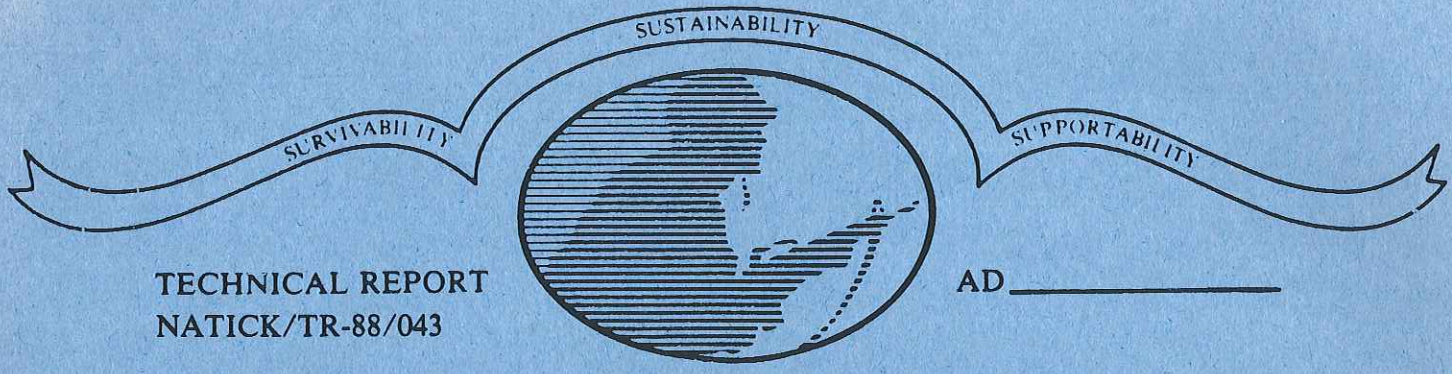


TECHNICAL REPORT
NATICK/TR-88/043

AD_____

MEASURER'S HANDBOOK: U.S. ARMY ANTHROPOMETRIC SURVEY 1987-1988

BY

CHARLES CLAUSER
ILSE TEBBETTS
BRUCE BRADTMILLER
JOHN McCONVILLE
AND
CLAIRE C. GORDON*

ANTHROPOLOGY RESEARCH PROJECT, INC.
YELLOW SPRINGS, OHIO 45387

MAY 4 1988
FINAL REPORT FOR THE PERIOD
OCTOBER 1986 TO MAY 1987

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MASSACHUSETTS 01760-5000

*SCIENCE AND ADVANCED TECHNOLOGY DIRECTORATE

DISCLAIMERS

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

DESTRUCTION NOTICE

For Classified Documents:

Follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For Unclassified/Limited Distribution Documents:

Destroy by any method that prevents disclosure of contents or reconstruction of the document.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) NATICK/TR-88/043
6a. NAME OF PERFORMING ORGANIZATION Anthropology Research Project, Inc. 6b. OFFICE SYMBOL (*If applicable*)	7a. NAME OF MONITORING ORGANIZATION U.S. Army Natick RD&E Center
6c. ADDRESS (*City, State, and ZIP Code*) 503 Xenia Avenue Yellow Springs, Ohio 45387	7b. ADDRESS (*City, State, and ZIP Code*) Natick, Massachusetts 01760-5000
8a. NAME OF FUNDING / SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (*If applicable*) STRNC-YBF	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Contract DAAK60-86-C-0128
8c. ADDRESS (*City, State, and ZIP Code*)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 728012.12 / PROJECT NO. OMA / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (*Include Security Classification*)
MEASURER'S HANDBOOK: U.S. ARMY ANTHROPOMETRIC SURVEY, 1987-1988

12. PERSONAL AUTHOR(S) Charles Clauser, Ilse Tebbetts, Bruce Bradtmiller, John McConville and Claire Gordon*

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (*Year, Month, Day*)	15. PAGE COUNT
Final	FROM Oct1986 TO May1987	1988 May 4	334

16. SUPPLEMENTARY NOTATION
*Affiliated with Science and Advanced Technology Directorate, US Army Natick Research, Development and Engineering Center

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
ANTHROPOMETRY, BODY SIZES, MEN, ANTHROPOMETRIC SURVEY, HUMAN BODY, WOMEN, MEASUREMENTS, DIMENSIONS, ARMY

19. ABSTRACT (*Continue on reverse if necessary and identify by block number*)

The purpose of this manual is to describe and explain the tools and procedures required for the precise and accurate measurement of U.S. Army men and women. The handbook contains instructions for the measurement of 132 directly measured dimensions of the body, and for obtaining additional head and hand data collected with the use of two pieces of custom-designed equipment: an electronic headboard and a hand photometric system. Also included in this generously illustrated measurer's guide are instructions for locating and drawing the landmarks required to define and standardize the dimensions, suggestions for handling subjects, and a guide to the operations and care of the personal computers to be used to record and edit the data in the field. The measurements obtained in this anthropometric survey will form the basis for ensuring that Army clothing, equipment, and systems properly accommodate Army personnel who run the body-size gamut from small women to large men.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Dr. Claire C. Gordon	22b. TELEPHONE (*Include Area Code*) 617-651-5429 22c. OFFICE SYMBOL STRNC-YBF

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

PREFACE

This handbook was prepared as a training document for members of the measuring team who collected the anthropometric and demographic data in the 1987-1988 Army survey. It is intended, in addition, to serve future anthropometrists and researchers as a detailed record of how the data in this landmark survey were obtained.

A number of people contributed their knowledge and talents to this effort. The authors are particularly grateful to the following persons for their careful review of the manuscript in its early stages: Edna Albert, Technical Editor at the U.S. Army Natick Research Development and Engineering Center; Dr. Kenneth Parham, Research Anthropologist and Dr. Owen Maller, Research Psychologist at Natick's Science and Advanced Technology Directorate; and Brenda Baker, Department of Anthropology, University of Massachusetts.

