

ANTHROPOMETRIC INDICES AMONG U. S. NAVY SUBMARINERS

by

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# ABSTRACT

As part of the Longitudinal Health Study conducted on a group of 1,017 U.S. Navy submariners eighteen anthropometric measurements were taken and are presented as statistical summaries. This information on the characteristics of submariner physical build can be incorporated into new designs for submarine equipment, e.g. consoles, berthing spaces, etc., and can also be used in future epidemiologic studies of submariner health.

## SUMMARY PAGE

### THE PROBLEMS

Anthropometry, the science of measuring the human body, is useful in describing a person's body build in order to design equipment and machine interfaces to match human body form. It can also be used in estimating body composition in terms of relative fat tissue and lean tissue masses. This body composition ratio (fat/lean) is considered to be an indicator of general health and performance capability.

No large investigation of U.S. Navy submariner anthropometry has been published. Data on anthropometric indices can contribute to the resolution of operational, engineering and medical problems confronting Navy submariners.

### THE FINDINGS

Eighteen anthropometric indices obtained during the Longitudinal Health Survey from 1972 to 1977 have been analyzed from a cohort of 1017 submariners. These submariners represent the full spectrum of Naval submariner occupational categories. Statistical analysis is presented for each anthropometric index.

### APPLICATION

This information can be applied to the design of submarines and equipment, to research into submariner performance, and to human factors research. It can also be incorporated into epidemiologic studies of submariner health, and can contribute toward the periodic evaluation of physical standards for military submarine personnel.

### ADMINISTRATIVE INFORMATION

The initial data analysis of this work was supported by the Naval Medical Command, Navy Medical Research and Development Command Work Unit No. MR00001.01-5078. It was submitted for review on 16 Feb 1989, cleared for publication on 11 April 1989, and designated NSMRL Report No. 1135.

Military anthropometry has been extensively investigated among U.S. Army and Marine Corps male and female personnel (1-2) and Naval aviators (3). However, submariners have not been specifically characterized in terms of anthropometric indices.

From 1972-1978, the Naval Submarine Medical Research Laboratory, Groton, Connecticut conducted the initial phase of a Longitudinal Health Survey on a cohort of 1,017 U.S. Navy submariners. The survey collected physical and historical information on fourteen multiphasic health profiles obtained during the initial examination of each submariner. Anthropometry was included for several reasons. First, there had, up to that time, been no large-scale anthropometric studies published of U.S. Navy submariners, and other reports discussing associations between morbidity and physical characteristics considered few measures of body build or stature. Second, additional information on the characteristics of submariner build could be incorporated into new designs for submarine equipment, particularly, engineering and weapon system consoles, berthing spaces, passageways, and compartment hatches and protective equipment. Finally, data collected on submarine anthropometrics could be used in future epidemiologic studies of submariner health, to examine associations between anthropometry and risk of chronic diseases (e.g. coronary artery disease and diabetes mellitus), acute morbidity (e.g., musculoskeletal disorders such as low back pain), and other submarine-related physical problems.

## METHOD

### The Cohort

The 1972-1978 Longitudinal Health Survey has been described elsewhere (4-5). This cohort was a non-random sample, as all who volunteered were accepted into the study. The cohort was nevertheless considered representative of the total Navy submarine population, based on its distribution by rank, rate, and paygrade. The ages of the submariners were recorded as of their last birthday. The mean age of the total population was 28.04 years. The standard deviation was 5.90 years, giving a coefficient of variation of 21.0 percent. The distribution and statistical values of age are given in Table I.

### The Measures

The eighteen anthropometric measures are given in Tables 2 to 19. They were recommended by Mr. Robert White of the U.S. Army Research Institute of Environmental Medicine, Natick, Mass. All measurements were taken by the same examiner, who was trained by White. Weight was recorded on spring scales (Detecto Model 419). Circumferences were measured with Swiss manufactured GPM anthropometers. Foot length was measured in a measuring box constructed at Naval Submarine Medical Research Laboratory. Skinfold thickness determinations were made with Lange MODEL skinfold calipers.

## THE STATISTICAL PROCEDURES

The statistical and computational procedures used in preparing this report are the same as those used in the analyses of the data from the 1966 survey of U.S. Army Soldiers by White, R.M., and Churchill, E. (2), from which, for purposes of comparability, the descriptions of the statistical procedures are taken.

The Standard Measures. The usefulness of any anthropometric survey depends in large measure on the extent to which the mass of data generated is translated by statistical analysis into summaries of value in the solution of design and related problems and which point up the important implications of the data.

The summary statistics provided here for each anthropometric variable are those which traditionally have been included in the U.S. Military anthropometric reports. Measures of skewness and kurtosis have been added to the list of summary statistics.

The statistical summaries have been chosen in the belief that they provide the simplest and most generally useful univariate summaries of the total data. As valuable as these statistics may prove to be, they contain only a small portion of the useful information embodied in the survey data.

The means, standard deviations, standard errors are listed in both metric and English unit limits. The statistics are given first (to the left of the statistics name in the tables) in the type of units in which the data were measured and then in the converted units. The interval in the frequency tables follow the same order.

## RESULTS AND DISCUSSION

Tables 2-19 give the detailed findings. They are presented in a descriptive format and can serve as a reference for interested personnel in the fields of human factors, clothing and uniform design, submarine medicine, environmental physiology, submarine equipment design, Naval submarine operations, and epidemiology.

This information can be of assistance in the design of submarines and equipment. It can also characterize population of submariners on the basis of body build and limb dimensions, and on the amounts of subcutaneous fat at various body sites. This latter information can be used in epidemiologic studies which try to relate risk for certain diseases and occupational injuries to multiphase health variables. Results from these studies can also be incorporated into defining standards for physical qualification for submariners.

$$\begin{array}{ccc} \text{Measures of Skewness} & \frac{\sum (X - \bar{X})^3}{N \cdot SD^3} & \text{and} \quad \text{Kurtosis} \quad \frac{\sum (x - \bar{x})^4}{N \cdot SD^4} \end{array}$$

have been added to the list of summary statistics to provide a basis for judging the level of agreement between the normal distribution and the active distribution of the data, and a frequency distribution of each variable is also presented.

#### REFERENCES

1. White, RM. United States Army Anthropometry: 1946-1977. Technical Report Natick/TR-79/007. U.S. Army Natick Research and Development Command, Natick, Mass., July 1978.
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3. Oberman, A, Mitchell, RE, Graybiel, A. Thousand Aviator Study Methodology. Monograph 11. U.S. Naval School of Aviation Medicine, Pensacola, FL, July 1965.
4. Sawyer, RN, Baker, JH. The Longitudinal Health Survey: I. Description. Naval Submarine Medical Research Laboratory Report No. 733. Groton, CT, December 1972.
5. Tansey, WA. The Longitudinal Health Study: A Multiphasic Medical Surveillance Program for U.S. Navy Submarine and Diving Personnel. Naval Submarine Medical Research Laboratory Report No. 786. Groton, CT, May 1974.

#### ACKNOWLEDGMENTS

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TABLE 1  
SUBMARINER ANTHROPOMETRICS

AGE

N = 1016

The Percentiles

| <u>Years</u> | <u>%ile</u> |
|--------------|-------------|
| 42           | 99th        |
| 41           | 98th        |
| 40           | 97th        |
| 39           | 95th        |
| 37           | 90th        |
| 35           | 85th        |
| 34           | 80th        |
| 33           | 75th        |
| 32           | 70th        |
| 30           | 65th        |
| 30           | 60th        |
| 29           | 55th        |
| 28           | 50th        |
| 27           | 45th        |
| 26           | 40th        |
| 25           | 35th        |
| 25           | 30th        |
| 24           | 25th        |
| 23           | 20th        |
| 22           | 15th        |
| 21           | 10th        |
| 21           | 5th         |
| 20           | 3rd         |
| 20           | 2nd         |
| 20           | 1st         |

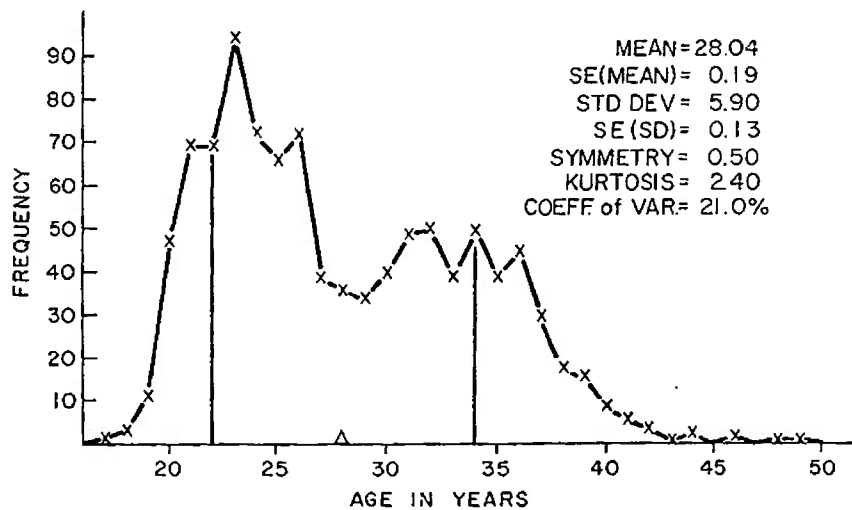


Table 2

## WEIGHT

Subject is weighed while wearing only undershorts. The unit of measures is kilograms.

