of the Head and Face*

25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48		
1	HEAD CIRCUMFERENCE	.257	.246	.050	.172	.139	-.021	.227	.316	.157	.214	.266	.242	.271	.300	.367	.375	.767	.745	.628	.614	.566	.527	.448	.417
2	SMELLING CREW/INCH	-.007	-.004	-.001	-.028	-.183	-.019	.173	.119	.374	.357	.370	.337	.348	.351	.376	.365	.475	.447	.325	.302	.274	.241	.174	.255
3	MIDLINE PONTAL CV	.154	.119	-.004	.030	.048	-.630	.138	.352	.093	.080	.110	.082	.091	.099	.153	.149	.295	.270	.174	.219	.195	.188	.166	.076
4	STRONG-FORMAL CV	.133	.135	.030	.095	.016	.072	.178	.221	.446	.452	.529	.489	.491	.529	.567	.493	.624	.610	.460	.416	.382	.271	.035	.040
5	STRONG-SUBNASAL CV	.230	.240	.057	.142	.146	.007	.325	.261	.154	.249	.255	.253	.312	.351	.383	.385	.298	.238	.119	.263	.240	.198	.040	.040
6	STRONG-SUBNASAL CV	.238	.234	.103	.141	.154	.050	.383	.329	.323	.321	.324	.354	.390	.427	.462	.393	.385	.298	.152	.451	.454	.448	.416	.093
7	STRONG-SUBNASAL CV	.241	.245	.102	.151	.187	.042	.323	.327	.325	.327	.328	.354	.381	.415	.454	.388	.384	.301	.151	.424	.428	.460	.534	.097
8	STRONG-SUBNASAL CV	.241	.245	.102	.151	.187	.042	.323	.327	.325	.327	.328	.354	.381	.415	.454	.388	.384	.301	.151	.424	.428	.460	.534	.097
9	STRONG-SUBNASAL CV	.241	.245	.102	.151	.187	.042	.323	.327	.325	.327	.328	.354	.381	.415	.454	.388	.384	.301	.151	.424	.428	.460	.534	.097
10	HEAD LENGTH	.189	.185	.009	.132	.111	.035	.235	.289	.124	.178	.159	.203	.281	.322	.377	.329	.398	.378	.332	.372	.353	.344	.296	.379
11	MAX HD DIAG/MENTON	.189	.205	.056	.170	.162	.088	.409	.479	.257	.305	.361	.317	.357	.407	.552	.435	.577	.561	.455	.492	.465	.463	.430	.321
12	MAX HD DIAG/MENTON	.218	.220	.023	.280	.039	.023	.110	.263	.011	.031	.071	.083	.107	.138	.180	.147	.537	.556	.487	.573	.520	.469	.382	.331
13	EAR BREADTH	.174	.129	.196	.169	.109	-.082	.056	.136	.112	-.083	-.077	-.045	-.049	-.034	-.007	-.045	.603	.613	.089	.187	.158	.157	.172	.074
14	EAR LENGTH	.206	.218	.236	.221	.177	.108	.101	.210	.078	.045	-.012	.011	.019	.054	.079	.027	.144	.150	.139	.228	.192	.184	.199	.071
15	EAR L ARYE TRAGION	.108	.132	.034	.146	.075	-.025	.023	.034	-.011	-.061	-.065	-.040	-.044	-.054	-.024	.128	.135	.082	.159	.129	.113	.106	.057	
16	HEAD BREADTH	.151	.126	.071	.120	.096	-.294	.071	.150	.093	.125	.175	.139	.158	.154	.190	.294	.070	.056	.043	.040	.013	.011	.069	.015
17	MAXIMUM PONTAL BR	.215	.233	.071	.051	.118	-.003	.116	.149	.065	.111	.120	.114	.142	.158	.126	.141	.158	.140	.072	.117	.091	.096	.110	.070
18	STRONG BREADTH	.270	.241	.223	.208	.081	.145	.072	.194	.114	.063	.042	-.037	.020	-.007	.044	.062	.110	.101	.110	.176	.157	.163	.233	.021
19	BIYOGNATHIC BR-DTH	.244	.243	.125	.145	.149	.133	.113	.207	.029	.021	.048	-.046	.068	.082	.127	.143	.133	.119	.093	.137	.109	.116	.178	.050
20	BIYOGNATHIC BREADTH	.232	.237	.009	.027	.027	-.068	-.043	.036	.073	.093	.091	.083	.106	.110	.102	.088	.134	.122	.109	.117	.095	.096	.136	.024
21	EAR-TO-EAR BREADTH	.152	.157	.677	.167	.081	.072	.075	.182	.111	.026	.051	-.056	.062	.082	.111	.121	.083	.081	.089	.110	.076	.064	.108	.046
22	BIYOCULAR BREADTH	.144	.073	.687	.026	.269	.006	.161	.117	.081	.102	.113	.112	.113	.131	.156	.121	.170	.154	.057	.112	.093	.096	.071	.038
23	INTERPUPILLARY END	.245	.167	.072	.032	.162	.019	.118	.114	.042	.077	.082	.077	.091	.108	.129	.109	.194	.182	.095	.138	.119	.120	.099	.024
24	INTEROCULAR BR-DTH	.292	.175	.073	.332	.038	.045	.085	.123	.019	.014	.033	-.000	.017	.033	.070	.085	.181	.174	.086	.140	.133	.141	.120	.022
25	MASAL BREADTH	.437	.042	.029	.138	.010	.054	.050	.058	.021	-.035	-.041	-.033	-.012	.011	.016	.182	.165	.161	.194	.203	.261	.263	.083	
26	LIP LENGTH	.437	.018	.075	.003	.036	-.049	.010	.030	-.009	.002	-.002	.007	.010	.012	.004	.182	.180	.147	.224	.213	.238	.255	.937	
27	EAR PROTRUSION	.042	.013	.009	.013	.020	.061	.106	.027	.005	-.016	.005	.002	.020	.031	.006	.006	.002	.014	.028	.020	.015	.034	.011	
28	SUBNASAL-MASAL XT	.029	.025	.099	.039	.020	.064	.071	.328	.156	.122	.045	.112	.143	.138	.172	.056	.093	.158	.125	.203	.201	.118	.077	.098
29	PHILTRUM LENGTH	.138	.063	.113	.023	.024	.121	.473	.335	.032	.026	.009	-.012	.018	.128	.170	.034	.112	.105	.132	.203	.201	.118	.038	.071
30	LIP-TO-LIP WEIGHT	.010	-.036	-.020	-.064	-.121	.326	.223	.030	.097	.057	.076	.159	.215	.082	.053	.037	.625	.902	.035	.091	.116	.038	.039	.039
31	MENTON-SUBNASAL	.054	.048	.061	.071	.473	.326	.788	.052	.066	.091	.084	.100	.248	.492	.172	.329	.217	.196	.175	.173	.182	.935	.144	
32	MENTON-MASAL BOOT	.453	.010	.106	.538	.335	.223	.788	.032	.031	.058	.145	.174	.287	.518	.184	.266	.296	.243	.307	.240	.207	.089	.171	
33	VERTEX-CHANELIA XT	.058	.010	.025	.133	.032	.030	.052	.032	.032	.947	.890	.860	.719	.852	.748	.650	.574	.009	-.094	-.242	.320	.365	.457	.168
34	VERTEX-MASAL BOOT	.021	.009	.005	.122	.025	.031	.046	.011	.047	.909	.909	.913	.888	.785	.663	.226	.156	-.059	.131	.298	.343	.440	.160	
35	VERTEX-ENT CANTRUS	.031	.002	.016	.045	.005	.097	.021	.059	.880	.900	.863	.877	.867	.730	.893	.240	.162	-.035	.151	.223	.269	.560	.123	
36	VERTEL-PHOSASAL	.041	.002	.005	.112	.012	.057	.084	.045	.880	.909	.863	.871	.871	.871	.871	.871	.871	.871	.871	.871	.871	.871	.871	
37	VERTEL-SUBNASAL	.033	.007	.002	.143	.018	.076	.100	.074	.879	.913	.877	.971	.971	.971	.971	.971	.971	.971	.971	.971	.971	.971	.971	
38	VERTEL-STOMION MGT	.012	.010	.020	.138	.128	.159	.248	.287	.852	.888	.857	.935	.935	.935	.935	.935	.935	.935	.935	.935	.935	.935	.935	
39	VERTEL-MENTON MGT	.011	.012	.031	.172	.170	.215	.492	.518	.748	.785	.780	.860	.860	.860	.860	.860	.860	.860	.860	.860	.860	.860	.860	
40	VERTEL-TRAGION MGT	.016	.004	.066	.056	.034	.082	.172	.184	.650	.683	.693	.628	.658	.668	.660	.660	.660	.660	.660	.660	.660	.660	.660	
41	WALL-CLABELIA LGTH	.182	.182	.006	.093	.112	.059	.529	.266	.174	.256	.340	.240	.265	.297	.351	.271	.962	.784	.758	.708	.651	.489	.571	
42	WALL-MASAL BOOT LG	.165	.180	.002	.158	.105	.037	.217	.296	.089	.126	.158	.185	.219	.282	.229	.962	.801	.822	.771	.710	.559	.594	.800	
43	WALL-ENT-L CANTRUS	.161	.147	.014	.125	.132	.025	.296	.443	.094	.059	.052	.021	.024	.104	.099	.784	.501	.776	.785	.733	.610	.800	.800	
44	WALL-PHOSASAL LGH	.203	.214	.026	.293	.093	.002	.175	.307	.252	.233	.151	.188	.149	.103	.004	.032	.758	.822	.776	.765	.943	.956	.837	.833
45	WALL-SUBNASAL LGH	.203	.213	.026	.201	.110	.035	.273	.340	.320	.298	.223	.301	.260	.204	.095	.014	.708	.771	.765	.943	.956	.837	.833	
46	WALL-TO-LIP LENGTH	.241	.238	.015	.118	.111	.091	.182	.209	.345	.349	.369	.348	.334	.271	.149	.047	.651	.710	.733	.891	.956	.881	.835	
47	WALL-TO-CHIN L-GTH	.243	.255	.034	.077	.038	.116	.033	.089	.457	.440	.468	.471	.448	.433	.302	.118	.499	.559	.610	.772	.837	.881	.553	
48	WALL-TRAGION L-GTH	.083	.093	.011	.098	.071	.039	.144	.171	.168	.160	.123	.161	.144	.110	.029	.010	.571	.594	.800	.633	.650	.635	.553	

*USAF 1967 Data

APPENDIX F

A BIVARIATE FREQUENCY TABLE FOR FACE LENGTH *
AND FACE BREADTH (Combined USAF 1947 and WAF 1948)

Face Length	Face Breadth																											
	108.5	110.5	112.5	114.5	116.5	118.5	120.5	122.5	124.5	126.5	128.5	130.5	132.5	134.5	136.5	138.5	140.5	142.5	144.5	146.5	148.5	150.5	152.5	154.5	156.5	158.5		
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* All values in millimeters