Drawings in this book were executed with diligent attention to detail by Gary Ball. Photographs were taken and retaken with painstaking care by Tebby Stanley.

Thanks also go to Jane Reese, Belva Hodge, Lori Deen, Julie Hiefner and Jean Bolin of Anthropology Research Project, Inc., for their help in the production of this handbook.

Last but not least are the 22 members of the measuring team whose experience during the month-long training period and the first few weeks in the field led to the incorporation of many useful modifications.

This book was prepared by the Anthropology Research Project, Inc. under Army Contract DAAK60-86-C-0128 with the U.S. Army Natick Research, Development and Engineering Center in Natick, Massachusetts. The contract monitor was Dr. Claire C. Gordon of the Human Factors Group.

TABLE OF CONTENTS

	Page
PREFACE	iii
LIST OF FIGURES	vii
LIST OF TABLES	xi
INTRODUCTION	1
SUBJECTS	2
Physical Anomalies	3
Safety	3
MEASURING INSTRUMENTS	4
Assembling and Reading the Anthropometer	5
Care and Maintenance of Measuring Instruments	9
Marking Instruments	9
MEASURING STATIONS	11
Subject Selection	13
In/Out Processing Station	14
Measuring Station Layout	14
THE LANDMARKS	16
Drawn Landmarks	16
Landmark Descriptions	17
Head and Face Landmarks	63
Undrawn Landmarks	65
THE MEASUREMENTS	67
Subject Posture	67
Parallax	67
Measurement Accuracy	68
Dimension Descriptions	69
USE OF THE DIMENSIONS	202

TABLE OF CONTENTS (continued)

	Page
A GLOSSARY OF ANATOMICAL AND ANTHROPOMETRIC TERMS	209
REFERENCES	213
APPENDIXES	
A. Instruction Manual for the Operation of the Hardware and Software Used in the 1987-1988 U.S. Army Survey	215
B. Instruction Manual for the Operation and Maintenance of the Hand Photometric System	237
C. Commercial Sources and Specifications for Anthropometric Instruments	255
D. Instruction Manual for the Operation and Maintenance of the Automated Headboard Device	263
E. The Visual Index	295
F. Allowable Observer Error	307
INDEX	315

LIST OF FIGURES

Figure		Page
1	Anthropometer: a. beam caliper; b. four sections of the basic anthropometer; c. beam caliper with paddles	6
2	Calipers and tapes: a. steel tape; b. spreading caliper; c. sliding caliper; d. Holtain caliper; e. Poech caliper; f. modified tape	6
3	Functional leg length anthropometer	6
4	Pupillometer	6
5	Foot measuring equipment: a. left foot box; b. modified sliding caliper; c. right foot box; d. block	7
6	Wall scales	7
7	Hand photometric system	7
8	Automated headboard device	8
9	Battery installation: pupillometer	9
10	Marking instruments: a. straightedge with level; b. plastic rules; c. steel tape	10
11	Landmark transfer rod	10
12	Flow chart for subject selection and processing	15
13	Suggested measuring station layout	16
14	Head and face landmarks to be located at measuring station #7	64
15	Axillary fold, posterior, landmark	66
16	Otobasion superior landmark	66
17	Posterior superior iliac spine landmark	66
18	Establishing the anthropometric sitting position	68
19	The body in the anatomical position	209
A-1	Compaq Portable Computer in the open operating position with the Brother M-1109 printer	216
A-2	A typical diskette (right), positioned for insertion into disk drive (left)	218
A-3	Compaq computer keyboard	219
B-1	Hand photometric system: rear left view	238

LIST OF FIGURES (continued)

Figure		Page
B-2	Hand Photometric System: right front view	239
B-3	Arm rest shelf catch	239
B-4	Arm rest shelf and extension bar	240
B-5	Subject seated at photobox	241
B-6	Hand alignment grid	242
B-7	Stylion indicator rod alignment	242
B-8	Nikon N2000 35-mm camera	244
B-9	Lens setting	245
B-10	Film advance mode	245
B-11	Adjusting film advance mode	245
B-12	Audible warning switch	246
B-13	Shooting mode selector	246
B-14	Film speed ring	246
B-15	Exposure compensation setting	246
B-16	Opening the camera	247
B-17	Internal camera parts	247
B-18	Positioning the film cartridge	248
B-19	Pulling out film leader	248
B-20	Loading the film	248
B-21	Remote shutter release	249
B-22	Frame counter window	249
B-23	Film rewind button and lever	249
B-24	Film rewind crank	250
B-25	Film advance indicator	250
B-26	Removing film	250

Figure		Page
B-27	Removing battery holder	251
B-28	Removing battery bracket	251
B-29	Installing batteries	251
B-30	Replacing battery bracket	252
B-31	Reattaching battery holder	252
B-32	Viewfinder eyepiece cover	252
B-33	Do not touch the reflex mirror	252
B-34	Do not touch the DX-contacts	253
B-35	Do not touch the shutter curtains	253
C-1	Anthropometer: a. beam caliper; b. four sections of the basic anthropometer; c. beam caliper with paddles	256
C-2	Calipers and tapes: a. steel tape; b. spreading caliper; c. sliding caliper; d. Holtain caliper; e. Poech caliper	256
C-3	Pupillometer	257
C-4	Functional leg length measuring instrument	258
C-5	Orientation of wall-mounted graphs	258
C-6	Foot measuring boxes	259
C-7	Modified sliding caliper	260
C-8	Landmark transfer rod	260
C-9	Scye marking aid	261
C-10	Modified tape	261
D-1	Axis system for headboard measurements	264
D-2	Principal components of the automated headboard device	265
D-3	The reference planes (headboards) and head stabilization clamp	266
D-4	The axis assemblies of the coordinate measuring system (CMS) and their range of movement	267
D-5	The vertical slide assembly shown partially unpacked in its shipping container	268

LIST OF FIGURES (continued)