N = 1016

The Percentiles

| <u>Kilograms</u> | <u>%ile</u> | <u>Pounds</u> |
|------------------|-------------|---------------|
| 118.35           | 99th        | 260.91        |
| 112.04           | 98th        | 247.01        |
| 108.41           | 97th        | 239.01        |
| 103.88           | 95th        | 229.01        |
| 97.66            | 90th        | 215.01        |
| 93.87            | 85th        | 206.96        |
| 91.08            | 80th        | 200.79        |
| 88.77            | 75th        | 195.70        |
| 86.78            | 70th        | 195.70        |
| 85.00            | 65th        | 191.33        |
| 83.36            | 60th        | 183.77        |
| 81.80            | 55th        | 180.33        |
| 80.29            | 50th        | 177.00        |
| 78.80            | 45th        | 173.72        |
| 77.32            | 40th        | 170.47        |
| 75.82            | 35th        | 167.15        |
| 74.26            | 30th        | 163.71        |
| 72.60            | 25th        | 160.05        |
| 70.77            | 20th        | 156.03        |
| 68.71            | 15th        | 151.48        |
| 66.19            | 10th        | 145.93        |
| 63.33            | 5th         | 139.61        |
| 60.59            | 3rd         | 133.57        |
| 59.17            | 2nd         | 130.44        |
| 57.19            | 1st         | 126.08        |

SUBMARINER ANTHROPOMETRICS-WEIGHT  
N=1016

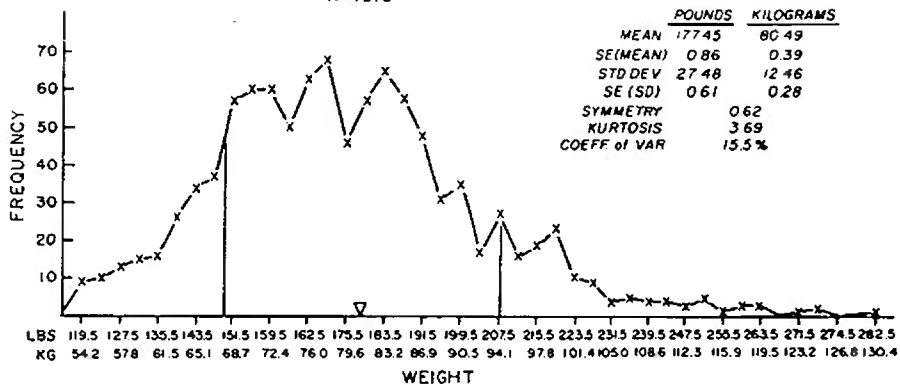
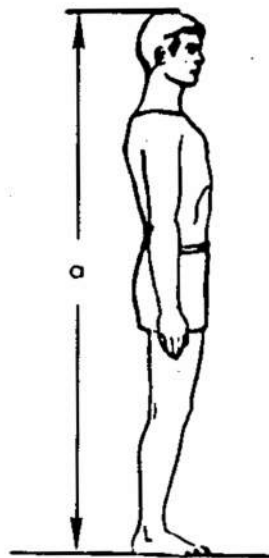


Table 3

## STATURE

Subject stands erect, with heels, together and head level. Height is measured as the vertical distance from the top of the head (vertical). The unit of measure is centimeters.

N = 1017

The Percentiles

a. Stature

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 194.19      | 99th | 76.45  |
| 191.74      | 99th | 75.49  |
| 190.32      | 97th | 74.92  |
| 188.49      | 95th | 74.21  |
| 185.91      | 90th | 73.19  |
| 184.91      | 90th | 72.54  |
| 182.98      | 85th | 72.04  |
| 181.88      | 75th | 71.61  |
| 180.91      | 70th | 71.22  |
| 179.15      | 65th | 70.87  |
| 178.31      | 60th | 70.53  |
| 177.48      | 55th | 70.20  |
| 176.64      | 50th | 69.87  |
| 175.79      | 45th | 69.54  |
| 174.90      | 40th | 69.21  |
| 173.95      | 30th | 68.86  |
| 172.92      | 25th | 68.08  |
| 171.76      | 20th | 67.62  |
| 170.42      | 15th | 67.10  |
| 168.74      | 10th | 66.43  |
| 166.65      | 5th  | 65.61  |
| 164.82      | 3rd  | 64.89  |
| 163.78      | 2nd  | 64.48  |
| 162.30      | 1st  | 63.90  |

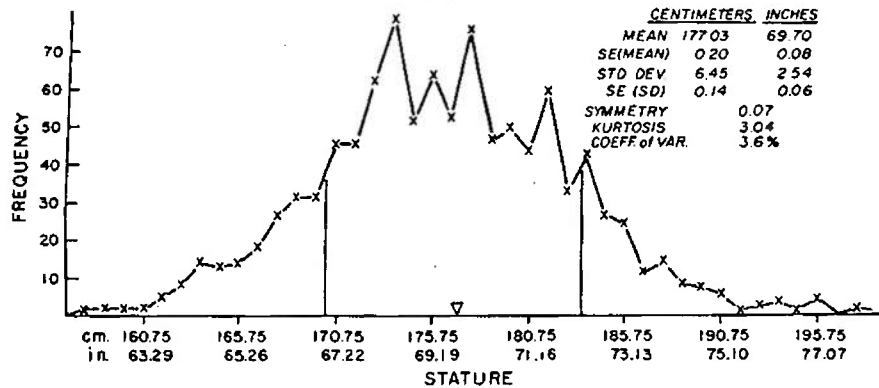
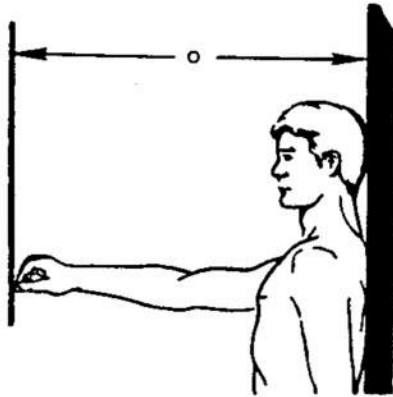
SUBMARINER ANTHROPOMETRICS - STATURE  
N = 1017

Table 4

## SUBMARINER ANTHROPOMETRICS

## FUNCTIONAL REACH

Subject stands erect against a wall, with his scapulae touching the wall. His right arm is extended forward horizontally, with the tips of his thumb and index fingers pressed together. Functional reach is measured as the horizontal distance from the wall to the outer edge of the junction of the tips of the thumb and index fingers. The unit of measure is centimeters.



o. Functional Reach

The Percentiles

| <u>Centimeters</u> | <u>%ile</u> | <u>Inches</u> |
|--------------------|-------------|---------------|
| 89.75              | 99th        | 35.33         |
| 88.45              | 98th        | 34.82         |
| 87.61              | 97th        | 34.49         |
| 86.47              | 95th        | 34.03         |
| 84.70              | 90th        | 33.35         |
| 83.52              | 85th        | 32.88         |
| 82.60              | 80th        | 32.52         |
| 82.81              | 75th        | 32.21         |
| 81.14              | 70th        | 31.94         |
| 80.51              | 65th        | 31.70         |
| 79.92              | 60th        | 31.47         |
| 79.36              | 55th        | 31.25         |
| 78.82              | 50th        | 31.03         |
| 78.28              | 45th        | 30.82         |
| 77.74              | 40th        | 30.60         |
| 77.18              | 35th        | 30.39         |
| 76.60              | 30th        | 30.39         |
| 75.98              | 25th        | 30.16         |
| 75.29              | 20th        | 29.91         |
| 74.48              | 15th        | 29.92         |
| 73.46              | 10th        | 28.92         |
| 72.11              | 5th         | 28.39         |
| 70.82              | 3rd         | 27.88         |
| 69.99              | 2nd         | 27.56         |
| 68.61              | 1st         | 27.01         |