APPENDIX G

Face Length Sizing Programs - Male
Direct Computation Method

RESULTS FOR 2-SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 2386, CONSTITUTING 98.60% OF TOTAL SAMPLE

SIZE NO. 1 RANGE = 105.50- 121.50 N = 1229 = 51.34 % OF SYSTEM = 80.02 % OF POPULATION
 SIZE NO. 2 RANGE = 121.50- 135.50 N = 1161 = 48.66 % OF SYSTEM = 47.98 % OF POPULATION

G-2

		S.D.	MEAN #1	MEAN #2
1	1 AGE	6.27	29.43	34.64
2	2 HEIGHT	21.07	169.83	177.67
3	13 HEIGHT (STATURE)	60.07	1760.36	1787.24
4	141 HEAD CIRCUMFERENCE	17.76	571.68	578.83
5	142 SAGITTAL ARCH/INTION	15.45	344.92	348.00
6	143 MINIMUM FRONTAL ARC	7.78	135.12	136.88
7	144 BIPAGION-CORONAL	12.78	355.40	359.77
8	145 BIPAGION-MENTON	7.63	385.99	310.14
9	146 BIPAGION-SUBNASALE	10.07	291.81	294.74
10	147 BIPAGION-MENTON	11.84	227.24	329.81
11	148 BIP-SUBMANDIBULAR	15.42	206.74	312.93
12	149 BIPAGION-POSTERIOR	10.89	292.78	296.31
13	150 HEAD LENGTH	6.54	197.27	200.17
14	151 HEAD DIAGONAL-MENTON	6.97	263.24	258.94
15	152 HEAD DIAGONAL-NOSE	9.87	217.20	231.65
16	153 EAR BREADTH	2.97	77.64	78.70
17	154 EAR LENGTH	4.18	65.28	66.64
18	155 EAR ABOVE TRAGION	2.92	29.16	29.58
19	156 HEAD BREADTH	6.38	165.32	156.74
20	157 MAXIMUM FRONTAL OR	4.51	115.47	116.60
21	158 BIPAGION BREADTH	4.46	141.56	143.63
22	159 BIZYGOMATIC BREADTH	5.05	141.31	143.23
23	160 BIGNITAL BREADTH	6.91	117.17	117.53
24	161 EAR-TO-EAR BREADTH	2.96	107.01	104.64
25	162 BICOCLAR BREADTH	4.82	91.25	92.18
26	163 INTERPUPILLARY OR	7.80	62.32	63.01
27	164 INTEROCULAR BREADTH	2.76	33.06	33.63
28	165 NOSE BREADTH	2.94	35.28	36.57
29	166 LIP LENGTH	7.78	52.20	52.30
30	167 EAR PROTRUSION	3.46	21.38	21.91
31	168 SUBNASALE-NASAL BT	3.33	49.47	52.58
32	169 PALATUM LENGTH	2.65	14.78	16.26
33	170 LIP-TO-LIP LENGTH	2.79	16.68	18.94
34	171 MENTON-SUBNASALE L	3.49	65.46	72.26
35	172 MENTON-NASAL ROOT	3.37	115.72	125.06
36	173 GLABELLA-TO-VERTEX	2.72	93.01	92.46
37	174 NASAL ROOT-TO-VRTX	2.69	107.57	107.34
38	175 XTAL CANTHUS-VRTX	2.70	119.19	119.81
39	176 PRONASALE-TO-VRTX	12.05	146.22	168.63
40	177 SUBNASALE-TO-VRTX	10.15	159.53	162.26
41	178 STATION-TO-VRTX	2.72	191.81	185.84
42	179 MENTON-TO-VRTX	2.27	227.71	231.86
43	180 TRAGION-TO-VRTX	6.82	132.99	135.36
44	181 GLABELLA-TO-HALL	6.56	202.17	204.87
45	182 NASAL ROOT-TO-HALL	6.75	200.24	203.15
46	183 XTAL CANTHUS-HALL	6.45	176.66	179.15
47	184 PRONASALE-TO-HALL	2.25	225.04	228.61
48	185 SUBNASALE-TO-HALL	7.88	208.42	211.45
49	186 LIP PROMINENCE-HALL	8.47	210.24	213.05
50	187 CHIN PROMINENCE-HALL	10.42	233.97	205.57
51	188 TRAGION-TO-HALL	6.43	102.54	104.20

RESULTS FOR 3-SYSTEM (SPECT COMPUTATION)

NUMBER IN SYSTEM = 2418, CONSTITUTING 99.59% OF TOTAL SAMPLE

SIZE NO. 1 RANGE = 101.50- 113.50 N = 312. = 12.94 % OF SYSTEM = 12.93 % OF POPULATION
 SIZE NO. 2 RANGE = 113.50- 125.50 N = 1647. = 68.17 % OF SYSTEM = 67.89 % OF POPULATION
 SIZE NO. 3 RANGE = 125.50- 137.50 N = 454. = 18.84 % OF SYSTEM = 18.76 % OF POPULATION

C-3

			S.D.	MEAN +1	MEAN +2	MEAN +3
1	1	AGE	6.28	29.34	29.81	31.27
2	2	HEIGHT	21.87	167.27	172.51	181.84
3	13	WEIGHT (STATURE)	60.25	1747.66	1771.57	1797.15
4	141	HEAD CIRCUMFERENCE	13.74	568.67	574.48	581.97
5	142	SAGITTAL ARC/MENTON	16.50	343.34	346.15	349.28
6	143	MINIMUM FRONTAL ARC	7.77	174.37	135.73	137.97
7	144	BITRAGION-CORONAL	12.38	353.51	357.18	361.65
8	145	BITRAGION-MIN FRONTAL	9.61	303.51	307.73	312.08
9	146	BITRAGION-SUPRNASALE	10.11	290.28	292.90	295.60
10	147	BITRAGION-MENTON	11.87	320.65	325.90	332.48
11	148	BIT-SUPRMANDIBULAR	15.36	304.04	309.05	316.24
12	149	BITRAGION-POSTERIOR	14.79	291.58	293.89	298.73
13	150	HEAD LENGTH	6.52	195.92	198.40	201.60
14	151	HEAD DIAGONL/MENTON	6.92	250.38	256.52	261.26
15	152	NO DIAG/INION-NOSE	9.89	215.82	218.90	223.38
16	153	EAR BREADTH	2.98	37.44	37.49	38.52
17	154	EAR LENGTH	4.19	64.58	65.86	67.20
18	155	EAR L ARCV TRAGION	2.92	28.97	29.36	29.66
19	156	HEAR BREADTH	5.29	154.81	155.91	157.17
20	157	MAXIMUM FRONTAL OP	6.52	115.05	115.91	117.06
21	158	BITRAGION BREADTH	5.50	141.42	142.27	144.13
22	159	BIZYGOMATIC BREADTH	5.09	140.98	142.04	143.84
23	160	BISONIAL BREADTH	5.91	117.19	117.25	117.66
24	161	EAR-TO-EAR BREADTH	7.98	146.41	148.91	150.67
25	162	BIOCHLAR BREADTH	4.82	90.75	91.65	92.53
26	163	INTERPUPILLARY BRO	3.61	62.05	62.67	63.18
27	164	INTEROCULAR BREADTH	2.76	32.81	33.25	33.76
28	165	NOSE BREADTH	2.93	35.29	35.39	35.65
29	166	LIP LENGTH	3.74	52.47	52.24	52.44
30	167	EAR PROTRUSION	3.25	21.11	21.59	22.18
31	168	SUPRNASALE-NASAL RT	3.31	48.04	51.19	53.95
32	169	PHILLTUM LENGTH	2.65	14.13	15.42	16.75
33	170	LIP-TO-LIP LENGTH	3.77	15.82	17.30	18.52
34	171	MENTON-SUPRNASALE L	3.86	62.49	68.55	74.90
35	172	MENTON-NASAL ROOT	3.07	110.58	119.74	128.28
36	173	GLABELLA-TO-VERTEX	9.70	92.69	92.99	91.93
37	174	NASAL ROOT-TO-VERTEX	3.29	107.28	107.63	106.96
38	175	XYPHL GAMBHUD-VERTEX	7.10	118.56	119.58	119.07
39	176	PRONASALE-TO-VERTEX	10.92	144.21	147.54	149.06
40	177	TO-NASALE-TO-VERTEX	10.14	157.54	160.93	162.85
41	178	STOMION-TO-VERTEX	9.68	178.64	183.59	187.13
42	179	MENTON-TO-VERTEX	9.17	219.02	227.33	234.81
43	180	TRAGION-TO-VERTEX	6.96	132.81	136.31	138.09
44	181	GLABELLA-TO-WALL	6.55	206.70	203.28	206.05
45	182	NASAL ROOT-TO-WALL	6.35	198.75	201.42	204.48
46	183	XYPHL GAMBHUD-WALL	6.45	175.64	177.59	180.36
47	184	PRONASALE-TO-WALL	7.24	227.18	226.51	230.16
48	185	SUPRNASALE-TO-WALL	7.68	247.15	249.60	212.75
49	186	LIP PROMINENCE-WALL	8.42	219.21	211.26	214.44
50	187	CHIL PROMINENCE-WALL	10.41	204.10	206.30	206.75
51	188	TRAGION-TO-WALL	6.41	101.82	103.12	105.19

RESULTS FOR 4-SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 2408, CONSTITUTING 99.50% OF TOTAL SAMPLE

SIZE NO.	RANGE	N	% OF SYSTEM	% OF POPULATION
1	103.50- 112.50	227	9.43	9.38
2	112.50- 121.50	1160	48.17	47.93
3	121.50- 130.50	912	38.00	37.81
4	130.50- 139.50	106	4.40	4.38