Figure		Page
D-6	The rotary bearing and the support housing with the vertical axis assembly removed	269
D-7	The vertical axis assembly	269
D-8	The rotary bearing and the back of the vertical axis assembly viewed from above and behind	270
D-9	The horizontal axis slide assembly and arm in its shipping container	271
D-10	The horizontal axis slide assembly and its mounting arm	271
D-11	Horizontal slide assembly showing the touch probe and the measurement instrumentation	273
D-12	Remote hand switch for manual recording of coordinates	274
D-13	Support rods in position for installation	278
D-14	Front view of the rotary support housing showing locations of bushings where calibration rods are installed	279
D-15	Top view of the fixed radius fixture	280
D-16	Front view of the headboard area showing the calibration equipment in place	281
D-17	The landmark locations and the order of measurement of coordinates	285
D-18	Frankfort plane	286
D-19	Rotary bearing area showing the retainer bolts, the computer cable, and safety bolt access port (see also Figure D-8)	290

LIST OF TABLES

Table		Page
1	Applications for the Dimensions to Be Measured in the Army Survey	202
F-1	Allowable Observer Error for Dimensions in the U.S. Army 1987-1988 Anthropometric Survey (values in mm)	310

MEASURER'S HANDBOOK
U.S. ARMY ANTHROPOMETRIC SURVEY, 1987-1988

INTRODUCTION

The systematic measuring of the human body is called anthropometry, from the Greek words anthropos meaning human being or man, and metron, to measure. Anthropometry is a subdiscipline of the more familiar field, anthropology, the study of man.

All U.S. military and many foreign services maintain anthropometric data bases detailing the body-size distributions of their personnel. These data are used primarily to guide the design and sizing of clothing and personal protective equipment and the design and layout of military workstations. More recently, and of growing importance, is the use of anthropometric data in devising computer-generated models of the body. These models are used to assess the body's reactions to life-threatening occurrences, such as vehicular crashes or ejection from an aircraft, or to guide the design and evaluation of aircraft and other vehicular workstations. The required data are obtained by measuring dimensions of the body.

In the U.S. Army anthropometric survey of 1987-1988, 132 directly measured dimensions were chosen as the most useful for meeting current and anticipated Army needs. In addition, hand photos will be taken for later measurement, and an automated headboard will be used to collect a set of three-dimensional head and face data. These measurements will form the basis for ensuring that Army clothing, equipment, and systems properly accommodate Army personnel who run the body-size gamut from small women to large men.

The sampling strategy to be used for this survey was developed to include preset numbers of men and women of different age categories and racial classifications. The twofold object of the sampling plan is to obtain a data base which can be used to accurately represent today's Army, and which can be restructured, as needed, to reflect changes in the ratios of different categories of personnel in the future. To achieve this objective, 5,000 Army men and 3,000 Army women will be measured for all dimensions. The successful completion of this task will depend on you and the other members of the measuring team.

The purpose of this manual is to describe and explain the tools and procedures required for the precise and accurate measurement of Army men and women and to familiarize anthropometrists (measurers) with the landmarks and dimensions of the body essential to the accomplishement of that task. Although really significant learning can only come from actual training and practice, this handbook will serve as an introduction to what the anthropometrist will be looking for and how to find it and measure it. Included here are tips on how to handle subjects, descriptions of the measuring instruments to be used, definitions and illustrations of body landmarks which serve as the point of origin and termination of the dimensions, descriptions and illustrations of the dimensions and the instructions for their measurement. Also included are a glossary of terms, and brief explanations of what uses the Army will make of the data collected on each dimension.

Additional information appears in six appendixes as follows: instructions for the use of the computers used in this survey (Appendix A);[1] instructions for the use of the hand photometric system (Appendix B);[2] commercial sources and specifications for the anthropometric instruments (Appendix C); instructions for the use of the automated headboard device (Appendix D);[3] a visual index (Appendix E); and an explanation of allowable observer error (Appendix F).

SUBJECTS

While the measurer is the central figure on which the success of the survey depends, another critical component in the effort is the anthropometric subject. Cooperation from the subject will make your job much easier.

Some men and women will be apprehensive about being measured, and some will not like it. There is no question that the measuring process intrudes significantly on the individual's personal sense of privacy. Subjects are stripped of most of their clothing, and their real or perceived imperfections revealed. They are touched and prodded when landmarks are located and drawn on the body. (In this survey there will be more than 100 landmarks drawn on each subject.) They will be touched while being measured and while being assisted into the body positions required for particular measurements. Because of nervousness, subjects will often perspire even though the measuring room seems cool to you. Have tissues available to offer them if you observe this. They'll appreciate it, and it will make taking measurements with the tape easier for you.

To relieve natural apprehension, subjects will have been exposed to extensive publicity given to this survey through Army media. Its importance to the Army and to them personally will be fully explained, and similar information about the survey and exactly what the measuring procedures entail will be explained to them in a briefing before they are measured. You can do much to make subjects comfortable by your professional demeanor.

A few pointers on the treatment and handling of subjects will make your task easier and enhance subjects' cooperation. Check the subject's name and Army rank from the data form when he or she enters your station, and the first time you address the subject use the rank and last name, e.g., Corporal Jackson, Sergeant Alexander, Captain Henry, Colonel Rodrigues. After that, just use the military rank. [All grades of privates are addressed as "Private"; sergeant majors are addressed as "Sergeant Major", first sergeants are addressed as "First Sergeant", and all other grades of sergeants are addressed as "Sergeant"; specialists are addressed as "Specialist"; 2nd and 1st lieutenants are addressed as "Lieutenant"; lieutenant colonels and colonels are referred to as "Colonel". You will not be measuring generals, but they will occasionally visit the survey site and will be in uniform. Whether they wear one, two, three, or four stars on their shoulders, all are addressed as "General".] If you forget his or her name or rank during the course of the measuring, address the subject as "sir" or "ma'am" regardless of rank.

When locating and drawing landmarks on the body, when taking measurements, and when assisting your subjects into the body position required for a measurement or series of measurements, grasp or touch them with relative firmness. Most people dislike a light touch just as they dislike a limp

handshake. A light touch can be misperceived and many subjects are ticklish. When asking a subject to assume a position for taking a measurement or when giving other instructions, say "please."