## LHS SUBMARINE - ANTHROPOMETRICS

## FUNCTIONAL REACH

N = 1017

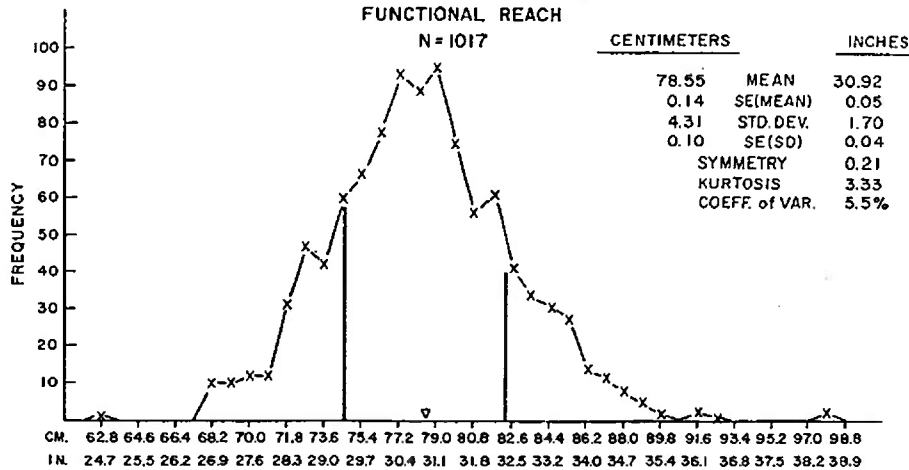


TABLE 5

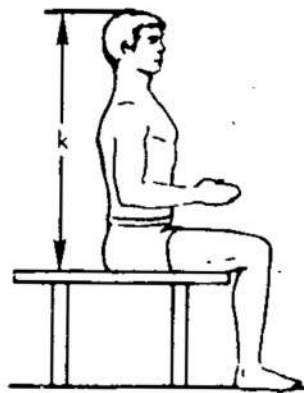
## SUBMARINER ANTHROPOMETRICS

## SITTING HEIGHT

Subject sits erect with head level and with feet resting on the floor. The seat is adjusted so that his knees are bent at right angles. Sitting height is measured as the vertical distance from the sitting surface to the top of the head (vertex). The unit of measure is centimeters.

N = 1017

## The Percentiles



k. Sitting Height

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 100.35      | 99th | 39.51  |
| 99.43       | 98th | 39.15  |
| 98.86       | 97th | 38.92  |
| 98.11       | 95th | 38.62  |
| 96.95       | 90th | 38.17  |
| 96.17       | 85th | 37.86  |
| 95.54       | 80th | 37.61  |
| 94.94       | 75th | 37.40  |
| 94.49       | 70th | 37.20  |
| 94.02       | 65th | 37.02  |
| 93.57       | 60th | 36.84  |
| 93.12       | 55th | 36.66  |
| 92.68       | 50th | 36.49  |
| 92.23       | 45th | 36.31  |
| 91.76       | 40th | 36.13  |
| 91.28       | 35th | 36.13  |
| 90.76       | 30th | 35.49  |
| 90.18       | 25th | 35.73  |
| 89.54       | 20th | 35.51  |
| 88.78       | 15th | 35.25  |
| 87.80       | 10th | 34.95  |
| 86.52       | 5th  | 34.06  |
| 85.40       | 3rd  | 33.62  |
| 84.71       | 2nd  | 33.35  |
| 83.65       | 1st  | 32.93  |

## LHS SUBMARINE -- ANTHROPOMETRICS

## SITTING HEIGHT

N = 1017

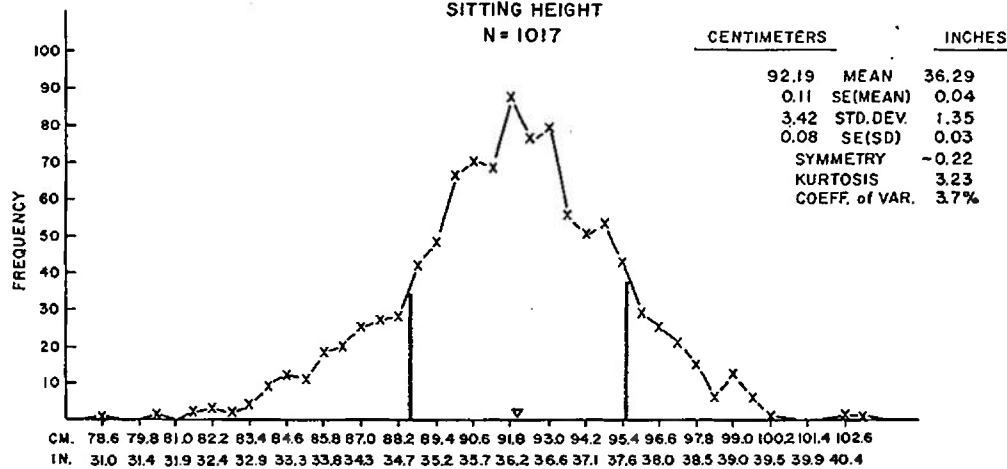


TABLE 6

## SUBMARINER ANTHROPOMETRICS

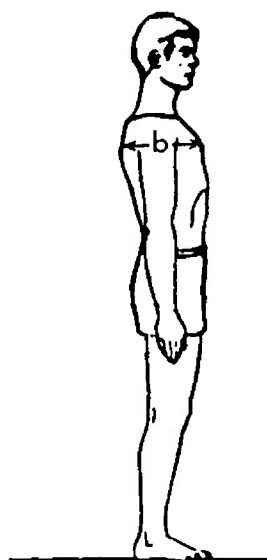
## CHEST DEPTH

Subject stands erect with his arms initially raised and then lowered after the anthropometer is in place under the right arm. The depth of the chest is measured at the level of the nipples during normal breathing. The unit of measure is centimeters.

N = 1017

The Percentiles

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 30.67       | 99th | 12.07  |
| 29.82       | 98th | 11.74  |
| 29.31       | 97th | 11.54  |
| 28.65       | 95th | 11.28  |
| 27.69       | 90th | 10.90  |
| 27.07       | 85th | 10.66  |
| 26.59       | 80th | 10.47  |
| 26.18       | 75th | 10.31  |
| 25.82       | 70th | 10.17  |
| 25.49       | 65th | 10.04  |
| 25.18       | 60th | 9.91   |
| 24.88       | 55th | 9.80   |
| 24.59       | 50th | 9.68   |
| 24.29       | 45th | 9.56   |
| 24.00       | 40th | 9.45   |
| 23.69       | 35th | 9.33   |
| 23.37       | 30th | 9.20   |
| 23.03       | 25th | 9.07   |
| 22.64       | 20th | 8.91   |
| 22.20       | 15th | 8.74   |
| 21.64       | 10th | 8.52   |
| 20.95       | 5th  | 8.25   |
| 20.31       | 3rd  | 8.00   |
| 19.95       | 2nd  | 7.85   |
| 19.39       | 1st  | 7.63   |



b. Chest Depth

## LHS SUBMARINE-ANTHROPOMETRICS

## CHEST DEPTH

N = 1017

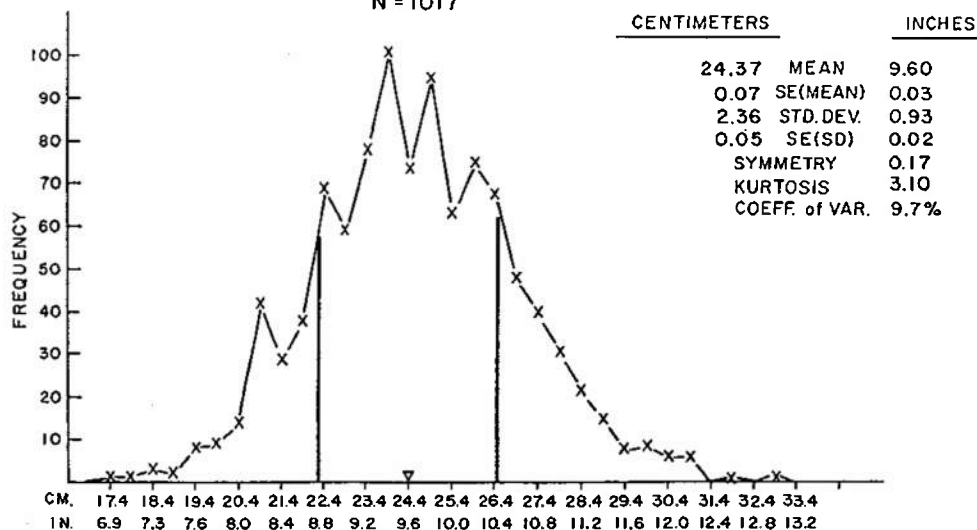
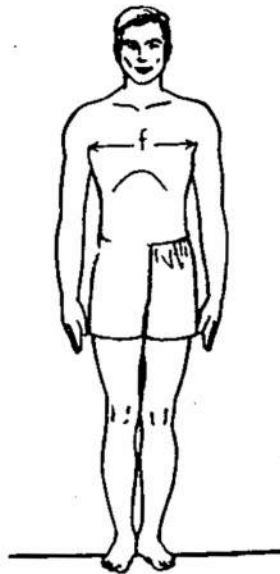


TABLE 7

## SUBMARINER ANTHROPOMETRICS

## CHEST BREADTH

Subject stands erect with his arm initially raised and then lowered after the anthropometer is in place. The breadth of the chest is measured at the level of the nipples during normal breathing. The unit of measure is centimeters.