		S.D.	MEAN +1	MEAN +2	MEAN +3	MEAN +4	
1	1	AGE	5.27	29.26	29.44	30.79	31.40
2	2	WEIGHT	29.91	165.92	170.54	178.37	183.14
3	13	HEIGHT (STATURE)	59.65	1743.99	1764.54	1787.77	1809.82
4	141	HEAD CIRCUMFERENCE	13.66	169.06	172.91	179.03	184.66
5	142	SAGITTAL ARCH/INTON	16.48	243.98	245.25	248.05	259.11
6	143	MINIMUM FRONTL APC	7.79	134.31	135.36	136.91	138.54
7	144	BITRAGION-CORONAL	12.32	253.67	255.91	259.86	264.35
8	145	BITRAGN-MIN FRONTAL	9.58	262.47	266.62	270.33	273.75
9	146	BITRAGN-SUPNASALE	19.08	290.06	292.02	295.00	295.29
10	147	BITRAGION-MENTON	11.76	219.92	224.23	230.04	234.20
11	148	BIT-SUBMANDIBULAR	15.37	203.53	207.61	213.26	217.47
12	149	BITRAGN-POSTERIOR	14.74	292.07	292.73	296.69	301.03
13	150	HEAD LENGTH	6.50*	195.95	197.63	200.27	202.91
14	151	HEAD DIAGON/MENTON	6.75	249.91	254.12	259.02	264.13
15	152	HC DIAGON/NOSE	9.83	215.42	217.78	221.78	224.41
16	153	EAR BREADTH	2.97	77.37	77.59	78.37	78.91
17	154	EAR LENGTH	4.15	64.33	65.46	66.77	67.88
18	155	EAR L ARCS TRAGION	2.91	28.93	29.18	29.65	29.99
19	156	HEAD BREADTH	6.38	154.89	155.45	156.93	156.58
20	157	MAXIMUM FRONTAL OR	6.59	114.96	115.57	116.83	116.42
21	158	BITRAGION BREADTH	6.66	141.41	141.72	143.71	143.65
22	159	BIZYGOMATIC BREADTH	6.06	140.90	141.52	143.41	143.30
23	160	BIGONIAL BREADTH	6.91	117.47	117.16	117.70	116.51
24	161	EAR-TO-EAR BREADTH	7.94	185.92	187.37	189.91	190.25
25	162	BIOCULAR BREADTH	4.83	90.65	91.46	92.23	92.23
26	163	INTERPUPILLARY BRG	3.61	61.97	62.53	63.02	63.23
27	164	INTEROCULAR BROWNH	2.76	32.64	33.21	33.48	33.92
28	165	NOSE BREADTH	2.97	35.12	35.33	35.61	35.61
29	166	LIP LENGTH	1.74	52.33	52.21	52.35	52.82
30	167	EAR PROTRUSION	7.75	20.94	21.48	21.97	22.16
31	168	SUBNASALE-NASAL RT	3.22	47.72	50.46	52.79	55.75
32	169	PHILLIUM LENGTH	2.82	14.96	15.01	16.35	16.99
33	170	LIP-TO-LIP LENGTH	7.76	15.76	17.01	17.93	19.51
34	171	MENTON-SUBNASALE L	7.67	62.14	67.01	72.24	77.53
35	172	MENTON-NASAL ROOT	2.38	109.89	117.49	125.00	133.04
36	173	GLABELLA-TO-VERTEX	3.79	92.43	93.11	92.28	92.51
37	174	NASAL ROOT-TO-VRTX	3.38	107.46	107.64	107.21	107.73
38	175	XIPHL CARTHUS-VRTX	7.68	118.67	119.39	119.67	121.32
39	176	PRONASALE-TO-VRTX	17.91	144.34	146.94	148.46	151.38
40	177	SUBNASALE-TO-VRTX	17.11	157.55	160.16	162.13	165.09
41	178	STOMION-TO-VERTEX	2.83	178.45	182.44	185.72	190.94
42	179	MENTON-TO-VERTEX	9.00	218.71	225.23	231.82	238.89
43	180	TRAGION-TO-VERTEX	6.02	132.81	133.47	135.27	137.46
44	181	GLABELLA-TO-NALI	6.92	200.92	202.51	204.98	207.33
45	182	NASAL ROOT-TO-NALL	6.32	198.86	200.62	203.22	206.00
46	183	XIPHL CARTHUS-NALL	6.43	175.89	175.87	179.24	181.57
47	184	PRONASALE-TO-NALL	7.18	223.03	225.55	228.73	231.77
48	185	SUBNASALE-TO-NALL	7.64	207.17	208.74	211.54	214.20
49	186	LIP PROTRUSION-NALL	8.79	209.20	219.49	213.13	215.81
50	187	CEPH PROTRUSION-NALL	17.41	264.29	267.46	265.64	267.33
51	188	TRAGION-TO-NALL	6.46	192.03	192.61	194.28	196.25

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RESULTS FOR 3-SYSTEM (PERCENT COMPUTATION)

NUMBER IN SYSTEM = 2466, CONSTITUTING 99.42% OF TOTAL SAMPLE

SIZE NO.	RANGE	N	% OF SYSTEM	% OF POPULATION
1	103.50- 113.50	127	5.28	5.25
2	113.50- 117.50	657	27.31	27.15
3	117.50- 124.50	1038	43.14	42.89
4	124.50- 131.50	606	24.83	20.91
5	131.50- 138.50	78	3.24	3.22

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	S.D.	MEAN +1	MEAN +2	MEAN +3	MEAN +4	MEAN +5
1 1 AGE	6.27	29.48	29.20	29.94	31.09	32.10
2 2 WEIGHT	22.00	156.59	169.16	172.93	181.13	193.85
3 13 HEIGHT (STATURE)	59.72	1741.73	1757.94	1774.53	1793.37	1912.00
4 141 HEAD CIRCUMFERENCE	13.63	567.88	570.97	575.20	581.02	584.67
5 142 SAGITTAL ARCHITECTURE	16.48	343.51	344.66	346.45	348.60	351.23
6 143 MENTUM FRONTAL ARC	7.79	132.96	135.92	136.92	137.83	137.85
7 144 BIFRACION-CORONAL	12.27	352.16	354.76	357.69	361.12	364.43
8 145 BIFRACION-MIN FRONTAL	9.64	292.17	305.42	308.29	311.56	313.44
9 146 BIFRACION-SUBNASALE	10.08	289.53	291.34	293.29	295.46	295.59
10 147 BIFRACION-MENTUM	11.77	319.65	322.81	326.40	331.61	334.64
11 149 BIFRACION-SUBMANDIBULAR	19.31	303.50	305.11	309.70	315.04	318.45
12 149 BIFRACION-POSTERIOR	14.74	291.28	292.25	294.23	297.96	300.94
13 150 HEAD LENGTH	6.48	195.73	195.92	198.70	201.05	203.41
14 151 HEAD REACH/MENTUM	5.75	249.26	252.92	256.06	260.27	265.24
15 152 HEAD REACH/NOSE	9.81	215.81	216.67	219.43	222.70	225.73
16 153 EAR BREADTH	3.98	37.46	37.60	37.96	38.47	38.97
17 154 EAR LENGTH	4.15	64.26	65.18	65.96	67.08	68.00
18 155 EAR I HAVE TRACION	2.92	29.14	29.10	29.44	29.55	30.08
19 156 HEAD BREADTH	5.37	154.16	155.20	156.05	157.31	156.79
20 157 MENTUM FRONTAL ARC	4.50	114.84	115.35	116.01	117.14	116.29
21 154 BIFRACION BREADTH	3.45	140.63	141.40	142.56	144.20	143.88
22 159 BIFRACION BREADTH	5.04	140.20	141.12	142.36	143.86	143.27
23 160 BIFRACION BREADTH	5.01	117.09	116.87	117.43	117.84	116.92
24 161 EAR-TO-HEAD BREADTH	7.04	184.95	187.10	188.28	190.57	190.10
25 162 BIFRACION BREADTH	4.82	90.17	91.29	91.78	92.44	91.92
26 163 INTEROCULAR BREADTH	3.60	61.65	62.31	62.78	63.14	63.10
27 164 INTEROCULAR BREADTH	2.75	32.32	32.97	33.34	33.81	33.44
28 165 NOSE BREADTH	2.94	35.18	35.28	35.46	35.56	35.64
29 166 LIP LENGTH	3.74	52.90	52.14	52.29	52.33	52.69
30 167 EAR PROTRUSION	3.35	20.77	21.38	21.67	22.07	22.10
31 168 SUBNASALE-NASAL PT	2.22	47.54	49.43	51.64	53.35	55.85
32 169 PHILTRUM LENGTH	2.62	13.09	14.61	15.52	16.57	17.33
33 170 LIP-TO-LIP LENGTH	3.76	15.40	16.55	17.44	18.24	19.28
34 171 MENTUM-SUBNASALE L	2.67	61.29	65.09	69.39	73.80	77.97
35 172 MENTUM-NASAL BODY	1.86	108.60	114.66	120.98	127.09	133.56
36 173 GLABELLA-TO-VERTEX	3.68	92.69	92.82	93.17	91.67	93.75
37 174 NASAL ROOT-TO-VRTX	9.37	106.83	107.44	107.78	106.75	108.85
38 175 XTRNL CANTHUS-VRTX	7.67	118.19	118.96	119.87	119.38	122.24
39 176 SUBNASALE-TO-VRTX	10.88	143.78	145.71	148.11	148.27	152.55
40 177 SUBNASALE-TO-VRTX	10.18	150.80	153.94	151.58	151.94	156.42
41 178 STOMION-TO-VRTX	3.63	177.68	180.87	184.38	185.94	191.49
42 179 MENTUM-TO-VRTX	8.96	217.00	222.66	228.62	233.10	240.27
43 181 TRACION-TO-VRTX	6.50	172.31	173.37	174.58	175.59	178.18
44 181 GLABELLA-TO-WALL	6.52	170.72	201.91	203.50	205.64	207.78
45 182 NASAL ROOT-TO-WALL	3.21	198.62	199.93	201.69	203.95	206.40
46 183 XTRNL CANTHUS-WALL	6.43	176.13	175.37	177.74	178.98	181.73
47 184 SUBNASALE-TO-WALL	7.19	227.19	224.77	226.72	229.63	232.34
48 185 SUBNASALE-TO-WALL	7.65	207.45	208.24	209.69	212.41	214.45
49 186 LIP PROMINENCE-WALL	4.70	200.47	210.15	211.27	214.09	215.96
50 187 LIP PROMINENCE-WALL	10.78	204.45	204.21	204.01	206.72	207.05
51 188 TRACION-TO-WALL	5.40	102.20	102.42	103.19	104.94	106.21

RESULTS FOR 6-SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 2411. CONSISTING 99.63% OF TOTAL SAMPLE

SIZE NO.	RANGE	N	% OF SYSTEM	% OF POPULATION
1	102.50- 113.50	60	2.49	2.48
2	114.50- 114.50	744	14.27	14.21
3	114.50- 120.50	974	34.69	34.46
4	121.50- 126.50	923	34.14	34.01
5	126.50- 132.50	290	12.49	12.36
6	132.50- 174.50	51	2.12	2.11

	S.D.	MEAN +1	MEAN +2	MEAN +3	MEAN +4	MEAN +5	MEAN +6
1	1	117	127	137	147	157	167
2	2	114	114	114	114	114	114
3	13	114	114	114	114	114	114
4	141	136	158	180	202	224	246
5	142	136	158	180	202	224	246
6	143	136	158	180	202	224	246
7	144	136	158	180	202	224	246
8	145	136	158	180	202	224	246
9	146	136	158	180	202	224	246
10	147	136	158	180	202	224	246
11	148	136	158	180	202	224	246
12	149	136	158	180	202	224	246
13	150	136	158	180	202	224	246
14	151	136	158	180	202	224	246
15	152	136	158	180	202	224	246
16	153	136	158	180	202	224	246
17	154	136	158	180	202	224	246
18	155	136	158	180	202	224	246
19	156	136	158	180	202	224	246
20	157	136	158	180	202	224	246
21	158	136	158	180	202	224	246
22	159	136	158	180	202	224	246
23	160	136	158	180	202	224	246
24	161	136	158	180	202	224	246
25	162	136	158	180	202	224	246
26	163	136	158	180	202	224	246
27	164	136	158	180	202	224	246
28	165	136	158	180	202	224	246
29	166	136	158	180	202	224	246
30	167	136	158	180	202	224	246
31	168	136	158	180	202	224	246
32	169	136	158	180	202	224	246
33	170	136	158	180	202	224	246
34	171	136	158	180	202	224	246
35	172	136	158	180	202	224	246
36	173	136	158	180	202	224	246
37	174	136	158	180	202	224	246
38	175	136	158	180	202	224	246
39	176	136	158	180	202	224	246
40	177	136	158	180	202	224	246
41	178	136	158	180	202	224	246
42	179	136	158	180	202	224	246
43	180	136	158	180	202	224	246
44	181	136	158	180	202	224	246
45	182	136	158	180	202	224	246
46	183	136	158	180	202	224	246
47	184	136	158	180	202	224	246
48	185	136	158	180	202	224	246
49	186	136	158	180	202	224	246
50	187	136	158	180	202	224	246
51	188	136	158	180	202	224	246