Chatting with your subjects will make your job more interesting. You are going to be interacting with many interesting men and women whose jobs in the Army run the gamut from armorers to pediatricians. Many will be interested in you and your job.

Most of the subjects with whom you deal will be pleasant -- or at least civil -- and cooperative. Inevitably, there will be a few subjects who will try your patience severely. Some will be highly critical of the survey, of the measurements, or of the way you are taking the measurements. Your knowledge of the survey will enable you to reply to some of the remarks but you will not be able nor should you try to respond to all of them. Unwelcome personal comments should be ignored whenever possible. Be as pleasant and professional as you can, and get the job done.

PHYSICAL ANOMALIES

You will not encounter serious problems of physical asymmetry or deformities in Army men and women since severe ones such as missing limbs would interfere with the performance of Army tasks and such individuals would not have passed Army physicals. However, as you'll soon learn, most people display some degree of asymmetry. Peoples' shoulders are not often of equal height, nor are their arms and legs of exactly the same length. Usually these differences between rights and lefts are not particularly noticeable; however, you will encounter subjects where such differences are obvious and would affect a measurement. If the affected body part is on the subject's right side where most measurements are routinely taken, the marker will already have decided that a particular dimension or series of dimensions should be measured on the left instead of the right side of the body, and will have drawn the necessary landmarks on the left side. The marker will also have decided when an athletic or surgical trauma or a birth defect such as a deformed ear may make it appropriate to measure the left instead of the right body member and will have so marked the subject. Therefore, you will have no need to question or comment to your partner or the subject about the matter. Just measure the left side and the recorder will enter into the computer the code that will indicate that the dimension was measured on the left side. While you should not initiate such conversation, your subject may well comment on the fact of his or her asymmetry or problem, and then talking about the matter is, of course, appropriate.

SAFETY

There are no procedures required in anthropometry that are in any way threatening or hazardous to subjects or anthropometrists. However, positive action is required to prevent the kind of accidents that can happen in a survey environment.

At some measuring and marking stations, the subject must stand on a platform or table. The platforms and tables have sturdy handrails for the subject to grasp and the tables have steps to make it easy for the subject to

get on them. It is your responsibility to keep an eye on the subject as he or she is getting on or off the table or platform and to be prepared to assist the subject if he or she should chance to stumble or fall.

At measuring station #2, when arm reaches are measured subjects are required to place their heels on a line on the floor and lean back so that their shoulders are against a wall. A nonslip surface for subjects to stand on will be affixed to the floor. It is the responsibility of the team members at this station to be sure that the nonskid surface is securely in place.

None of the measuring instruments offers an inherent threat to the subject or anthropometrist. Care must be taken not to jab a subject with the blades of an anthropometer or caliper. Particular care must be taken when measuring dimensions near the eyes to ensure that an instrument does not touch the eye itself. When measuring EYE HEIGHT, SEATED, tell the subject that you will keep the blade of the anthropometer away from the eye so that he or she will not reflexively move his or her head and perhaps bump into the anthropometer during the measurement.

At some measuring stations subjects are required to maintain a rigidly erect standing posture for a series of measurements. Though these postures need only be maintained for a few minutes, a few subjects will become woozy and feel faint, especially if the measuring environment is too warm. You must tell each subject to let you know if he or she does become woozy. If this happens, immediately have the subject sit, and do not continue measuring until the subject assures you that he or she feels fine and wishes to continue.

Though very unlikely, it <u>is</u> possible that a subject will faint. Be alert to this possibility so that if it happens you can help ease the subject to the floor. Immediately inform the team supervisor or her assistant and do not let the subject get up until instructed to do so.

For sanitary purposes, measurers will wash their hands and wipe instruments off with alcohol before each subject is measured.

MEASURING INSTRUMENTS

The instruments that will be used for measuring the body in this survey are the following:

anthropometer
functional leg length anthropometer
beam caliper
sliding caliper
modified sliding caliper
spreading caliper
Holtain caliper
Poech caliper
steel tape
modified tape
foot boxes
wall-mounted measuring scale
scales (weighing)
pupillometer
automated headboard device
hand photometric system

These are illustrated in Figures 1 through 8 along with various measuring aids such as dowels and blocks. [The uses of these aids are described in individual measurement descriptions (pp. **70 to 201**) where appropriate.]

The anthropometer is the basic tool of the anthropometrist and is used to measure all linear dimensions. The bottom half or three-quarters is detachable to form the instrument that is used for measuring heights from a standing surface to the lower parts of the body, or from a sitting surface to the head or upper body parts of a seated subject. The detached upper half forms a beam caliper to measure breadths, depths, and body segment lengths. The modified anthropometer with foot support is used to measure FUNCTIONAL LEG LENGTH.

The smaller sliding, spreading, Holtain, and Poech calipers are used primarily for measuring dimensions of the head, face, and hands. The traditional steel tape and the specially modified tape are used to measure body circumferences and arcs.

Wall-mounted scales (sheets of laminated millimeter graph paper) provide an efficient method for obtaining measures of arm reach. Similarly, the footbox facilitates positioning and measuring of the foot.

The more complex measuring systems include the pupillometer [the use of which is described in the measurement description for INTERPUPILLARY BREADTH (p. **137**)], the automated headboard device, and the hand photometric system, (described in detail in Appendixes B and D, respectively). Commercial sources for the standard instruments and specifications for the custom-made instruments are given in Appendix C.