f. Chest Breadth

## The Percentiles

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 41.40       | 99th | 16.30  |
| 40.55       | 98th | 15.97  |
| 40.00       | 97th | 15.75  |
| 39.26       | 95th | 15.01  |
| 38.12       | 90th | 15.46  |
| 37.36       | 85th | 14.71  |
| 36.77       | 80th | 14.48  |
| 36.27       | 75th | 14.28  |
| 35.82       | 70th | 14.10  |
| 35.42       | 65th | 13.95  |
| 35.04       | 60th | 13.80  |
| 34.69       | 55th | 13.66  |
| 34.34       | 50th | 13.52  |
| 33.99       | 45th | 13.38  |
| 33.65       | 40th | 13.25  |
| 33.30       | 35th | 13.11  |
| 32.94       | 30th | 13.97  |
| 32.55       | 25th | 12.81  |
| 32.12       | 20th | 12.65  |
| 31.64       | 15th | 12.46  |
| 31.03       | 10th | 12.22  |
| 30.29       | 5th  | 11.93  |
| 29.58       | 3rd  | 11.64  |
| 29.15       | 2nd  | 11.48  |
| 28.47       | 1st  | 11.21  |

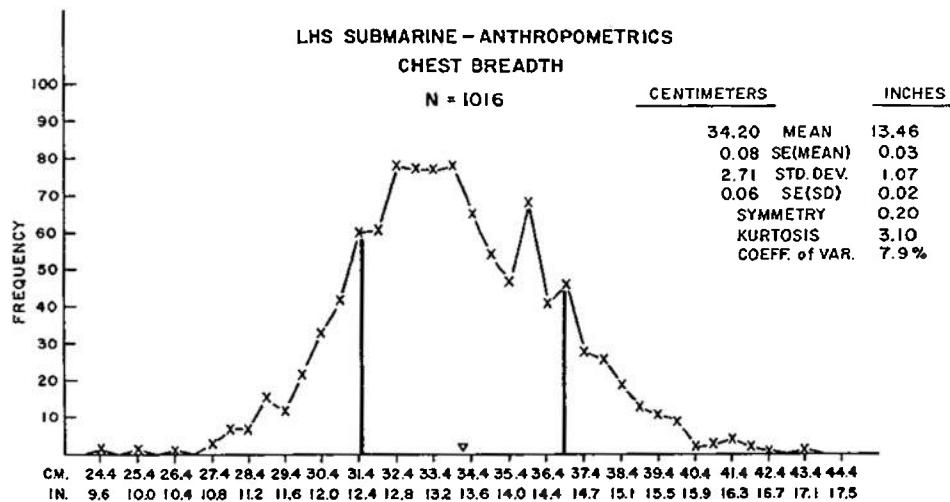


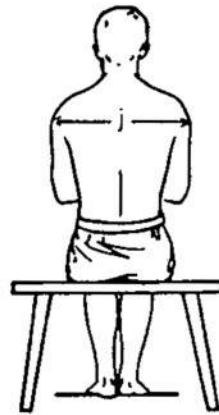
TABLE 8

## SUBMARINER ANTHROPOMETRICS

## SHOULDER BREADTH

Subject sits erect with his arms bent to form right angles at the elbows and with his elbows held against the body. The maximum breadth across the shoulders is measured at the level of the bulges of the deltoid muscles in the upper arms. The unit of measure is centimeters.

N = 1017

The Percentiles

J. Shoulder Breadth  
(Bideltoid Breadth)

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 55.43       | 99th | 21.79  |
| 54.38       | 98th | 21.41  |
| 53.78       | 97th | 21.17  |
| 52.99       | 95th | 20.86  |
| 51.80       | 90th | 20.40  |
| 51.04       | 85th | 20.09  |
| 50.45       | 80th | 19.86  |
| 49.96       | 75th | 19.67  |
| 49.53       | 70th | 19.50  |
| 49.14       | 65th | 19.35  |
| 48.78       | 60th | 19.21  |
| 48.44       | 55th | 19.07  |
| 48.11       | 50th | 18.94  |
| 47.78       | 45th | 18.81  |
| 47.45       | 40th | 18.68  |
| 47.12       | 35th | 18.55  |
| 46.77       | 30th | 18.42  |
| 46.40       | 25th | 18.27  |
| 45.99       | 20th | 18.11  |
| 45.51       | 15th | 17.92  |
| 44.91       | 10th | 17.68  |
| 44.13       | 5th  | 17.37  |
| 43.36       | 3rd  | 17.07  |
| 42.88       | 2nd  | 16.88  |
| 42.09       | 1st  | 16.57  |

## LHS SUBMARINE--ANTHROPOMETRICS

## SHOULDER BREADTH

N = 1017

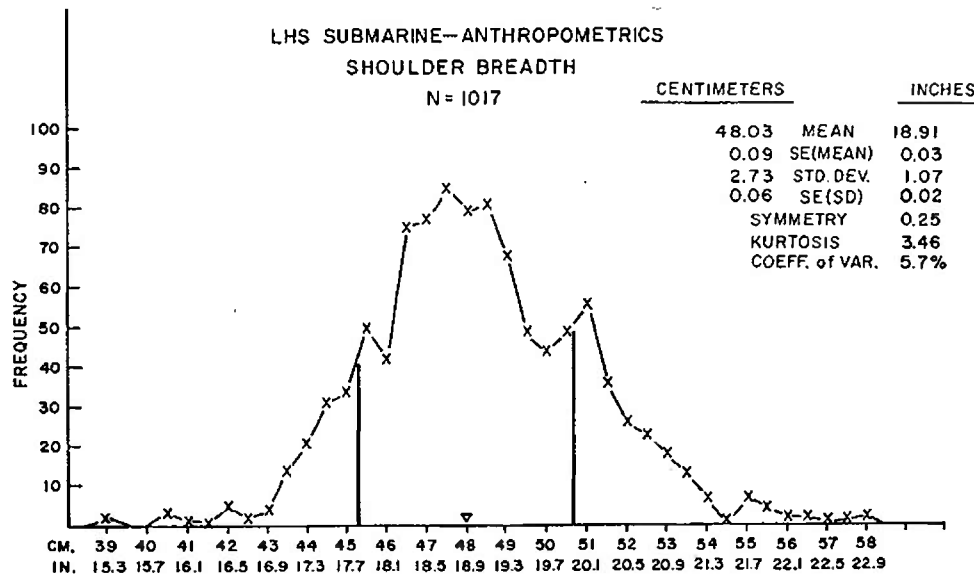
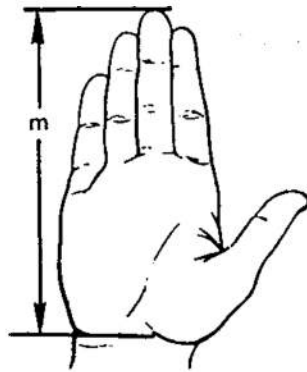


TABLE 9

## SUBMARINER ANTHROPOMETRICS

## HAND LENGTH

Subject sits with his right hand and fingers extended and palm p. The length of the right hand is measured from the wrist crease to the tip of the middle finger. The unit of measure is centimeters.



m. Hand Length

The Percentiles

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 21.17       | 99th | 8.34   |
| 20.98       | 98th | 8.26   |
| 20.85       | 97th | 8.21   |
| 20.65       | 95th | 8.13   |
| 20.32       | 90th | 8.00   |
| 20.10       | 85th | 7.91   |
| 19.91       | 80th | 7.84   |
| 19.76       | 75th | 7.78   |
| 19.61       | 70th | 7.72   |
| 19.49       | 65th | 7.67   |
| 19.36       | 60th | 7.62   |
| 19.25       | 55th | 7.58   |
| 19.13       | 50th | 7.53   |
| 19.02       | 45th | 7.49   |
| 18.91       | 40th | 7.44   |
| 18.79       | 35th | 7.40   |
| 18.67       | 30th | 7.35   |
| 18.55       | 25th | 7.30   |
| 18.41       | 20th | 7.25   |
| 18.24       | 15th | 7.18   |
| 18.04       | 10th | 7.10   |
| 17.78       | 5th  | 7.00   |
| 17.53       | 3rd  | 6.90   |
| 17.37       | 2nd  | 6.84   |
| 17.10       | 1st  | 6.73   |