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APPENDIX G (continued)

Face Length Sizing Programs - Male
Regression Equation Method

RESULTS FOR 2-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 105.50- 120.50 (MIDPOINT = 113.00)
 SIZE NO. = 2 RANGE = 120.50- 135.50 (MIDPOINT = 128.00)

			S.D.	MEAN +1	MEAN +2
1	1	AGE	5.28	28.64	30.47
2	2	WEIGHT	21.16	167.66	179.82
3	13	HEIGHT (STATURE)	60.70	1752.82	1795.07
4	141	HEAD CIRCUMFERENCE	13.92	569.76	580.89
5	142	SAGITTAL ARC/INTION	16.56	344.05	348.90
6	143	MINIMUM FRONTAL ARC	7.82	134.56	137.50
7	144	BITRAGION-CORONAL	12.44	354.20	361.11
8	145	BITRAGN-MIN FRONTAL	9.75	304.57	311.71
9	146	BITRAGN-SUBNASALE	10.15	290.85	295.48
10	147	BITRAGION-MENTON	12.03	321.61	331.57
11	148	BIT-SUBMANDIBULAR	15.52	304.97	314.88
12	149	BITRAGN-POSTERIOR	14.85	291.62	297.49
13	150	HEAD LENGTH	6.59	196.37	201.17
14	151	HEAD DIAGNL/MENTON	7.15	251.66	260.62
15	152	NO DIAG/INTION-NOSE	9.97	216.15	222.74
16	153	EAR BREADTH	2.99	37.48	38.49
17	154	EAR LENGTH	4.22	64.88	67.08
18	155	EAR L ABOVE TRAGION	2.92	29.04	29.72
19	156	HEAD BREADTH	5.40	155.02	157.03
20	157	MAXIMUM FRONTAL 90	4.53	115.21	116.89
21	158	BITRAGION BREADTH	5.50	141.23	143.89
22	159	BIZYGOMATIC BREADTH	5.10	140.97	143.61
23	160	BIGONIAL BREADTH	6.90	117.02	117.63
24	161	EAR-TO-EAR BREADTH	4.01	186.52	190.18
25	162	BIOCULAR BREADTH	4.84	91.03	92.43
26	163	INTERPUPILLARY BRD	3.61	62.20	63.22
27	164	INTEROCULAR BREADTH	2.76	32.88	33.72
28	165	NOSE BREADTH	2.93	35.25	35.61
29	166	LIP LENGTH	3.74	52.26	52.35
30	167	EAR PROTRUSION	3.35	21.21	22.09
31	168	SUBNASALE-NASAL RT	3.45	48.92	53.86
32	169	PHILTRUM LENGTH	2.68	14.41	16.69
33	170	LIP-TO-LIP LENGTH	3.79	16.32	18.43
34	171	MENTON-SUBNASALE L	4.39	64.01	74.24
35	172	MENTON-NASAL ROOT	4.33	113.00	128.00
36	173	GLABELLA-TO-VERTEX	9.70	93.12	92.36
37	174	NASAL ROOT-TO-VRTX	9.37	107.58	107.33
38	175	XTRNL CANTHUS-VRTX	7.68	118.97	120.08
39	176	PRONASALE-TO-VRTX	10.95	145.49	149.44
40	177	SUBNASALE-TO-VRTX	10.17	158.73	163.13
41	178	STOMION-TO-VERTEX	9.78	180.20	197.27
42	179	MENTON-TO-VERTEX	9.52	221.35	234.40
43	180	TRAGION-TO-VERTEX	6.85	133.11	135.88
44	181	GLABELLA-TO-WALL	4.62	201.35	205.70
45	182	NASAL ROOT-TO-WALL	6.43	199.34	204.10
46	183	XTRNL CANTHUS-WALL	6.51	175.95	179.91
47	184	PRONASALE-TO-WALL	7.34	224.02	229.70
48	185	SUBNASALE-TO-WALL	7.74	207.63	212.20
49	186	LIP PROMINCE-WALL	8.48	209.48	213.86
50	187	CHIN PROMINCE-WALL	10.45	203.62	205.92
51	188	TRAGION-TO-WALL	6.45	102.01	104.75

RESULTS FOR 3-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 101.50- 113.50 (MIDPOINT = 107.50)
 SIZE NO. = 2 RANGE = 113.50- 125.50 (MIDPOINT = 119.50)
 SIZE NO. = 3 RANGE = 125.50- 137.50 (MIDPOINT = 131.50)

			S.D.	MEAN +1	MEAN +2	MEAN +3
1	1	AGE	6.28	27.97	29.43	30.90
2	2	WEIGHT	21.05	163.20	172.93	182.66
3	13	HEIGHT (STATURE)	60.25	1737.32	1771.13	1804.93
4	141	HEAD CIRCUMFERENCE	13.78	569.68	574.59	583.49
5	142	SAGITTAL ARC/INION	16.51	342.27	346.15	350.03
6	143	MINIMUM FRONTAL BR	7.80	133.48	135.84	138.19
7	144	BITRAGION-CORONAL	12.38	351.66	357.19	362.72
8	145	BITRAGION-MIN FRONTAL	9.67	301.95	307.67	313.38
9	146	BITRAGION-SUBNASALE	10.17	289.15	292.86	296.57
10	147	BITRAGION-MENTON	11.91	317.96	325.93	333.90
11	148	BIT-SUBMANDIBULAR	15.43	301.34	309.27	317.19
12	149	BITRAGION-POSTERIOR	14.82	289.47	294.16	298.86
13	150	HEAD LENGTH	6.54	194.61	198.45	202.29
14	151	HEAD DIAGNL/MENTON	6.98	248.37	255.54	262.71
15	152	H/DIAG/INION-NOSE	9.90	213.74	219.01	224.28
16	153	EAR BREADTH	2.99	37.11	37.92	38.72
17	154	EAR LENGTH	4.20	64.07	65.83	67.60
18	155	EAR L ARVE TRAGION	2.92	28.79	29.33	29.88
19	156	HEAD BREADTH	5.38	154.29	155.89	157.50
20	157	MAXIMUM FRONTAL BR	4.52	114.59	115.97	117.28
21	158	BITRAGION BREADTH	9.49	140.26	142.38	144.50
22	159	BIZYCOMATIC BREADTH	5.08	140.00	142.11	144.22
23	160	BIGONIAL BREADTH	6.99	116.80	117.29	117.77
24	161	EAR-TO-EAR BREADTH	7.98	135.18	138.11	141.03
25	162	BIOCULAR BREADTH	4.83	90.71	91.63	92.75
26	163	INTERPUPTILIARY BRD	3.60	61.82	62.64	63.46
27	164	INTEROCULAR BREADTH	2.75	32.58	33.25	33.92
28	165	NOSE BREADTH	2.93	35.12	35.41	35.70
29	166	LIP LENGTH	3.74	52.22	52.30	52.37
30	167	EAR PROTRUSION	3.35	20.89	21.59	22.30
31	168	SUBNASALE-NASAL RT	3.34	47.10	51.06	55.01
32	169	PILLIUM LENGTH	2.65	13.67	15.40	17.22
33	170	LIP-TO-LIP LENGTH	3.77	15.55	17.23	18.92
34	171	MENTON-SUBNASALE L	4.01	60.26	68.44	76.63
35	172	MENTON-NASAL ROOT	3.46	107.50	119.50	131.50
36	173	GLABELLA-TO-VERTEX	9.70	93.40	92.79	92.18
37	174	NASAL ROOT-TO-VPTX	9.37	107.67	107.47	107.27
38	175	XTRNL CANTHUS-VPTX	7.68	118.56	119.45	120.34
39	176	PRONASALE-TO-VPTX	10.93	144.94	147.20	150.36
40	177	SUBNASALE-TO-VPTX	10.14	137.11	160.64	164.16
41	178	STOMION-TO-VERTEX	9.70	177.61	183.26	188.92
42	179	MENTON-TO-VERTEX	9.24	216.56	227.01	237.45
43	180	TRAGION-TO-VERTEX	6.03	132.10	134.31	136.52
44	181	GLABELLA-TO-WALL	6.58	199.73	203.27	206.82
45	182	NASAL ROOT-TO-WALL	6.38	197.58	201.42	205.25
46	183	XTRNL CANTHUS-WALL	6.48	174.49	177.66	180.83
47	184	PRONASALE-TO-WALL	7.27	221.94	226.48	231.02
48	185	SUBNASALE-TO-WALL	7.70	205.92	209.64	213.37
49	186	LIP PROMINCE-WALL	8.49	207.87	211.37	214.88
50	187	CHIN PROMINCE-WALL	10.44	202.77	204.61	206.45
51	188	TRAGION-TO-WALL	6.43	101.01	103.20	105.39

RESULTS FOR 4-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 107.00- 112.50 (MIDPOINT = 109.75)
 SIZE NO. = 2 RANGE = 110.50- 121.50 (MIDPOINT = 116.00)
 SIZE NO. = 3 RANGE = 121.50- 130.50 (MIDPOINT = 126.00)
 SIZE NO. = 4 RANGE = 130.50- 139.50 (MIDPOINT = 135.00)