ASSEMBLING AND READING THE ANTHROPOMETER

The anthropometer comes in four sections, each of which is 50 cm long. Since each anthropometer is individually graduated, it is important that sections of different instruments not be mixed. A unique number for each anthropometer is stamped at one end of each section to prevent mixing them up. Assemble the anthropometer so that the scale on one side reads continuously from 1 to 210 cm, and the scale on the other side reads from 1 to 95 cm. The slide is generally not removed from the beam. If it is removed, however, it should be placed on the beam in such a way that the shape of the slide matches exactly the shape of the fixed head at the top of the anthropometer. When the slide is moved all the way to the top of the correctly assembled anthropometer, the anthropometer scale will read 210 cm and the beam caliper scale will read 0.6 cm. Another quick check for accurate assembly is to make sure that the blade of the slide is immediately below or in line with the blade of the head when the two are brought together.

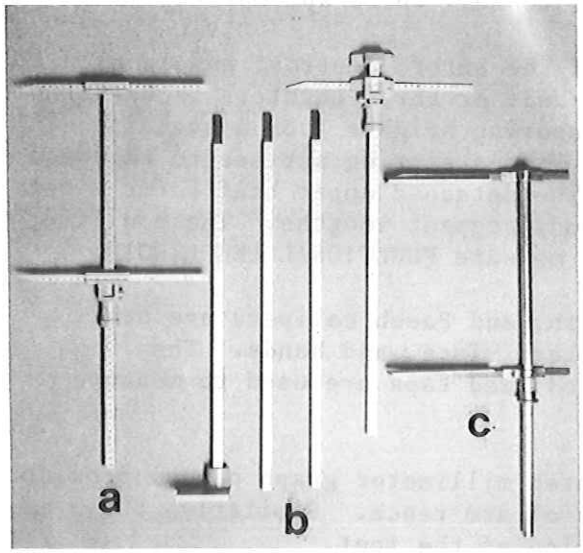


Figure 1. Anthropometer:
a. beam caliper;
b. four sections of the basic anthropometer;
c. beam caliper with paddles.

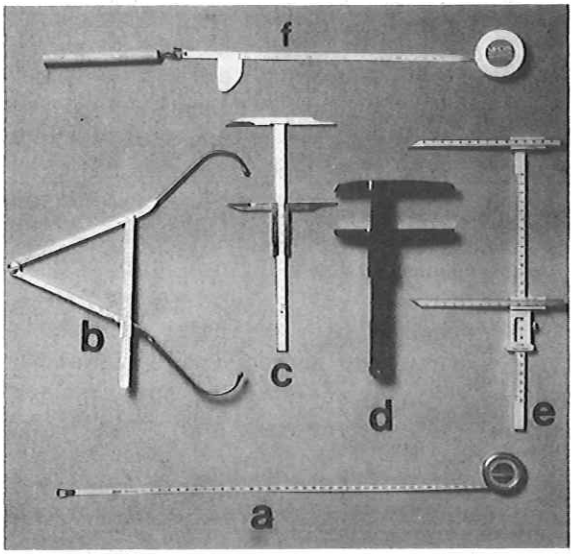


Figure 2. Calipers and tapes:
a. steel tape;
b. spreading caliper;
c. sliding caliper;
d. Holtain caliper;
e. Poech caliper;
f. modified tape.

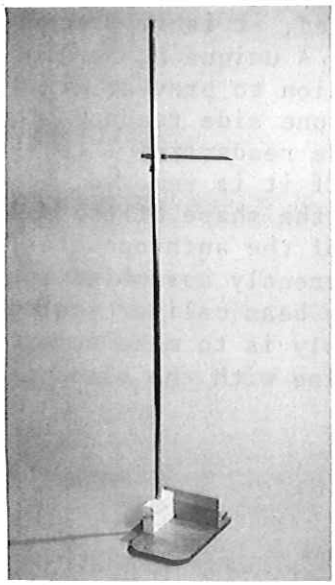


Figure 3. Functional leg length anthropometer.

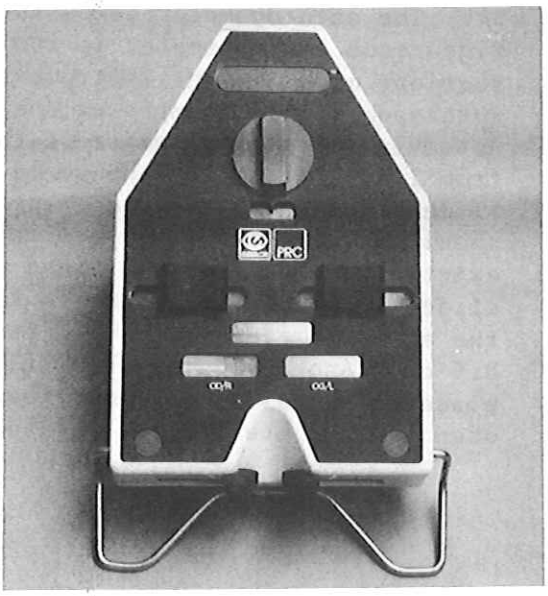


Figure 4. Pupillometer.

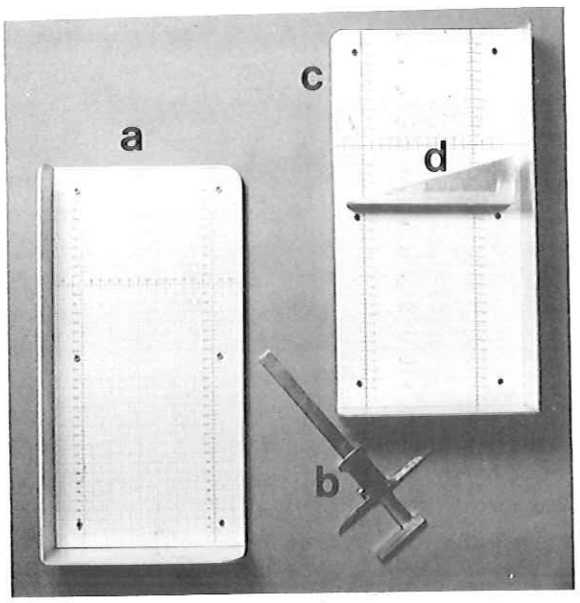


Figure 5. Foot measuring equipment: a. left foot box; b. modified sliding caliper; c. right foot box; d. block.