## LHS SUBMARINE - ANTHROPOMETRICS

## HAND LENGTH

N = 1016

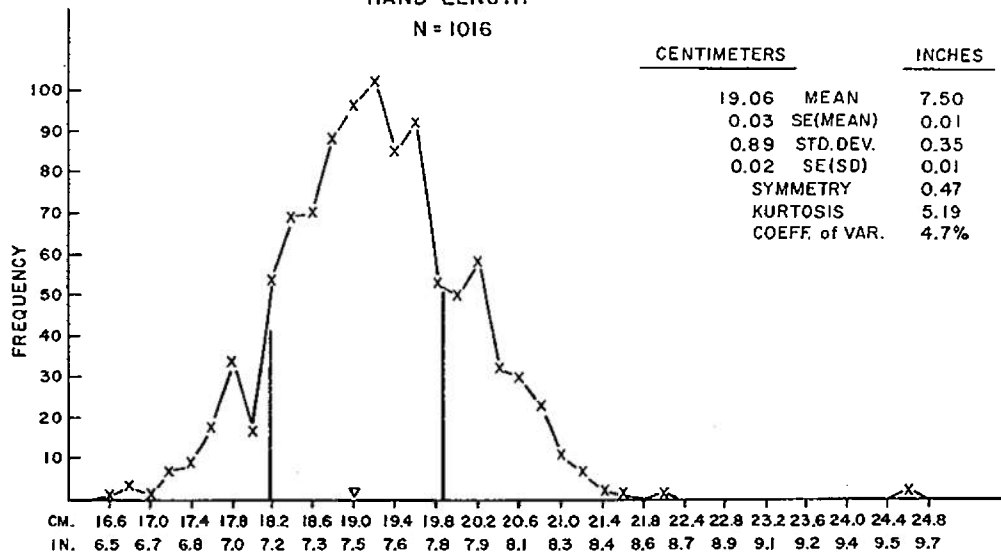
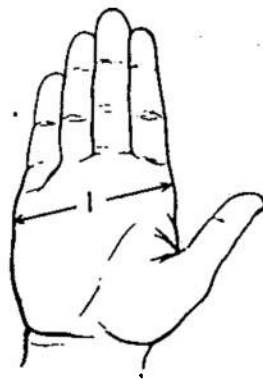


TABLE 10

## SUBMARINER ANTHROPOMETRICS

## HAND BREADTH

Subject sits with his right hand and fingers extended and palm up. The breadth of the hand is measured at the level of the knuckles (distal ends of the metacarpal bones). The unit of measure is centrimeters.



1. Hand Breadth.

## The Percentiles

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 10.12       | 99th | 3.98   |
| 9.98        | 98th | 3.93   |
| 9.89        | 97th | 3.89   |
| 9.77        | 95th | 3.85   |
| 9.60        | 90th | 3.78   |
| 9.48        | 85th | 3.73   |
| 9.40        | 80th | 3.70   |
| 9.32        | 75th | 3.67   |
| 9.25        | 70th | 3.64   |
| 9.19        | 65th | 3.62   |
| 9.13        | 60th | 3.59   |
| 9.07        | 55th | 3.57   |
| 9.01        | 50th | 3.55   |
| 8.95        | 45th | 3.53   |
| 8.90        | 40th | 3.50   |
| 8.84        | 35th | 3.48   |
| 8.78        | 30th | 3.46   |
| 8.71        | 25th | 3.43   |
| 8.64        | 20th | 3.40   |
| 8.55        | 15th | 3.37   |
| 8.45        | 10th | 3.33   |
| 8.33        | 5th  | 3.28   |
| 8.22        | 3rd  | 3.24   |
| 8.16        | 2nd  | 3.21   |
| 8.08        | 1st  | 3.18   |

## LHS SUBMARINE - ANTHROPOMETRICS

## HAND BREADTH

N=1016

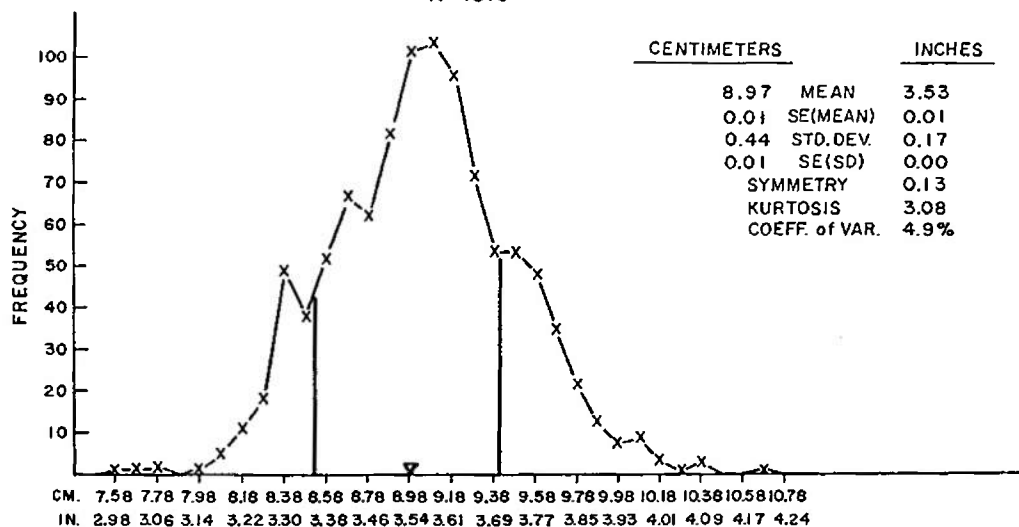


TABLE 11

## SUBMARINER ANTHROPOMETRICS

## FOOT LENGTH

Subject stands erect with his weight evenly distributed on both feet. The maximum length of the right foot is measured from the back of the heel to the tip of the longest toe. The unit of measure is centimeters.

N = 1017

The Percentiles

n. Foot Length

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 29.73       | 99th | 11.70  |
| 29.41       | 98th | 11.58  |
| 29.21       | 97th | 11.50  |
| 28.94       | 95th | 11.39  |
| 28.50       | 90th | 11.22  |
| 28.10       | 85th | 11.10  |
| 27.96       | 80th | 11.01  |
| 27.75       | 75th | 10.93  |
| 27.56       | 70th | 10.85  |
| 27.38       | 65th | 10.78  |
| 27.21       | 60th | 10.71  |
| 27.05       | 55th | 10.65  |
| 26.88       | 50th | 10.58  |
| 26.72       | 45th | 10.52  |
| 26.55       | 40th | 10.45  |
| 26.38       | 35th | 10.39  |
| 26.20       | 30th | 10.31  |
| 26.00       | 25th | 10.24  |
| 25.78       | 20th | 10.15  |
| 25.53       | 15th | 10.05  |
| 25.21       | 10th | 9.93   |
| 24.83       | 5th  | 9.78   |
| 24.50       | 3rd  | 9.65   |
| 24.31       | 2nd  | 9.57   |
| 24.04       | 1st  | 9.47   |

## LHS SUBMARINE - ANTHROPOMETRICS

## FOOT LENGTH

N = 1017

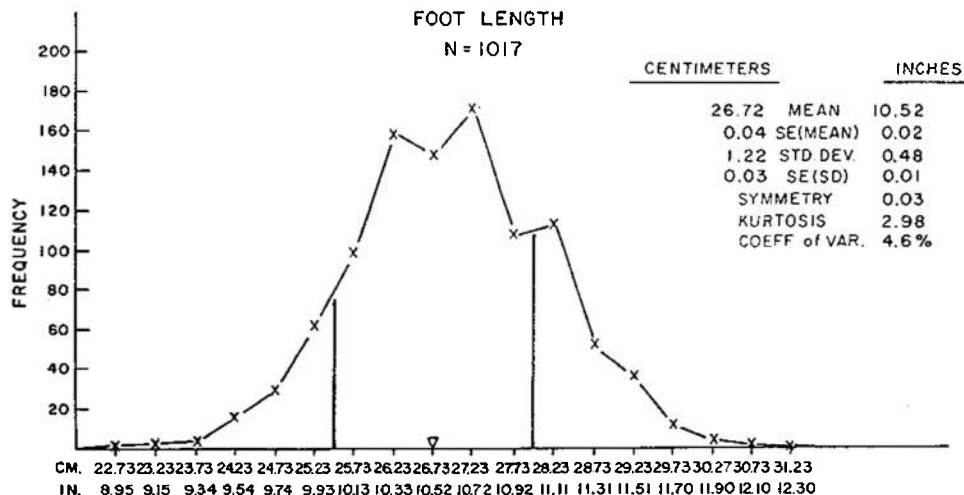
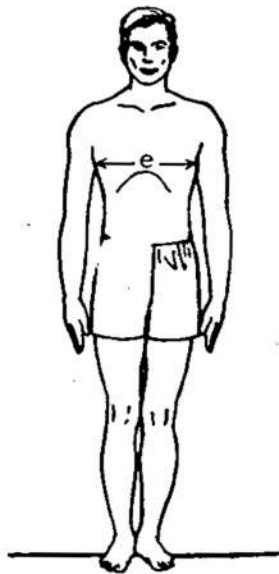


TABLE 12

## SUBMARINER ANTHROPOMETRICS

## CHEST CIRCUMFERENCE - INSPIRATION

Subject stands erect with his arms initially raised and then lowered after the tape is in place. The maximum horizontal circumference of the chest is measured at the level of the nipples at full inspiration. The unit of measure is centimeters.