		S.D.	MEAN +1	MEAN +2	MEAN +3	MEAN +4	
1	1	AGE	64.27	28.03	29.13	30.23	31.32
2	2	HEIGHT	29.97	167.61	170.90	174.20	177.50
3	13	HEIGHT (STATURE)	59.91	1738.73	1764.08	1789.44	1814.79
4	141	HEAD CIRCUMFERENCE	17.68	566.05	572.73	579.41	586.09
5	142	SAGITTAL ARC/INION	15.50	242.47	345.34	344.25	351.17
6	143	MINIMUM FRONTAL ARC	7.79	173.58	135.35	137.11	138.88
7	144	BITRAGION-CORONAL	12.73	261.89	366.04	360.19	364.33
8	145	BITRAGION-MIN FRONTAL	9.61	282.19	386.48	310.76	315.05
9	146	BITRAGION-SURNASALE	11.10	283.31	297.09	296.87	297.65
10	147	BITRAGION-MENTON	11.81	318.29	324.27	330.24	336.22
11	148	BIT-SURNASALE	15.75	301.67	307.51	313.56	319.50
12	149	BITRAGION-POSTERIOR	14.79	289.68	293.19	296.71	300.23
13	150	HEAD LENGTH	6.50	194.77	197.65	200.53	203.41
14	151	HEAD BITRAGION-MENTON	6.15	248.67	254.05	259.42	264.80
15	152	HEAD BITRAGION-NOSE	9.85	213.96	217.91	221.86	225.82
16	153	EAR BREADTH	2.94	37.15	37.75	38.35	38.96
17	154	EAR LENGTH	6.19	64.14	65.46	66.79	68.11
18	155	EAR L ABOVE TRAGION	2.92	24.81	29.22	29.63	30.04
19	156	HEAD BREADTH	6.38	154.35	155.56	156.76	157.97
20	157	MAXIMUM FRONTAL BR	4.51	114.65	115.65	116.66	117.67
21	158	BITRAGION BREADTH	5.47	140.35	141.94	143.53	145.12
22	159	BITRAGION BREADTH	5.06	140.09	141.67	143.26	144.84
23	160	BITRAGION BREADTH	6.09	116.82	117.19	117.55	117.92
24	161	EAR-TO-EAR BREADTH	7.05	145.31	147.60	149.69	191.88
25	162	BITRAGION BREADTH	4.82	90.56	91.40	92.24	93.08
26	163	INTEROCCIPITAL BR	3.50	61.86	62.47	63.08	63.69
27	164	INTEROCCIPITAL BR	2.75	32.50	33.11	33.61	34.12
28	165	NOSE BREADTH	2.93	35.13	35.35	35.56	35.78
29	166	LIP LENGTH	7.74	52.23	52.28	52.33	52.39
30	167	EAR PROMINENCE	3.35	20.22	21.45	21.98	22.51
31	168	SURNASALE-NASAL PT	3.29	47.27	50.23	53.20	56.17
32	169	PHILTRUM LENGTH	2.63	13.65	15.02	16.38	17.75
33	171	LIP-TO-LIP LENGTH	7.76	15.62	16.89	18.15	19.41
34	171	MENTON-SURNASALE L	3.69	50.60	56.74	72.88	79.02
35	172	MENTON-NASAL ROOT	2.60	108.90	117.00	126.00	135.00
36	173	GLABELLA-TO-VERTEX	9.69	97.37	92.92	92.46	92.01
37	174	NASAL ROOT-TO-VPX	9.27	107.67	107.51	107.35	107.21
38	175	XIPHI CANTHUS-VPX	7.08	118.59	119.25	119.93	120.60
39	176	PRONASALE-TO-VPX	10.91	144.17	146.54	148.91	151.28
40	177	SURNASALE-TO-VPX	10.11	157.26	159.99	162.54	165.19
41	178	STOMION-TO-VERTEX	9.66	177.85	182.09	186.33	190.56
42	179	MENTON-TO-VERTEX	9.07	217.00	224.83	232.66	240.49
43	181	TRAGION-TO-VERTEX	6.02	132.10	133.85	135.51	137.17
44	181	GLABELLA-TO-WALL	6.54	199.88	202.53	205.19	207.85
45	182	NASAL ROOT-TO-WALL	6.34	197.74	201.62	203.50	205.37
46	183	XIPHI CANTHUS-WALL	6.45	176.67	177.00	179.38	181.76
47	184	PRONASALE-TO-WALL	7.22	222.12	225.53	228.94	232.35
48	185	SURNASALE-TO-WALL	7.67	206.07	208.87	211.66	214.45
49	186	LIP PROMINENCE-WALL	8.42	208.01	210.64	213.27	215.90
50	187	RAIN PROMINENCE-WALL	10.47	202.85	206.23	209.61	212.99
51	188	TRAGION-TO-WALL	5.42	161.19	162.74	164.39	166.03

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RESULTS FOR 5-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 197.50- 110.50 (MIDPOINT = 107.00)
 SIZE NO. = 2 RANGE = 110.50- 117.50 (MIDPOINT = 114.00)
 SIZE NO. = 3 RANGE = 117.50- 124.50 (MIDPOINT = 121.00)
 SIZE NO. = 4 RANGE = 124.50- 131.50 (MIDPOINT = 128.00)
 SIZE NO. = 5 RANGE = 131.50- 138.50 (MIDPOINT = 135.00)

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			S.D.	MEAN +1	MEAN +2	MEAN +3	MEAN +4	MEAN +5
1	1	AGE	6.27	27.91	28.76	29.61	30.47	31.32
2	2	HEIGHT	20.93	162.80	168.47	174.15	179.82	185.50
3	13	HEIGHT (STATURE)	20.73	1735.91	1755.63	1775.35	1795.07	1814.79
4	141	HEAD CIRCUMFERENCE	11.63	565.31	570.51	575.70	580.89	586.09
5	142	SAGITTAL ARC/INTION	15.49	242.10	344.37	346.64	348.90	351.17
6	143	MINIMUM FRONTAL ARC	7.78	133.30	134.76	136.13	137.50	138.88
7	146	BITRAGION-CORONAL	12.31	251.43	254.66	257.88	261.11	264.33
8	145	BITRAGION-MIN FRONTAL	9.58	221.72	205.05	208.38	211.71	215.05
9	146	BITRAGION-SUBNASALE	12.08	228.08	221.16	223.32	225.48	227.65
10	147	BITRAGION-MENTON	11.76	217.53	222.28	226.92	231.57	236.22
11	143	BIT-SUBMANDIBULAR	15.21	321.01	305.63	310.26	314.88	319.50
12	149	BITRAGION-POSTERIOR	14.78	289.27	292.01	294.75	297.49	300.23
13	150	HEAD LENGTH	6.48	194.45	196.69	198.93	201.17	203.41
14	151	HEAD DIAGONAL-MENTON	6.77	248.08	252.26	256.44	260.62	264.80
15	152	H) DIAGONAL-NOSE	9.82	213.52	216.59	219.67	222.74	225.82
16	153	EAR BREADTH	2.38	37.08	37.55	38.02	38.49	38.96
17	154	EAR LENGTH	4.18	63.99	65.02	66.05	67.08	68.11
18	155	EAR L ARVE TRAGION	2.92	28.77	29.08	29.40	29.72	30.04
19	156	HEAD BREADTH	5.27	254.22	155.16	156.09	157.03	157.97
20	157	MAXIMUM FRONTAL BR	4.51	114.53	115.32	116.10	116.89	117.67
21	158	BITRAGION BREADTH	5.46	140.17	141.41	142.65	143.89	145.12
22	159	BIZYGOMATIC BREADTH	5.06	139.92	141.15	142.38	143.61	144.84
23	160	BIGONIAL BREADTH	6.90	116.78	117.06	117.35	117.63	117.92
24	161	EAR-TO-EAR BREADTH	7.05	185.06	186.77	188.47	190.18	191.88
25	162	OCULAR BREADTH	4.82	90.47	91.12	91.77	92.43	93.08
26	163	INTERPUPILLARY ARC	1.80	61.79	62.26	62.74	63.22	63.69
27	164	INTEROCULAR BREADTH	2.76	32.55	32.94	33.33	33.72	34.12
28	165	NOSE BREADTH	2.03	35.11	35.28	35.44	35.61	35.78
29	166	LIP LENGTH	7.74	52.22	52.26	52.30	52.35	52.39
30	167	EAR PROTRUSION	7.25	20.86	21.27	21.68	22.09	22.51
31	168	SUBNASALE-NASAL RT	3.21	46.94	44.25	51.55	53.86	56.17
32	169	PHILTRUM LENGTH	2.62	13.50	14.56	15.62	16.69	17.75
33	170	LIP-TO-LIP LENGTH	3.75	15.48	16.46	17.44	18.43	19.41
34	171	MENTON-SUBNASALE L	7.82	69.91	64.69	69.47	74.24	79.02
35	172	MENTON-NASAL ROOT	2.02	107.00	114.00	121.00	128.00	135.00
36	173	GLABELLA-TO-VERTEX	9.69	93.42	93.07	92.71	92.36	92.01
37	174	NASAL ROOT-TO-VRTX	9.27	107.68	107.56	107.45	107.33	107.21
38	175	XTN) CANTHUS-TO-VRTX	7.68	118.52	119.04	119.56	120.08	120.60
39	176	PRONASALE-TO-VRTX	10.90	143.91	149.75	147.60	149.44	151.28
40	177	SUBNASALE-TO-VRTX	10.10	153.97	159.02	161.08	163.13	165.19
41	178	STOMION-TO-VERTEX	9.61	177.38	130.67	133.97	137.27	140.56
42	179	MENTON-TO-VERTEX	9.91	216.13	222.22	228.31	234.40	240.49
43	180	TRAGION-TO-VERTEX	6.61	132.01	133.70	134.59	135.48	137.17
44	181	GLABELLA-TO-WALL	6.53	199.58	202.65	203.72	205.78	207.85
45	182	NASAL ROOT-TO-WALL	6.32	197.42	199.56	201.90	204.14	206.37
46	183	XTRN) CANTHUS-WALL	5.44	174.34	176.21	178.06	179.91	181.76
47	184	PRONASALE-TO-WALL	7.19	221.75	224.40	227.05	229.70	232.35
48	185	SUBNASALE-TO-WALL	7.65	225.76	227.94	230.11	232.28	234.45
49	186	LIP FRONT-TO-WALL	4.41	207.72	209.77	211.81	213.86	215.90
50	187	CHIN PROMINENCE-WALL	10.43	282.70	283.77	284.84	285.92	286.99
51	188	TRAGION-TO-WALL	6.41	100.91	102.19	103.47	104.75	106.03

RESULTS FOR 6-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 102.51- 108.50 (MIDPOINT = 105.50)
 SIZE NO. = 2 RANGE = 108.50- 114.50 (MIDPOINT = 111.50)
 SIZE NO. = 3 RANGE = 114.51- 120.50 (MIDPOINT = 117.50)
 SIZE NO. = 4 RANGE = 120.51- 126.50 (MIDPOINT = 123.50)
 SIZE NO. = 5 RANGE = 126.51- 132.50 (MIDPOINT = 129.50)
 SIZE NO. = 6 RANGE = 132.51- 138.50 (MIDPOINT = 135.50)