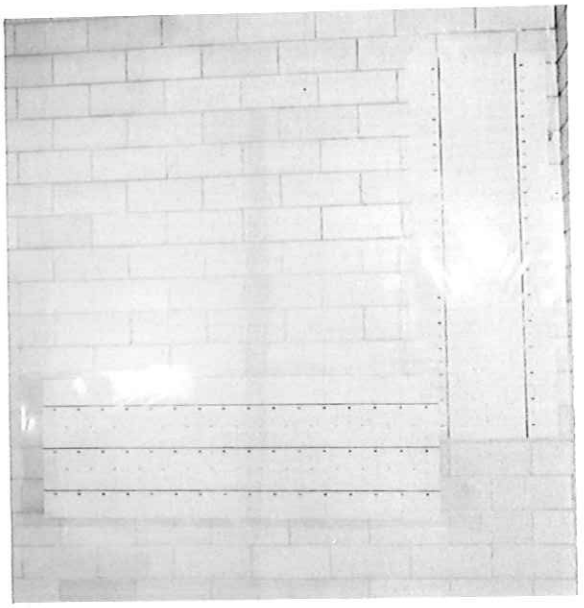


Figure 6. Wall scales.

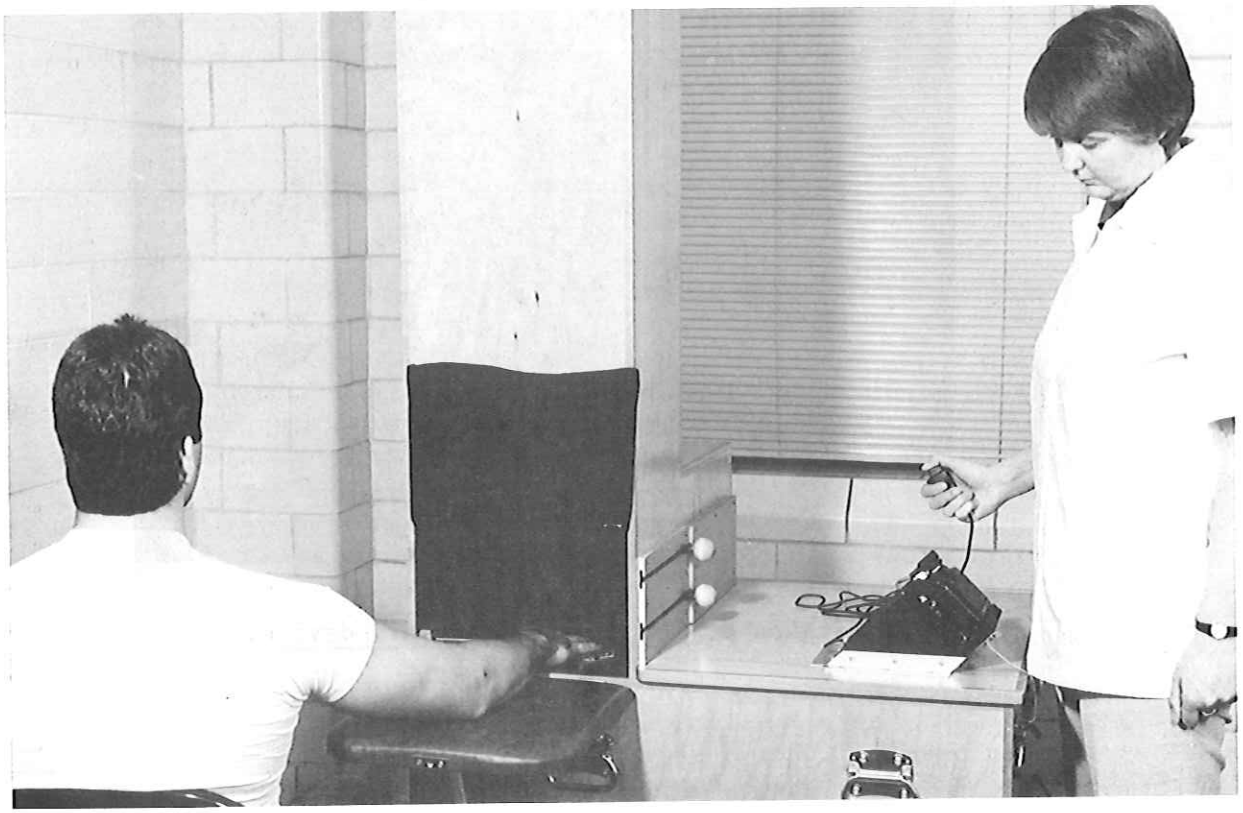


Figure 7. Hand photometric system.