e. Chest Circumference  
Inspiration

## The Percentiles

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 123.76      | 99th | 48.72  |
| 120.67      | 98th | 47.51  |
| 118.66      | 97th | 46.80  |
| 116.56      | 95th | 45.89  |
| 113.30      | 90th | 44.61  |
| 111.25      | 85th | 43.80  |
| 109.69      | 80th | 43.18  |
| 108.38      | 75th | 42.67  |
| 107.22      | 70th | 42.21  |
| 106.18      | 65th | 41.80  |
| 105.19      | 60th | 41.41  |
| 104.25      | 55th | 41.04  |
| 103.33      | 50th | 40.68  |
| 102.41      | 45th | 40.32  |
| 101.49      | 40th | 39.96  |
| 100.55      | 35th | 39.59  |
| 99.56       | 30th | 39.20  |
| 98.50       | 25th | 38.78  |
| 97.33       | 20th | 38.32  |
| 96.01       | 15th | 37.80  |
| 94.38       | 10th | 37.80  |
| 92.49       | 5th  | 37.16  |
| 90.76       | 3rd  | 35.73  |
| 89.85       | 2nd  | 35.37  |
| 88.59       | 1st  | 34.88  |

LHS SUBMARINE - ANTHROPOMETRICS  
CHEST CIRCUMFERENCE - INSPIRATION

N = 1014

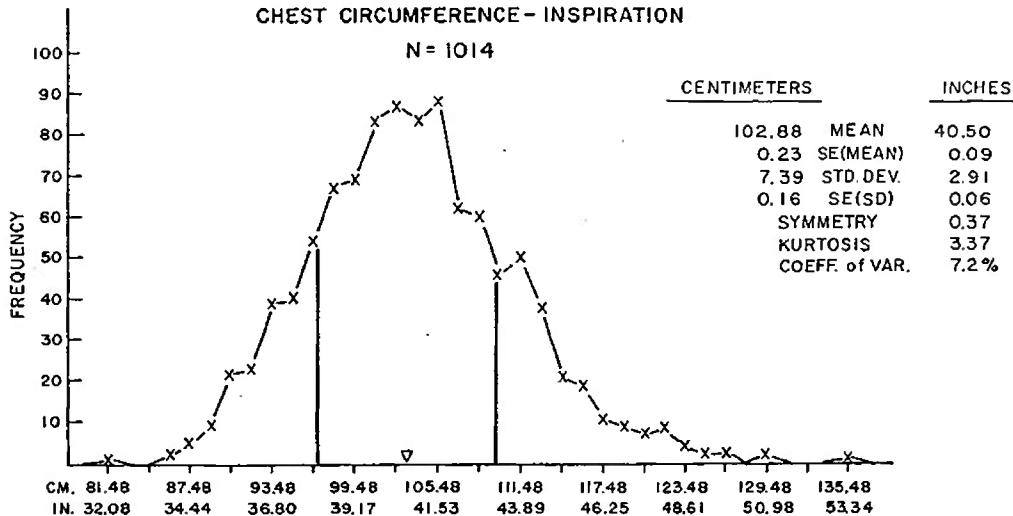


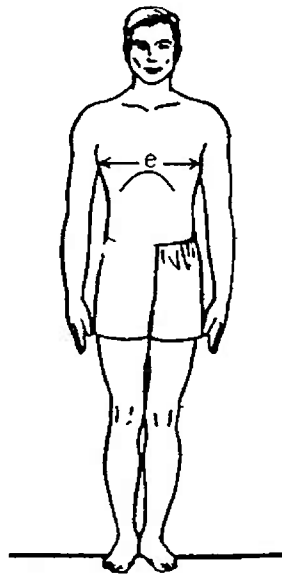
TABLE 13

## SUBMARINER ANTHROPOMETRICS

## CHEST CIRCUMFERENCE - EXPIRATION

Subject stands erect with his arms initially raised and then lowered after the tape is in place. The maximum horizontal circumference of the chest is measured at the level of the nipples at full expiration. The unit of measure is centimeters.

## The Percentiles



e. Chest Circumference  
Expiration

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 117.42      | 99th | 46.23  |
| 115.04      | 98th | 45.29  |
| 113.49      | 97th | 44.68  |
| 111.34      | 95th | 43.83  |
| 108.01      | 90th | 42.52  |
| 105.77      | 85th | 41.64  |
| 104.03      | 80th | 40.96  |
| 102.54      | 75th | 40.37  |
| 101.24      | 70th | 39.86  |
| 100.05      | 65th | 39.39  |
| 98.94       | 60th | 38.95  |
| 97.89       | 55th | 38.54  |
| 96.87       | 50th | 38.14  |
| 95.86       | 45th | 37.74  |
| 94.87       | 40th | 37.35  |
| 93.87       | 35th | 36.96  |
| 92.84       | 30th | 36.55  |
| 91.75       | 25th | 36.12  |
| 90.57       | 20th | 35.66  |
| 89.24       | 15th | 35.13  |
| 87.63       | 10th | 34.50  |
| 85.75       | 5th  | 33.76  |
| 83.92       | 3rd  | 33.04  |
| 82.89       | 2nd  | 33.64  |
| 81.29       | 1st  | 32.00  |

LHS SUBMARINE - ANTHROPOMETRICS  
CHEST CIRCUMFERENCE-EXPIRATION

N = 1016

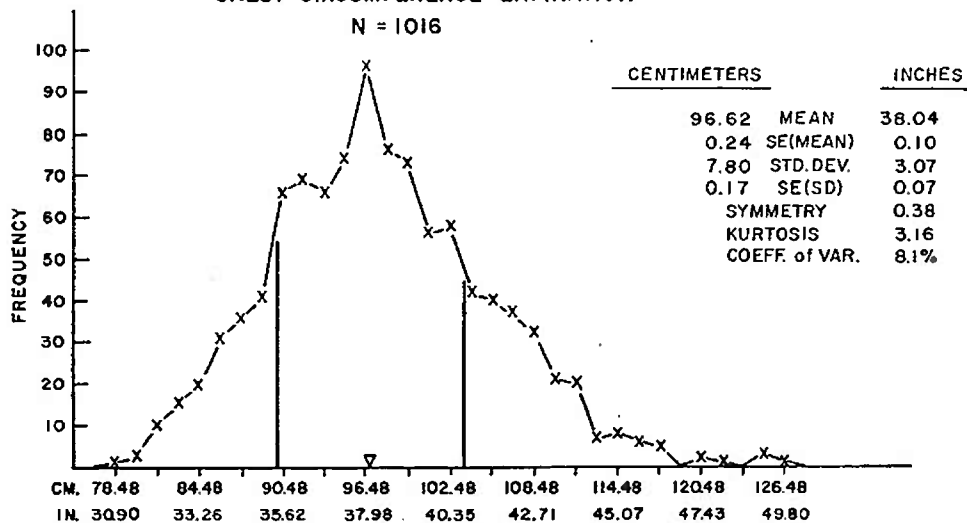
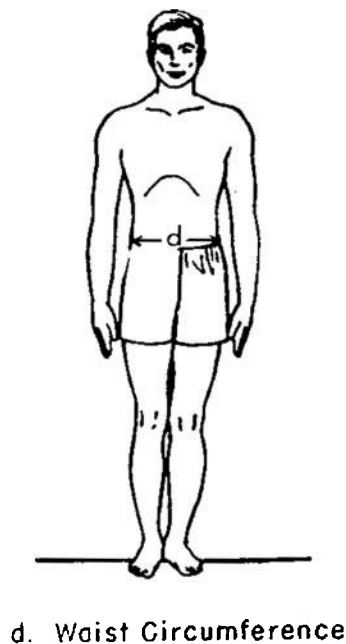


TABLE 14

## SUBMARINER ANTHROPOMETRICS

## ABDOMINAL CIRCUMFERENCE

Subject stands erect with abdomen relaxed. The maximum horizontal circumference of the waist is measured at the level of the umbilicus. The unit of measure is centimeters.

The Percentiles

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 117.45      | 99th | 46.24  |
| 113.88      | 98th | 44.83  |
| 111.66      | 97th | 43.96  |
| 108.71      | 95th | 42.80  |
| 104.32      | 90th | 41.07  |
| 101.45      | 85th | 39.94  |
| 99.24       | 80th | 39.07  |
| 97.36       | 75th | 38.33  |
| 95.71       | 70th | 37.68  |
| 94.21       | 65th | 37.09  |
| 92.80       | 60th | 36.54  |
| 91.47       | 55th | 36.01  |
| 90.17       | 50th | 35.50  |
| 88.89       | 45th | 34.99  |
| 87.61       | 40th | 34.49  |
| 86.32       | 35th | 33.98  |
| 84.97       | 30th | 33.45  |
| 83.55       | 25th | 32.89  |
| 81.99       | 20th | 32.28  |
| 80.24       | 15th | 31.59  |
| 78.11       | 10th | 30.75  |
| 75.64       | 5th  | 29.78  |
| 73.31       | 3rd  | 28.96  |
| 72.04       | 2nd  | 28.36  |
| 70.16       | 1st  | 27.62  |