			S.D.	MEAN +1	MEAN +2	MEAN +3	MEAN +4	MEAN +5	MEAN +6
1	1	AGE	5.27	27.72	28.44	29.19	29.92	30.69	31.39
2	2	HEIGHT	21.91	161.58	166.65	171.31	176.17	181.04	185.90
3	13	HEIGHT (STATURE)	59.66	1731.69	1748.69	1765.49	1782.39	1799.30	1816.20
4	141	HEAD CIRCUMFERENCE	13.60	564.20	568.65	573.10	577.56	582.01	586.46
5	142	SAGITTAL ARC/INTON	16.49	741.62	343.55	345.90	347.44	349.39	351.33
6	143	MAXIMUM FRONTAL ARC	7.78	133.00	134.27	135.45	136.62	137.80	138.98
7	144	BITRAGION-CORONAL	12.30	350.74	353.50	356.27	359.03	361.80	364.56
8	145	BITRAGION-MEN FRONTAL	9.65	201.00	303.86	306.71	309.57	312.43	315.28
9	146	BITRAGION-SUBNASALE	11.08	288.83	290.39	292.24	294.09	295.95	297.80
10	147	BITRAGION-MENTON	11.74	216.63	320.62	324.60	328.58	332.57	336.55
11	148	BIT-SUBMANDIBULAR	15.30	700.02	303.98	307.94	311.91	315.87	319.83
12	149	BITRAGION-POSTERIOR	16.77	288.68	291.03	293.38	295.73	298.08	300.43
13	150	HEAD LENGTH	6.47	193.97	195.89	197.81	199.73	201.65	203.57
14	151	HEAD DIAGN/MENTON	6.74	247.18	250.75	254.35	257.93	261.51	265.10
15	152	NO DIAG/INTON-NOSE	9.81	212.86	215.50	218.13	220.77	223.40	226.04
16	153	EAR BREADTH	2.98	36.98	37.38	37.78	38.19	38.59	38.99
17	154	EAR LENGTH	4.18	63.77	64.66	65.54	66.42	67.30	68.19
18	155	EAR L ABOVE TRAGION	2.92	28.70	28.97	29.24	29.52	29.79	30.06
19	156	HEAD BREADTH	5.37	154.02	154.82	155.62	156.43	157.23	158.03
20	157	MAXIMUM FRONTAL OP	4.51	114.37	115.04	115.71	116.38	117.05	117.72
21	158	BITRAGION BREADTH	5.46	179.91	140.97	142.03	143.09	144.15	145.21
22	159	BIZYGOMATIC BREADTH	5.05	170.65	140.71	141.75	142.82	143.87	144.93
23	160	BIGONIAL BREADTH	6.90	116.72	116.96	117.21	117.45	117.69	117.94
24	161	EAR-TO-EAR BREADTH	7.95	144.73	146.15	147.62	149.00	190.54	192.00
25	162	BIOCCULAR BREADTH	4.82	90.38	90.89	91.45	92.01	92.56	93.12
26	163	INTERPUPILLARY BRO	7.60	61.69	62.09	62.50	62.91	63.32	63.73
27	164	INTEROCULAR BREADTH	2.76	72.46	32.80	33.14	33.47	33.81	34.15
28	165	NOSE BREADTH	2.93	35.07	35.22	35.36	35.50	35.65	35.79
29	166	LIP LENGTH	7.74	52.21	52.25	52.28	52.32	52.35	52.39
30	167	EAR PROTRUSION	7.38	20.77	21.12	21.48	21.83	22.18	22.53
31	168	SUBNASALE-NASAL RT	3.10	45.44	48.42	50.40	52.38	54.36	56.33
32	169	PHILTRUM LENGTH	2.61	13.27	14.14	15.09	16.00	16.91	17.83
33	170	LIP-TO-LIP LENGTH	7.75	15.27	16.11	16.95	17.79	18.64	19.48
34	171	MENTON-SUBNASALE L	7.65	68.89	62.99	67.08	71.17	75.27	79.36
35	172	MENTON-NASAL ROOT	1.73	105.50	111.50	117.50	123.50	129.50	135.50
36	173	GLABELLA-TO-VERTEX	9.69	93.60	93.19	92.89	92.59	92.29	91.98
37	174	NASAL ROOT-TO-VRTX	9.37	107.71	107.61	107.50	107.40	107.30	107.20
38	175	XYPHL GANTHUS-VRTX	7.68	118.41	118.45	119.30	119.75	120.19	120.64
39	176	PROMASALE-TO-VRTX	10.90	143.52	145.10	146.68	148.26	149.83	151.41
40	177	SUBNASALE-TO-VRTX	11.10	186.53	158.29	160.05	161.81	163.57	165.33
41	178	STANTION-TO-VERTEX	9.60	176.67	179.50	182.32	185.15	187.97	190.80
42	179	MENTON-TO-VERTEX	8.07	214.82	220.04	225.27	230.49	235.71	240.93
43	180	TRAGION-TO-VERTEX	6.51	171.23	132.54	133.94	135.05	136.16	137.26
44	181	GLABELLA-TO-WALL	9.52	199.14	200.91	202.68	204.45	206.23	208.00
45	182	NASAL ROOT-TO-WALL	6.31	196.94	198.86	200.78	202.70	204.62	206.53
46	183	XYPHL GANTHUS-WALL	6.43	173.97	175.95	177.13	178.72	180.30	181.89
47	184	PROMASALE-TO-WALL	7.18	221.18	223.45	225.72	228.00	230.27	232.54
48	185	SUBNASALE-TO-WALL	7.69	205.30	207.16	209.02	210.88	212.75	214.61
49	186	LIP PROMINCE-WALL	8.43	207.28	209.04	210.79	212.54	214.30	216.05
50	187	CHIN PROMINCE-WALL	11.47	202.47	203.39	204.31	205.23	206.15	207.07
51	188	TRAGION-TO-WALL	5.41	100.64	101.74	102.83	103.93	105.03	106.12

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APPENDIX G (continued)

Face Length Sizing Programs - Female
Direct Computation Method

RESULTS FOR 2-SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 1873. CONSTITUTING 98.32% OF TOTAL SAMPLE

SIZE NO. 1 RANGE = 98.50- 105.50 N = 875. = 46.72 % OF SYSTEM = 45.93 % OF POPULATION
 SIZE NO. 2 RANGE = 105.50- 120.50 N = 998. = 53.28 % OF SYSTEM = 52.39 % OF POPULATION

		S.D.	MEAN #1	MEAN #2
1	AGE	6.38	22.41	24.29
2	WEIGHT	16.21	123.61	130.39
3	STATURE	58.35	1606.51	1633.29
4	HEAD LENGTH	6.55	162.31	185.63
5	HEAD BREADTH	5.89	144.33	145.81
6	HEAD CIRCUMFERENCE	15.89	545.12	551.59
7	TRAGION-TOP HEAD	7.60	126.33	128.01
8	ECTOCANTHUS-TOP HD	9.21	117.19	117.99
9	PRONASALE-TOP HEAD	11.65	146.14	146.79
10	SUBNASALE-TOP HEAD	10.90	157.62	150.33
11	STOMION-TOP HEAD	11.07	176.25	179.88
12	MENTON-TOP HEAD	10.75	215.23	222.26
13	TRAGION TO WALL	8.96	100.95	102.38
14	ECTOCANTHUS-WALL	9.56	162.21	164.69
15	PRONASALE TO WALL	9.40	210.07	213.44
16	SUBNASALE TO WALL	9.72	195.48	197.70
17	LIP PROTRUSION-WALL	10.51	191.99	193.93
18	MENTON TO WALL	11.37	182.33	182.40
19	SAGITTAL CURVATURE	14.76	346.18	349.30
20	BITRAGION-CORONAL	13.87	336.96	341.16
21	BIOCULAR BREADTH	4.87	95.98	97.33
22	BIAURICULAR BROTTH	9.49	157.83	158.69
23	SITRAGION BREADTH	4.96	128.15	129.49
24	SIZYGOMATIC BROTTH	5.76	128.32	129.53
25	BIGONIAL BREADTH	5.59	101.12	102.46
26	NASAL BREADTH	3.26	31.66	32.16
27	LIP LENGTH	4.20	43.43	44.07
28	MENTON-SUBNASALE L	4.37	52.81	57.55
29	MENTON-SELLIGN LTH	3.43	101.23	110.53
30	SUBNASALE-SELLIGN	3.53	43.38	47.23
31	EAR LENGTH	4.41	51.74	52.93
32	EAR BREADTH	3.33	29.50	30.06

RESULTS FOR 3-SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 1899. CONSTITUTING 99.69% OF TOTAL SAMPLE

SIZE NO. 1 RANGE = 89.50- 101.50 N = 390. = 20.54 % OF SYSTEM = 20.47 % OF POPULATION
 SIZE NO. 2 RANGE = 101.50- 113.50 N = 1288. = 67.83 % OF SYSTEM = 67.61 % OF POPULATION
 SIZE NO. 3 RANGE = 113.50- 125.50 N = 221. = 11.64 % OF SYSTEM = 11.60 % OF POPULATION

	S.D.	MEAN #1	MEAN #2	MEAN #3
1	6.38	22.10	23.48	25.39
2	16.18	121.94	127.50	135.52
3	58.46	1598.43	1623.23	1647.83
4	6.53	181.43	184.32	187.53
5	5.88	143.65	145.29	146.97
6	15.81	542.35	549.42	555.21
7	7.56	125.25	127.53	129.24
8	9.17	116.37	117.79	119.03
9	11.62	145.07	147.84	150.71
10	10.85	156.47	159.35	162.42
11	10.99	174.72	178.60	182.51
12	10.59	212.25	219.82	226.73
13	8.94	108.23	101.78	103.96
14	9.51	161.07	163.88	167.43
15	9.34	208.64	212.11	216.37
16	9.66	194.17	196.78	200.05
17	10.47	190.71	193.20	196.06
18	11.36	181.87	182.26	183.75
19	14.70	344.02	348.33	352.01
20	13.79	334.75	338.67	344.60
21	4.88	95.71	96.81	98.02
22	9.48	157.46	158.24	160.36
23	4.94	127.71	128.95	130.60
24	5.75	127.92	129.11	130.21
25	5.60	101.14	101.86	103.14
26	3.27	31.49	31.93	32.82
27	4.19	43.27	43.72	45.05
28	4.24	51.08	55.73	61.18
29	3.08	98.04	106.99	115.69
30	3.56	42.38	45.69	49.64
31	4.37	51.28	52.39	54.11
32	3.31	29.21	29.84	30.62

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RESULTS FOR 4--SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 1892. CONSTITUTING 99.32% OF TOTAL SAMPLE

SIZE NO. 1 RANGE = 85.50- 94.50 N = 57. = 3.01 % OF SYSTEM = 2.99 % OF POPULATION
 SIZE NO. 2 RANGE = 94.50- 103.50 N = 552. = 29.18 % OF SYSTEM = 28.98 % OF POPULATION
 SIZE NO. 3 RANGE = 103.50- 112.50 N = 1089. = 53.33 % OF SYSTEM = 52.97 % OF POPULATION
 SIZE NO. 4 RANGE = 112.50- 121.50 N = 274. = 14.48 % OF SYSTEM = 14.38 % OF POPULATION

	S.D.	MEAN #1	MEAN #2	MEAN #3	MEAN #4
1	6.35	21.55	22.27	23.49	25.92
2	16.05	118.37	123.25	127.58	135.88
3	58.08	1585.16	1604.33	1624.83	1646.68
4	6.52	180.42	181.82	184.62	187.28
5	5.87	141.79	144.44	145.24	146.90
6	15.76	538.54	544.02	549.91	554.86
7	7.56	124.33	125.90	127.67	128.92
8	9.18	115.63	116.80	117.90	118.75
9	11.64	143.86	145.79	148.08	150.09
10	13.88	154.32	157.37	159.58	161.69
11	11.01	171.58	175.91	178.68	181.73
12	10.58	207.72	214.37	220.31	225.70
13	8.94	98.77	100.54	102.01	103.62
14	9.53	159.11	161.72	164.05	166.82
15	9.35	205.58	209.67	212.31	215.73
16	9.67	196.89	194.97	197.00	199.47
17	10.48	187.05	191.58	193.37	195.61
18	11.37	180.12	182.16	182.24	183.50
19	14.74	343.58	345.13	348.41	351.99
20	13.74	336.60	336.02	340.13	343.95
21	4.86	95.33	95.76	97.01	97.86
22	9.47	156.42	157.81	158.19	160.26
23	4.93	127.26	128.02	128.97	130.55
24	5.74	126.77	128.27	129.17	130.08
25	5.60	100.77	101.18	101.94	103.09
26	3.28	30.93	31.61	31.98	32.55
27	4.16	42.70	43.39	43.77	44.79
28	4.13	48.14	50.31	56.00	60.53
29	2.41	92.32	100.32	107.58	115.61
30	3.45	39.79	43.15	45.97	49.13
31	4.38	51.30	51.56	52.42	53.96
32	3.31	29.21	29.33	29.89	30.45