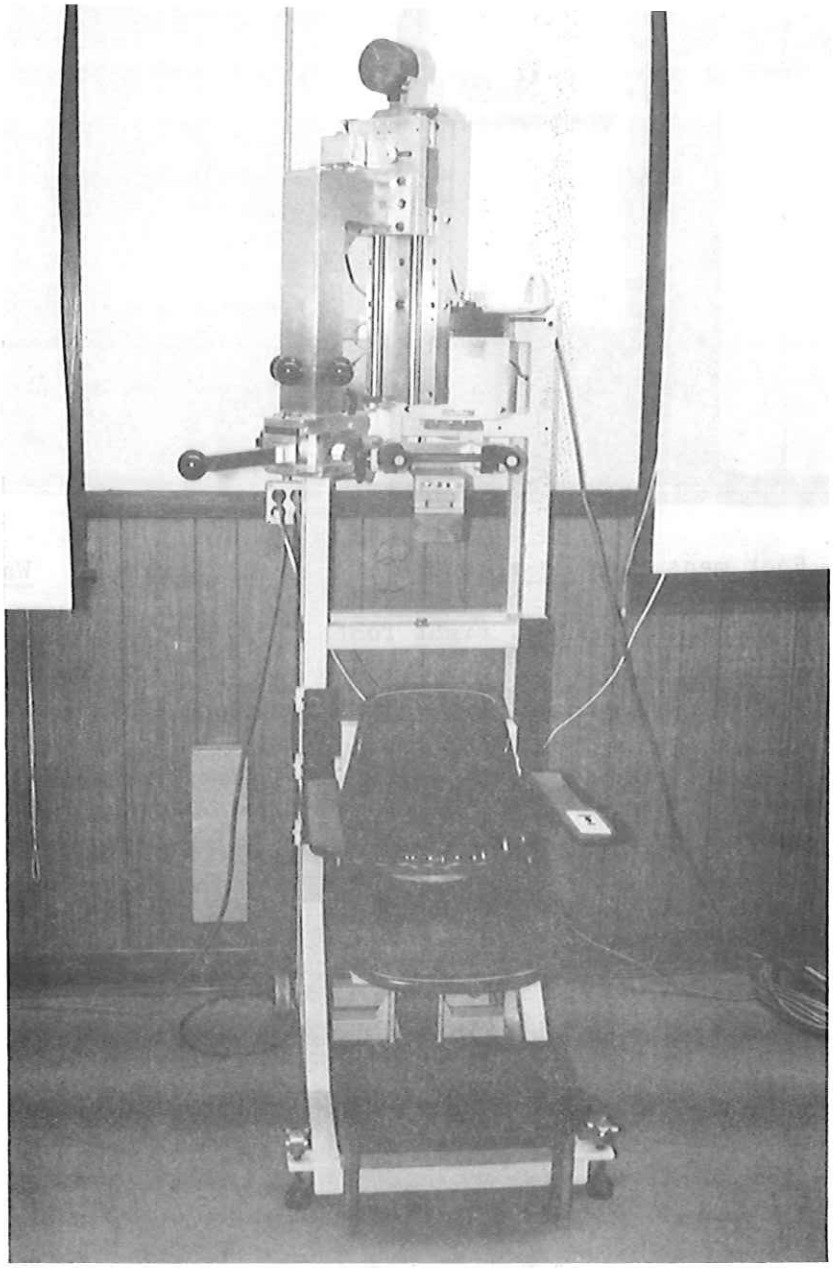


Figure 8. Automated headboard device.

CARE AND MAINTENANCE OF MEASURING INSTRUMENTS

Anthropometers and calipers are precision measuring instruments. They are not fragile, but care must be taken in their use. It is important that they not be dropped or knocked off a table since such a mishap could cause the instrument to be bent and, thus, misaligned. If an instrument is dropped, use a caliper gauge to check its accuracy before using it again. A damaged instrument must be repaired or replaced. A particular note of caution: do not lean an anthropometer against a wall or table. It can easily fall and be damaged.

The anthropometer, calipers, and tape must be cleaned with isopropyl alcohol after each subject is measured.

The batteries of the pupillometer are placed in a compartment located on the side of the instrument and closed by a sliding cover (see Figure 9). The pupillometer should always be laid down with the reading face up to prevent light from coming in. If it is inadvertently placed upside down, the lamp will light up and the user will be warned by the indicator lamp "V". The nose pads are of flexible material and may be removed for replacement and cleaning. They too should be cleaned with alcohol after each use.

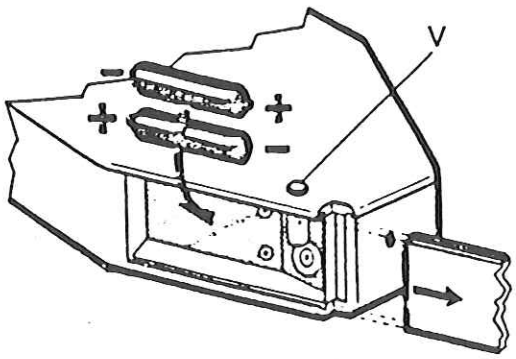


Figure 9. Battery installation: pupillometer.

MARKING INSTRUMENTS

Although most landmarks are located by sight or by palpation, some require the use of instruments. These include a landmark transfer rod for transferring landmarks from one side of the body to the same level on another side, a straight edge with level for locating several scye landmarks, and a variety of plastic rules. The marking instruments are shown in Figures 10 and 11.

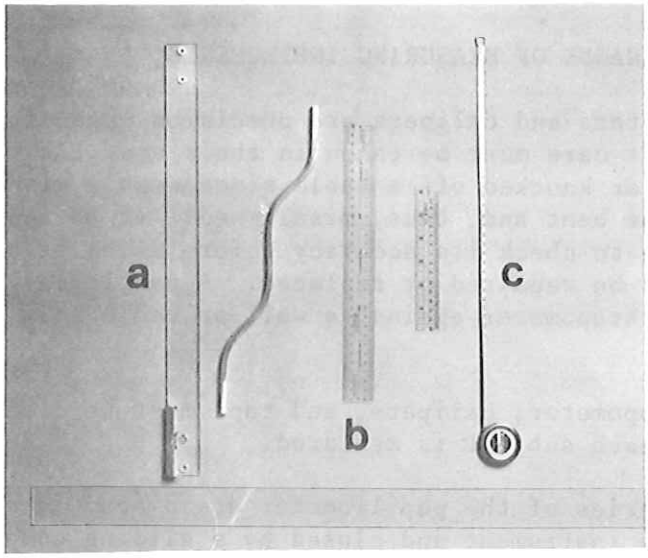


Figure 10. Marking instruments: a. straightedge with level; b. plastic rules; c. steel tape.

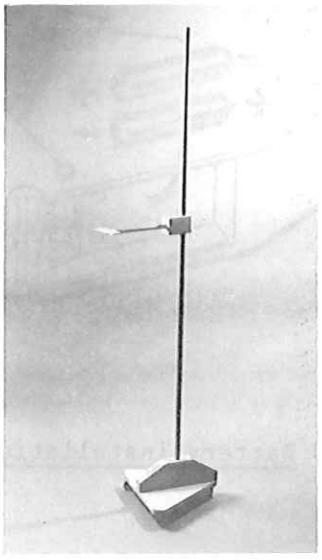


Figure 11. Landmark transfer rod.