## LHS SUBMARINE - ANTHROPOMETRICS

## ABDOMINAL CIRCUMFERENCE

N = 1015

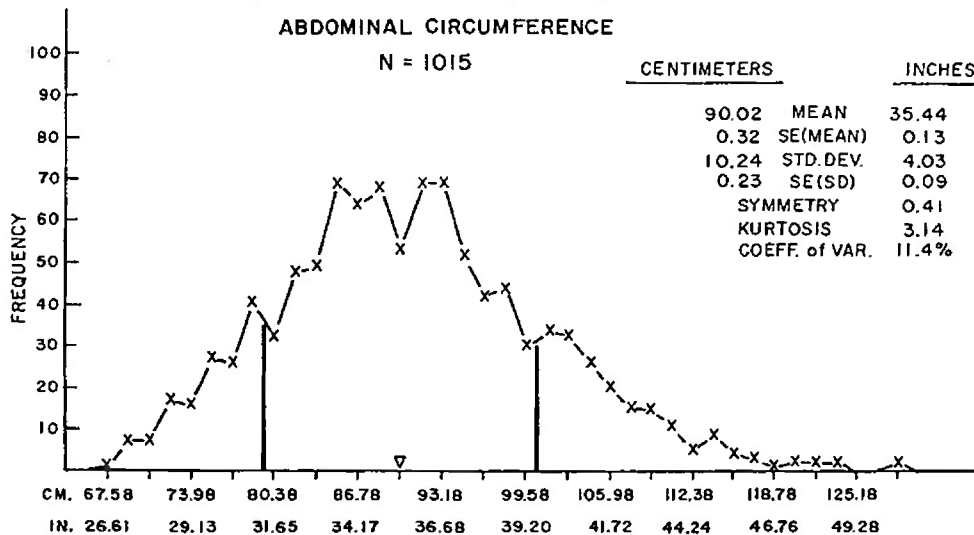


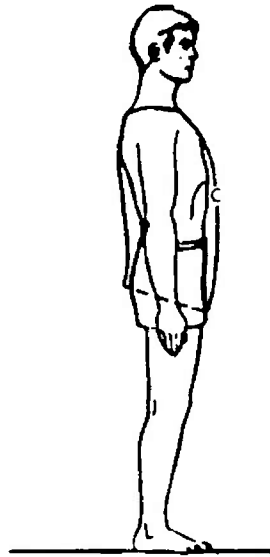
TABLE 15

## SUBMARINER ANTHROPOMETRICS

## VERTICAL TRUNK CIRCUMFERENCE

Subject stands erect with his feet slightly apart. The vertical circumference of the trunk is measured with a steel tape passed through the crotch, to the right of the scrotum, and then over the midpoints of the right shoulder and right buttock. The unit of measure is centimeters.

## The Percentiles



c. Vertical Trunk Circumference  
(Standing)

| Centimeters | %ile | Inches |
|-------------|------|--------|
| 188.23      | 99th | 74.11  |
| 184.23      | 98th | 72.55  |
| 182.03      | 97th | 71.66  |
| 179.23      | 95th | 70.56  |
| 175.41      | 90th | 69.06  |
| 173.08      | 85th | 68.14  |
| 171.35      | 80th | 67.46  |
| 169.91      | 75th | 66.89  |
| 168.65      | 70th | 66.40  |
| 167.51      | 65th | 65.95  |
| 166.44      | 60th | 65.53  |
| 165.41      | 55th | 65.12  |
| 164.40      | 50th | 64.73  |
| 163.39      | 45th | 64.33  |
| 162.37      | 40th | 63.92  |
| 161.31      | 35th | 63.51  |
| 160.18      | 30th | 63.06  |
| 158.95      | 25th | 62.58  |
| 175.56      | 20th | 62.03  |
| 155.94      | 15th | 61.03  |
| 153.86      | 10th | 60.58  |
| 151.20      | 5th  | 59.53  |
| 148.74      | 3rd  | 58.56  |
| 147.27      | 2nd  | 57.98  |
| 145.02      | 1st  | 57.09  |

LHS SUBMARINE - ANTHROPOMETRICS  
VERTICAL TRUNK CIRCUMFERENCE

N=1015

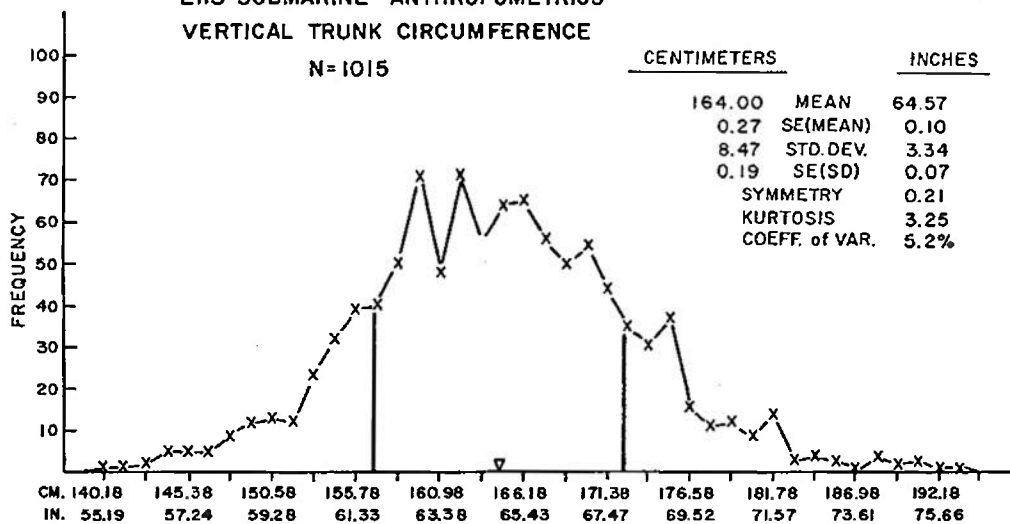
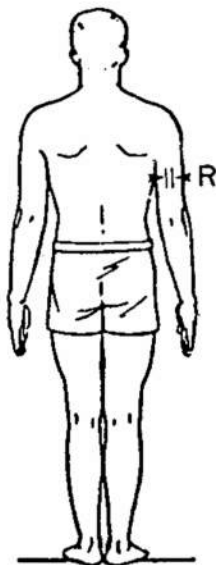


TABLE 16

## SUBMARINER ANTHROPOMETRICS

## TRICEPS SKINFOLD THICKNESS

The skinfold is picked up on the dorsum of the right arm, at a point midway between the acromial process of the scapula and the tip of the olecranon. Measurement is made with the forearm flexed to 90° and the arm pendant. The unit of measure is millimeters.



R. Triceps Skinfold

## The Percentiles

| Millimeters | File | Inches |
|-------------|------|--------|
| 4.35        | 99th | 1.71   |
| 3.98        | 98th | 1.57   |
| 3.76        | 97th | 1.48   |
| 3.47        | 95th | 1.37   |
| 3.05        | 90th | 1.20   |
| 2.78        | 85th | 1.10   |
| 2.59        | 80th | 1.02   |
| 2.42        | 75th | 0.95   |
| 2.28        | 70th | 0.90   |
| 2.15        | 65th | 0.85   |
| 2.04        | 60th | 0.80   |
| 1.93        | 55th | 0.76   |
| 1.83        | 50th | 0.72   |
| 1.73        | 45th | 0.68   |
| 1.63        | 40th | 0.64   |
| 1.54        | 35th | 0.60   |
| 1.44        | 30th | 0.57   |
| 1.34        | 25th | 0.53   |
| 1.23        | 20th | 0.49   |
| 1.12        | 15th | 0.44   |
| 0.99        | 10th | 0.39   |
| 0.85        | 5th  | 0.34   |
| 0.72        | 3rd  | 0.28   |
| 0.65        | 2nd  | 0.26   |
| 0.57        | 1st  | 0.22   |

## LHS SUBMARINE-ANTHROPOMETRICS

## TRICEPS SKINFOLD THICKNESS

N = 713

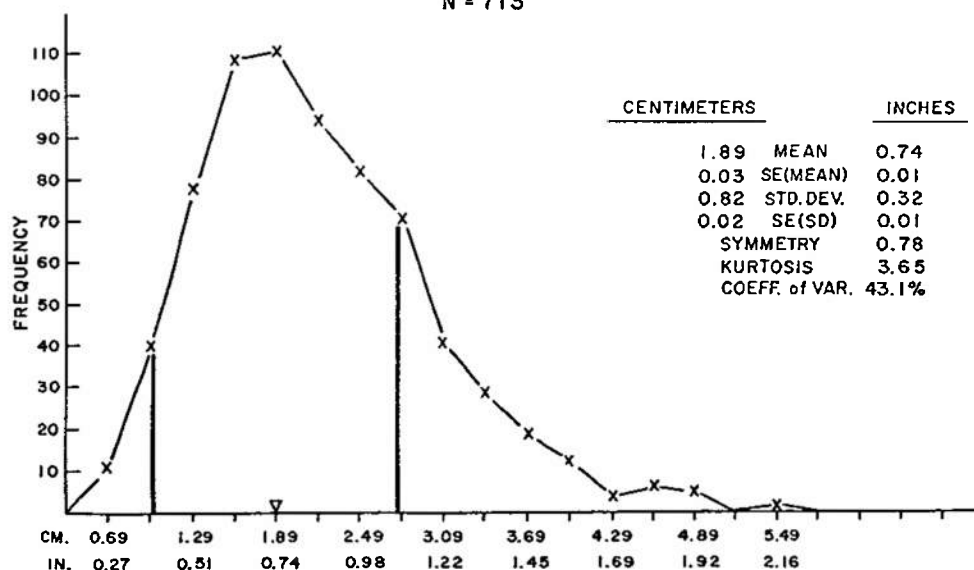
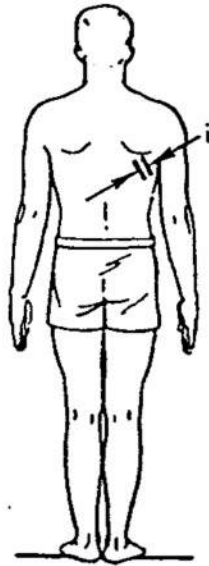