G
L

RESULTS FOR 5-SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 1899. CONSTITUING 99.69% OF TOTAL SAMPLE

SIZE NO.	1	2	3	4	5
RANGE =	89.50-	96.50-	103.50-	110.50-	117.50-
N =	97.0	509.0	831.0	393.0	69.0
% OF SYSTEM =	5.11	26.80	43.76	20.70	3.63
% OF POPULATION	5.09	26.72	43.62	20.63	3.62

	S.D.	MEAN #1	MEAN #2	MEAN #3	MEAN #4	MEAN #5
1 AGE	6.22	22.21	22.22	23.10	25.56	25.57
2 WEIGHT	16.06	118.96	123.55	127.04	132.88	137.87
3 STATURE	58.19	1589.67	1604.97	1623.26	1639.02	1653.46
4 HEAD LENGTH	6.48	180.80	181.90	184.29	186.46	189.19
5 HEAD BREADTH	5.88	142.67	144.46	145.11	146.39	147.17
6 HEAD CIRCUMFERENCE	15.71	540.64	544.23	549.35	553.34	558.04
7 TRAGION-TOP HEAD	7.57	125.43	125.83	127.58	128.52	129.28
8 ECTOCANTHUS-TOP HD	9.18	116.57	116.72	117.77	118.55	119.29
9 PRONASALE-TOP HEAD	11.62	145.87	145.75	147.82	149.49	151.39
10 SUBNASALE-TOP HEAD	10.85	156.10	157.30	159.28	161.09	163.57
11 STOMION-TOP HEAD	10.98	173.82	175.88	178.46	181.07	183.64
12 TRAGION-TOP HEAD	10.50	210.05	214.54	219.62	224.33	228.55
13 TRAGION TO WALL	8.94	99.64	100.56	101.85	103.07	103.87
14 ECTOCANTHUS-WALL	9.51	160.18	161.80	163.81	165.84	168.16
15 PRONASALE TO WALL	9.31	206.84	209.84	211.96	214.64	217.62
16 SUBNASALE TO WALL	9.63	192.03	195.16	196.70	198.73	201.10
17 LIP PROTRUSION-WALL	10.45	188.54	191.75	193.12	194.74	197.72
18 MENTON TO WALL	11.37	180.89	182.24	182.16	182.98	183.90
19 SAGITTAL CURVATURE	14.68	345.02	345.07	346.33	349.73	356.55
20 BITRAGION-CORONAL	13.78	332.94	336.06	339.91	342.79	343.14
21 BIOCULAR BREADTH	4.87	95.48	95.77	96.89	97.69	98.00
22 BIAURICULAR BROTH	9.48	156.82	157.88	158.04	159.68	159.94
23 BITRAGION BREADTH	4.93	127.67	128.01	128.82	130.13	130.88
24 BIZYGOMATIC BROTH	5.74	127.59	128.25	129.02	129.92	130.97
25 BIGONIAL BREADTH	5.58	106.90	101.19	101.71	102.98	103.59
26 NASAL BREADTH	3.27	31.00	31.67	31.92	32.29	33.52
27 LIP LENGTH	4.17	42.89	43.42	43.65	44.32	46.30
28 MENTON-SUBNASALE L	4.05	48.94	52.53	55.51	59.29	62.51
29 MENTON-SELLION LTH	1.92	93.87	100.73	106.75	113.20	119.67
30 SUBNASALE-SELLION	3.40	40.55	43.31	45.63	48.16	51.16
31 EAR LENGTH	4.38	51.59	51.51	52.32	53.60	53.17
32 EAR BREADTH	3.31	29.38	29.34	29.81	30.37	30.42

RESULTS FOR 6-SYSTEM (DIRECT COMPUTATION)

NUMBER IN SYSTEM = 1893. CONSTITUTING 99.37% OF TOTAL SAMPLE

SIZE NO. 1 RANGE = 90.50- 96.50 N = 90.0 = 4.75 % OF SYSTEM = 4.72 % OF POPULATION
 SIZE NO. 2 RANGE = 96.50- 102.50 N = 400.0 = 21.13 % OF SYSTEM = 21.00 % OF POPULATION
 SIZE NO. 3 RANGE = 102.50- 108.50 N = 742.0 = 39.20 % OF SYSTEM = 38.95 % OF POPULATION
 SIZE NO. 4 RANGE = 108.50- 114.50 N = 489.0 = 25.83 % OF SYSTEM = 25.67 % OF POPULATION
 SIZE NO. 5 RANGE = 114.50- 120.50 N = 152.0 = 8.03 % OF SYSTEM = 7.98 % OF POPULATION
 SIZE NO. 6 RANGE = 120.50- 126.50 N = 20.0 = 1.06 % OF SYSTEM = 1.05 % OF POPULATION

	S.O.	MEAN #1	MEAN #2	MEAN #3	MEAN #4	MEAN #5	MEAN #6
1	6.34	22.37	22.03	22.93	24.69	25.95	25.15
2	16.03	119.08	122.96	126.04	131.33	135.76	138.95
3	58.13	1590.53	1602.36	1619.63	1635.00	1647.03	1662.45
4	6.46	186.94	181.67	183.69	186.06	187.75	188.75
5	5.86	142.56	144.32	144.77	146.23	146.89	148.10
6	15.61	540.03	543.35	548.07	553.07	555.26	560.40
7	7.96	125.58	125.53	127.18	128.39	129.14	131.15
8	9.18	116.63	116.56	117.61	118.28	118.89	120.90
9	11.61	145.01	145.58	147.19	149.26	150.52	153.85
10	10.84	156.02	157.06	158.65	160.85	162.36	165.85
11	10.97	173.71	175.61	177.77	180.54	182.07	187.20
12	10.44	210.13	213.88	218.47	223.12	226.78	232.50
13	8.91	99.59	100.35	101.41	102.92	104.12	103.30
14	9.45	160.31	161.32	163.30	165.40	167.63	168.20
15	9.25	207.13	209.19	211.55	214.02	216.34	217.70
16	9.60	192.38	194.65	196.36	198.36	200.04	200.40
17	10.43	188.93	191.14	192.92	194.56	195.95	196.70
18	11.36	181.28	181.92	182.13	182.94	183.49	182.65
19	14.65	345.69	344.41	347.66	349.90	352.39	355.35
20	13.75	333.12	335.84	338.99	341.70	344.57	346.35
21	4.87	95.36	95.78	96.54	97.57	97.91	99.00
22	9.47	156.37	158.04	157.63	159.29	160.02	160.70
23	4.92	127.54	127.82	128.54	129.89	130.63	131.60
24	5.73	127.42	128.18	128.74	129.95	130.09	131.40
25	5.57	100.70	101.23	101.33	102.90	103.14	103.95
26	3.27	31.10	31.61	31.83	32.24	32.73	34.45
27	4.19	42.88	43.30	43.67	44.08	45.05	45.90
28	4.03	48.98	52.22	54.92	57.88	61.17	65.55
29	1.63	94.17	100.11	105.47	111.11	116.90	122.25
30	3.39	40.72	43.17	45.06	47.43	49.57	51.00
31	4.37	51.67	51.56	52.01	53.14	54.29	51.95
32	3.32	29.49	29.40	29.72	30.03	30.68	31.05

APPENDIX G (continued)

Face Length Sizing Programs - Female
Regression Equation Method

RESULTS FOR 2-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 90.50- 105.50 (MIDPOINT = 98.00)
 SIZE NO. = 2 RANGE = 105.50- 120.50 (MIDPOINT = 113.00)

			S.D.	MEAN #1	MEAN #2
1	1	AGE	6.39	21.28	24.26
2	2	WEIGHT	16.29	121.34	132.09
3	7	STATURE	58.96	1599.31	1638.64
4	96	HEAD LENGTH	6.62	181.25	186.42
5	97	HEAD BREADTH	5.90	143.75	146.29
6	98	HEAD CIRCUMFERENCE	15.93	542.67	553.51
7	99	TRAGION-TOP HEAD	7.59	125.60	128.59
8	100	ECTOCANTHUS-TOP HD	9.17	116.59	118.51
9	101	PRONASALE-TOP HEAD	11.65	145.20	149.55
10	102	SUBNASALE-TOP HEAD	10.89	156.52	161.23
11	103	STOMION-TOP HEAD	11.07	174.81	181.06
12	104	MENTON-TOP HEAD	10.89	212.65	224.28
13	105	TRAGION TO WALL	8.96	100.12	103.02
14	106	ECTOCANTHUS-WALL	9.58	160.98	165.82
15	107	PRONASALE TO WALL	9.44	208.51	214.63
16	108	SUBNASALE TO WALL	9.72	194.01	198.75
17	109	LIP PROTRUSION-WALL	10.51	190.63	194.94
18	110	MENTON TO WALL	11.36	181.71	182.84
19	111	SAGITTAL CURVATURE	14.78	344.47	350.61
20	112	BITRAGION-CORONAL	13.88	335.10	342.56
21	113	BIOCULAR BREADTH	4.89	95.66	97.59
22	114	BIAURICULAR BREADTH	9.48	157.34	159.14
23	115	BITRAGION BREADTH	4.96	127.63	129.91
24	116	BIZYGOMATIC BREADTH	5.75	127.87	129.90
25	117	BIGONIAL BREADTH	5.60	100.81	102.72
26	118	NASAL BREADTH	3.29	31.35	32.42
27	119	LIP LENGTH	4.19	43.05	44.38
28	120	MENTON-SUBNASALE L	4.56	51.04	58.96
29	121	MENTON-SELLION LTH	4.33	98.00	113.00
30	122	SUBNASALE-SELLION	3.73	42.18	48.13
31	123	EAR LENGTH	4.41	51.36	53.18
32	124	EAR BREADTH	3.32	29.29	30.23

RESULTS FOR 3-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 89.50- 101.50 (MIDPOINT = 95.50)
 SIZE NO. = 2 RANGE = 101.50- 113.50 (MIDPOINT = 107.50)
 SIZE NO. = 3 RANGE = 113.50- 125.50 (MIDPOINT = 119.50)

			S.D.	MEAN #1	MEAN #2	MEAN #3
1	1	AGE	6.37	20.78	23.17	25.55
2	2	WEIGHT	16.19	119.55	128.15	136.75
3	7	STATURE	58.56	1592.76	1624.22	1655.68
4	96	HEAD LENGTH	6.56	180.39	184.52	188.66
5	97	HEAD BREADTH	5.89	143.33	145.36	147.39
6	98	HEAD CIRCUMFERENCE	15.82	540.86	549.53	558.21
7	99	TRAGION-TOP HEAD	7.58	125.11	127.49	129.88
8	100	ECTOCANTHUS-TOP HO	9.17	116.27	117.80	119.34
9	101	PROMASALE-TOP HEAD	11.62	144.48	147.96	151.44
10	102	SUBNASALE-TOP HEAD	10.86	155.73	159.51	163.28
11	103	STOMION-TOP HEAD	11.01	173.77	178.77	183.76
12	104	MENTON-TOP HEAD	10.70	210.71	220.01	229.32
13	105	TRAGION TO WALL	8.95	99.64	101.96	104.28
14	106	ECTOCANTHUS-WALL	9.55	160.18	164.05	167.92
15	107	PROMASALE TO WALL	9.38	207.49	212.38	217.28
16	108	SUBNASALE TO WALL	9.68	193.22	197.01	200.80
17	109	LIP PROTRUSION-WALL	10.49	189.91	193.36	196.81
18	110	MENTON TO WALL	11.35	181.52	182.42	183.32
19	111	SAGITTAL CURVATURE	14.74	343.45	348.36	353.26
20	112	BITRAGION-CORONAL	13.82	333.86	339.83	345.80
21	113	BIOCULAR BREADTH	4.88	95.34	96.88	98.42
22	114	BIAURICULAR BROTH	9.48	157.04	158.48	159.92
23	115	BITRAGION BREADTH	4.94	127.25	129.08	130.90
24	116	BIZYGOMATIC BRDTH	5.74	127.53	129.16	130.78
25	117	BIGONIAL BREADTH	5.59	100.49	102.02	103.54
26	118	NASAL BREADTH	3.28	31.17	32.03	32.89
27	119	LIP LENGTH	4.19	42.83	43.89	44.95
28	120	MENTON-SUBNASALE L	4.35	49.72	56.05	62.39
29	121	MENTON-SELLION LTH	3.46	95.50	107.50	119.50
30	122	SUBNASALE-SELLION	3.58	41.19	45.95	50.72
31	123	EAR LENGTH	4.40	51.06	52.52	53.97
32	124	EAR BREADTH	3.32	29.14	29.89	30.64

RESULTS FOR 4-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 85.50- 94.50 (MIDPOINT = 90.00)
 SIZE NO. = 2 RANGE = 94.50- 103.50 (MIDPOINT = 99.00)
 SIZE NO. = 3 RANGE = 103.50- 112.50 (MIDPOINT = 108.00)
 SIZE NO. = 4 RANGE = 112.50- 121.50 (MIDPOINT = 117.00)

	S.D.	MEAN #1	MEAN #2	MEAN #3	MEAN #4
1 AGE	6.36	19.69	21.48	23.27	25.06
2 HEIGHT	16.10	115.61	122.06	128.51	134.96
3 STATURE	58.25	1578.34	1601.93	1625.53	1649.12
4 HEAD LENGTH	6.51	176.49	181.59	184.69	187.79
5 HEAD BREADTH	5.87	142.40	143.92	145.44	146.97
6 HEAD CIRCUMFERENCE	15.73	536.88	543.39	549.89	556.40
7 FRAGION-TOP HEAD	7.56	124.01	125.80	127.59	129.38
8 ECTOCANTHUS-TOP HD	9.16	115.57	116.72	117.87	119.02
9 101 PRONASALE-TOP HEAD	11.60	142.88	145.49	148.10	150.71
10 102 SUBNASALE-TOP HEAD	10.84	154.01	156.83	159.66	162.49
11 103 STOMION-TOP HEAD	10.97	171.48	175.23	178.98	182.72
12 104 MENTON-TOP HEAD	10.55	206.44	213.42	220.40	227.38
13 105 FRAGION TO WALL	8.94	98.58	100.32	102.06	103.80
14 106 ECTOCANTHUS-WALL	9.52	158.40	161.31	164.21	167.12
15 107 PRONASALE TO WALL	9.34	205.25	208.92	212.59	216.26
16 108 SUBNASALE TO WALL	9.66	191.48	194.32	197.17	200.01
17 109 LIP PROTRUSION-WALL	10.46	188.33	190.92	193.50	196.09
18 110 MENTON TO WALL	11.35	181.11	181.79	182.46	183.14
19 111 SAGITTAL CURVATURE	14.71	341.20	344.88	348.56	352.24
20 112 BITRAGION-CORONAL	13.77	331.12	335.60	340.08	344.55
21 113 BIOCULAR BREADTH	4.87	94.54	95.79	96.95	98.10
22 114 BIAURICULAR BREADTH	9.47	156.38	157.46	158.54	159.62
23 115 BITRAGION BREADTH	4.93	126.42	127.78	129.15	130.52
24 116 BIZYGOMATIC BREADTH	5.73	126.78	126.00	129.22	130.45
25 117 BIGONIAL BREADTH	5.58	99.80	100.94	102.08	103.22
26 118 NASAL BREADTH	3.28	30.78	31.42	32.07	32.71
27 119 LIP LENGTH	4.18	42.35	43.14	43.94	44.73
28 120 MENTON-SUBNASALE L	4.18	46.82	51.57	56.32	61.07
29 121 MENTON-SELLION LTH	2.60	90.00	99.00	108.00	117.00
30 122 SUBNASALE-SELLION	3.46	39.00	42.58	46.15	49.72
31 123 EAR LENGTH	4.39	50.40	51.49	52.58	53.67
32 124 EAR BREADTH	3.31	26.79	29.36	29.92	30.48

RESULTS FOR 5-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 89.50- 96.50 (MIDPOINT = 93.00)
 SIZE NO. = 2 RANGE = 96.50- 103.50 (MIDPOINT = 100.00)
 SIZE NO. = 3 RANGE = 103.50- 110.50 (MIDPOINT = 107.00)
 SIZE NO. = 4 RANGE = 110.50- 117.50 (MIDPOINT = 114.00)
 SIZE NO. = 5 RANGE = 117.50- 124.50 (MIDPOINT = 121.00)

	S.D.	MEAN #1	MEAN #2	MEAN #3	MEAN #4	MEAN #5
1	6.35	20.29	21.68	23.07	24.46	25.85
2	16.05	117.76	122.78	127.79	132.81	137.83
3	58.10	1586.20	1694.55	1622.91	1641.26	1659.61
4	6.49	179.52	181.94	184.35	186.76	189.17
5	5.87	142.93	144.09	145.28	146.46	147.65
6	15.69	539.05	544.11	549.17	554.23	559.29
7	7.55	124.61	126.00	127.39	128.79	130.18
8	9.16	115.95	116.84	117.74	118.63	119.53
9	11.59	143.75	145.78	147.81	149.84	151.87
10	10.83	154.95	157.15	159.35	161.55	163.75
11	10.95	172.73	175.65	178.56	181.47	184.39
12	10.48	208.77	214.20	219.62	225.05	230.48
13	8.93	99.16	100.51	101.86	103.22	104.57
14	9.50	159.37	161.63	163.89	166.15	168.41
15	9.31	206.47	209.33	212.18	215.04	217.89
16	9.64	182.43	194.64	196.85	199.06	201.27
17	10.45	189.19	191.20	193.22	195.23	197.24
18	11.35	181.34	181.86	182.39	182.91	183.44
19	14.70	342.43	345.29	348.15	351.01	353.88
20	13.75	332.61	336.10	339.58	343.06	346.54
21	4.86	95.02	95.92	96.82	97.72	98.62
22	3.47	156.74	157.58	158.42	159.26	160.10
23	4.92	126.87	127.94	129.00	130.07	131.13
24	5.73	127.19	128.14	129.09	130.04	130.99
25	5.58	100.18	101.07	101.95	102.84	103.73
26	3.27	30.99	31.49	31.99	32.50	33.00
27	4.18	42.61	43.23	43.85	44.47	45.08
28	4.09	48.40	52.09	55.79	59.48	63.18
29	2.02	93.00	100.00	107.00	114.00	121.00
30	3.40	40.19	42.97	45.75	48.53	51.31
31	4.38	50.76	51.81	52.45	53.30	54.15
32	3.31	28.98	29.42	29.86	30.29	30.73

RESULTS FOR 6-SIZE SYSTEM (REGRESSION EQUATION METHOD)

SIZE NO. = 1 RANGE = 90.50- 96.50 (MIDPOINT = 93.50)
 SIZE NO. = 2 RANGE = 96.50- 102.50 (MIDPOINT = 99.50)
 SIZE NO. = 3 RANGE = 102.50- 108.50 (MIDPOINT = 105.50)
 SIZE NO. = 4 RANGE = 108.50- 114.50 (MIDPOINT = 111.50)
 SIZE NO. = 5 RANGE = 114.50- 120.50 (MIDPOINT = 117.50)
 SIZE NO. = 6 RANGE = 120.50- 126.50 (MIDPOINT = 123.50)

	S.O.	MEAN #1	MEAN #2	MEAN #3	MEAN #4	MEAN #5	MEAN #6
1	6.35	20.39	21.58	22.77	23.96	25.16	26.35
2	16.04	118.12	122.42	126.72	131.02	135.32	139.62
3	58.03	1527.51	1603.24	1618.97	1634.70	1650.43	1666.16
4	6.48	179.70	181.76	183.83	185.90	187.97	190.03
5	5.86	142.99	144.01	145.02	146.04	147.05	148.07
6	15.67	539.41	543.75	548.09	552.42	556.76	561.10
7	7.55	124.71	125.90	127.10	128.29	129.48	130.67
8	9.16	118.01	116.78	117.55	118.31	119.08	119.85
9	11.59	143.90	145.64	147.38	149.12	150.86	152.60
10	10.82	155.11	156.99	158.88	160.76	162.65	164.53
11	10.94	172.94	175.44	177.93	180.43	182.93	185.43
12	10.44	209.16	213.81	218.46	223.11	227.77	232.42
13	8.93	99.25	100.41	101.57	102.73	103.89	105.05
14	9.50	159.53	161.47	163.40	165.34	167.28	169.21
15	9.30	206.67	209.12	211.57	214.02	216.46	218.91
16	9.64	192.58	194.48	196.38	198.27	200.17	202.06
17	10.45	189.33	191.06	192.79	194.51	196.24	197.96
18	11.35	181.37	181.82	182.27	182.72	183.17	183.62
19	14.69	342.63	345.09	347.54	349.99	352.44	354.90
20	13.74	332.86	335.95	338.03	341.82	344.80	347.79
21	4.86	95.09	95.86	96.63	97.40	98.17	98.94
22	9.47	156.80	157.52	158.24	158.96	159.68	160.40
23	4.92	126.95	127.86	128.77	129.69	130.60	131.51
24	5.73	127.26	128.07	128.88	129.70	130.51	131.33
25	5.57	100.24	101.00	101.76	102.53	103.29	104.05
26	3.27	31.03	31.46	31.89	32.32	32.75	33.18
27	4.18	42.56	43.19	43.72	44.24	44.77	45.30
28	4.05	48.66	51.83	55.00	58.16	61.33	64.50
29	1.73	93.50	99.50	105.50	111.50	117.50	123.50
30	3.38	40.39	42.77	45.16	47.54	49.92	52.30
31	4.38	50.82	51.55	52.27	53.00	53.73	54.45
32	3.31	29.01	29.39	29.76	30.14	30.51	30.89