TABLE 17

## SUBMARINER ANTHROPOMETRICS

## SUBSCAPULER SKINFOLD THICKNESS

The skinfold is picked up under the angle of the right scapula. The fold is pointing slightly downward and outward. The unit of measure is millimeters.



i. Subscapular Skinfold

The Percentiles

| Millimeters | %ile | Inches |
|-------------|------|--------|
| 4.72        | 99th | 1.86   |
| 4.43        | 98th | 1.74   |
| 4.24        | 97th | 1.67   |
| 3.97        | 95th | 1.56   |
| 3.55        | 90th | 1.40   |
| 3.26        | 85th | 1.28   |
| 3.04        | 80th | 1.20   |
| 2.85        | 75th | 1.12   |
| 2.68        | 70th | 1.05   |
| 2.52        | 65th | 0.99   |
| 2.38        | 60th | 0.94   |
| 2.24        | 55th | 0.88   |
| 2.11        | 50th | 0.83   |
| 1.98        | 45th | 0.78   |
| 1.86        | 40th | 0.73   |
| 1.73        | 35th | 0.68   |
| 1.61        | 30th | 0.63   |
| 1.48        | 25th | 0.58   |
| 1.34        | 20th | 0.53   |
| 1.20        | 15th | 0.47   |
| 1.05        | 10th | 0.41   |
| 0.92        | 5th  | 0.36   |
| 0.80        | 3rd  | 0.32   |
| 0.77        | 2nd  | 0.30   |
| 0.76        | 1st  | 0.30   |

## LHS SUBMARINE-ANTHROPOMETRICS

## SUBSCAPULAR SKINFOLD THICKNESS

N = 712

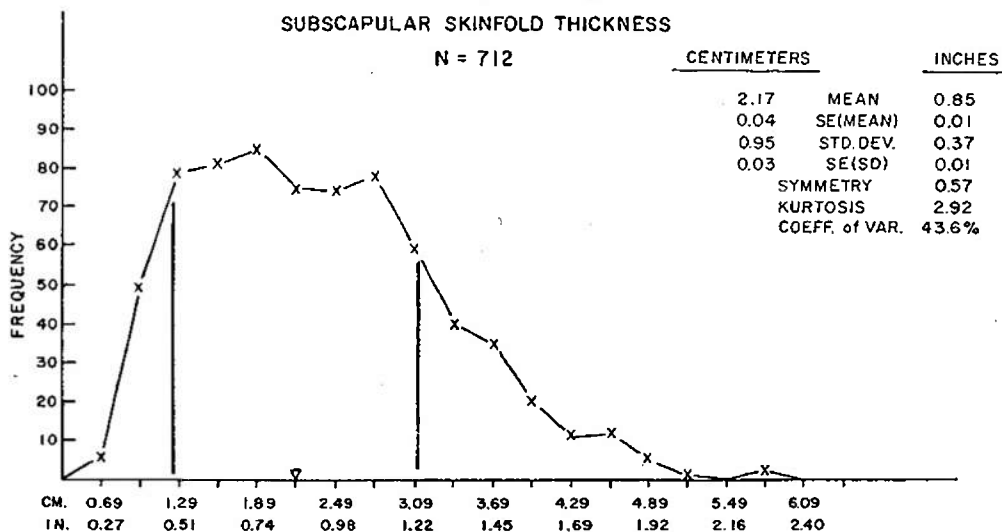
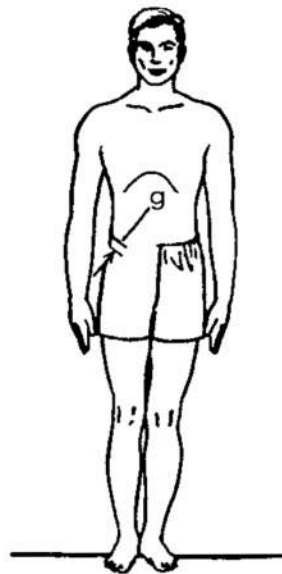


TABLE 18

## SUBMARINER ANTHROPOMETRICS

## MIDAXILLARY SKINFOLD THICKNESS

The skinfold is picked up one centimeter above and two centimeters medial to the right anterior superior iliac spine. The unit of measure is millimeters.



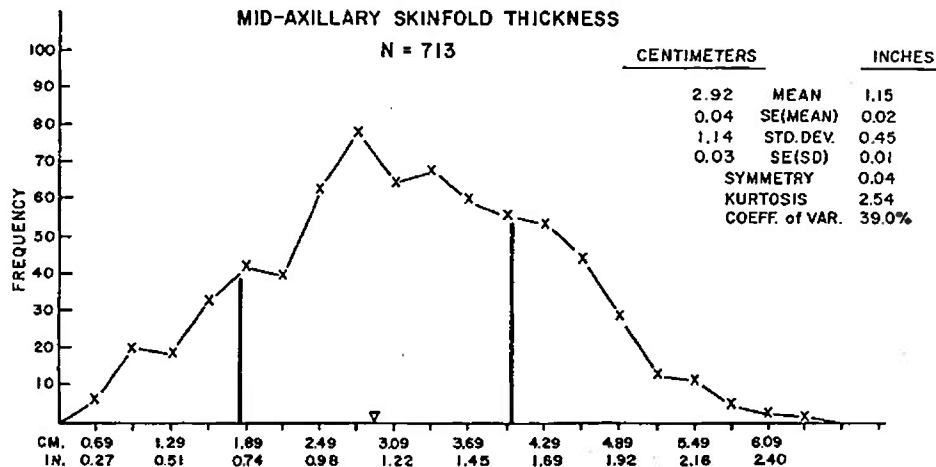
g. Suprailiac (Midoxillary) Skinfold

## The Percentiles

| Millimeters | %ile | Inches |
|-------------|------|--------|
| 5.52        | 99th | 2.18   |
| 5.25        | 98th | 2.07   |
| 5.08        | 97th | 2.00   |
| 4.85        | 95th | 1.91   |
| 4.47        | 90th | 1.76   |
| 4.21        | 85th | 1.66   |
| 3.99        | 80th | 1.57   |
| 3.80        | 75th | 1.50   |
| 3.63        | 70th | 1.43   |
| 3.46        | 65th | 1.36   |
| 3.30        | 60th | 1.30   |
| 3.14        | 55th | 1.24   |
| 2.98        | 50th | 1.17   |
| 2.82        | 45th | 1.11   |
| 2.66        | 40th | 1.05   |
| 2.50        | 35th | 0.98   |
| 2.32        | 30th | 0.91   |
| 2.13        | 25th | 0.84   |
| 1.92        | 20th | 0.76   |
| 1.69        | 15th | 0.66   |
| 1.41        | 10th | 0.55   |
| 1.10        | 5th  | 0.43   |
| 0.85        | 3rd  | 0.34   |
| 0.74        | 2nd  | 0.29   |
| 0.62        | 1st  | 0.15   |

LHS SUBMARINE-ANTHROPOMETRICS  
MID-AXILLARY SKINFOLD THICKNESS

N = 713



| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                                        |                                                                                                                        | Form Approved<br>OMB No. 0704-0188                     |                                    |
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| 12. PERSONAL AUTHOR(S)<br>Mooney, Loren W., Bowman, Jeffry and Callahan, A..B.                                                                                                                                                                                                                                                                                                                                                                      |       |                                        |                                                                                                                        |                                                        |                                    |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |                                        |                                                                                                                        |                                                        |                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |                                        |                                                                                                                        |                                                        |                                    |
| 19. ABSTRACT (Continue on reverse if necessary and identify by block number)                                                                                                                                                                                                                                                                                                                                                                        |       |                                        |                                                                                                                        |                                                        |                                    |
| <p>As part of the Longitudinal Health Study conducted on a group of 1,017 U.S. Navy submariners eighteen anthropometric measurements were taken and are presented as statistical summaries. This information on the characteristics of submariner physical build can be incorporated into new designs for submarine equipment, e.g. consoles, berthing spaces, etc., and can also be used in future epidemiologic studies of submariner health.</p> |       |                                        |                                                                                                                        |                                                        |                                    |
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