MEASURING STATIONS

The measurements to be taken in this survey have been divided into seven manageable groups, each group to be measured at a specific station. The dimensions assigned to each station, in order of measurement, are as follows.

Station #1

Stature
Cervicale Height
Neck Height, Lateral
Acromial Height
Axilla Height
Suprasternale Height
Chest Height
Tenth Rib Height
Waist Height (Natural Indentation)
Iliocristale Height
Waist Height (Omphalion)
Waist Breadth
Waist Depth
Hip Breadth
Chest Depth
Chest Breadth
Bustpoint/Thelion-Bustpoint/Thelion Breadth
Acromion-Radiale Length
Radiale-Stylion Length
Shoulder-Elbow Length
Forearm-Hand Length
Axillary Arm Circumference
Elbow Circumference
Wrist Circumference
Biceps Circumference, Flexed
Forearm Circumference, Flexed

Station #2

Thumbtip Reach
Wrist-Wall Length
Wrist-Wall Length, Extended
Overhead Fingertip Reach
Overhead Fingertip Reach, Extended
Span
Overhead Fingertip Reach, Sitting
Lateral Femoral Epicondyle Height
Knee Height, Midpatella
Calf Height
Lateral Malleolus Height
Wrist Height, Sitting

Station #3

Functional Leg Length
Crotch Length (Omphalion)
Crotch Length (Natural Indentation)
Vertical Trunk Circumference (ASCC)
Vertical Trunk Circumference (USA)
Waist (Natural Indentation)-Waist (Omphalion) Length
Waist-Hip Length
Buttock Circumference
Thigh Circumference
Gluteal Furrow Height
Buttock Height
Trochanteric Height
Wrist Height
Crotch Height
Buttock Depth
Bispinous Breadth
Bimalleolar Breadth
Heel Breadth
Crotch Length, Posterior (Omphalion)
Crotch Length, Posterior (Natural Indentation)

Station #4

Head Circumference
Bitragion Coronal Arc
Bitragion Crinion Arc
Bitragion Frontal Arc
Bitragion Subnasale Arc
Bitragion Chin Arc
Bitragion Submandibular Arc
Bizygomatic Breadth
Head Length
Head Breadth
Menton-Sellion Length
Ear Length
Ear Length above Tragion
Ear Breadth
Ear Protrusion
Interpupillary Breadth
Thumb Breadth
Wrist-Thumbtip Length
Wrist-Center of Grip Length
Hand Length
Wrist-Index Finger Length
Hand Breadth
Hand Circumference

Station #5

Eye Height, Sitting
Sitting Height
Cervicale Height, Sitting
Midshoulder Height, Sitting
Acromial Height, Sitting
Elbow Rest Height
Waist Height, Sitting (Natural Indentation)
Waist Height, Sitting (Omphalion)
Thigh Clearance
Knee Height, Sitting
Popliteal Height
Buttock-Knee Length
Buttock-Popliteal Length
Hip Breadth, Sitting
Biacromial Breadth
Bideltoid Breadth
Forearm-Forearm Breadth
Abdominal Extension Depth, Sitting

Station #6

Weight
Neck Circumference
Neck Circumference, Base
Shoulder Circumference
Chest Circumference at Scye
Chest Circumference
Chest Circumference Below Breast
Waist Circumference (Natural Indentation)
Waist Circumference (Omphalion)
Waist Front Length (Natural Indentation)
Waist Front Length (Omphalion)
Strap Length
Neck-Bustpoint/Thelion Length
Shoulder Length
Interscye II
Interscye I
Scye Depth
Waist Back Length (Natural Indentation)
Waist Back Length (Omphalion)
Scye Circumference
Sleeve Outseam
Sleeve Length: Spine-Scye
Sleeve Length: Spine-Elbow
Sleeve Length: Spine-Wrist
Lower Thigh Circumference
Knee Circumference
Calf Circumference
Ankle Circumference
Heel/Ankle Circumference
Ball of Foot Circumference

Station #7

Hand photometric system - hand photos
Automated headboard device - three-dimensional head and face coordinates of the following points:

Alare, right and left
Cheilion, right and left
Crinion
Ectoorbitale, posterior: right and left
Frontotemporale, right and left
Glabella
Gonion, right and left
Infraorbitale, right and left
Menton
Promenton
Pronasale
Sellion
Stomion
Subnasale
Tragion, right and left
Zygion, right and left
Zygofrontale, right and left

Station #8

Ball of Foot Length
Foot Breadth, Horizontal
Foot Length

Basically, one pair of anthropometrists will be assigned to each measuring station, although male and female measurer/recorder pairs will rotate between station #3 (sex-sensitive measurements) and station #7 (hand photos and three-dimensional head measurements) depending on the sex of the subjects to be measured.

Other stations will include an in/out processing station and two marking stations where several team members will locate and draw marks on subjects to be used later by the measurers in locating the dimensions to be measured (see next section: LANDMARKS).

SUBJECT SELECTION

The 8,000 subjects to be measured in this survey will be selected according to a carefully devised sampling strategy. The sampling plan will ensure that the survey sample includes sufficient numbers of all the age, gender, and racial/ethnic groups found in the Army. Approximately 30,000 soldiers will be screened to achieve this end. The screening process will include the collection of biographical data and measurements of stature and weight. Two team members will work with Army personnel at the subject selection station.

Subject selection will ordinarily occur at or near a Company's headquarters and/or barracks. There, groups of 80-120 soldiers will assemble at morning and afternoon formations where they will be briefed about the survey. The soldiers will fill out biographical questionnaires which include information needed to select survey subjects, and will be asked to change into the standard shorts (for women, shorts and T-shirts) so they can be measured for stature and weight by the team members. A physician's scale and anthropometer will be used to obtain the measurements. Read the scale to the closest tenth of a kilogram, and stature to the closest 1 mm.

Using the biographical and measurement information as input, Army personnel will select subjects on the basis of computer programs. Those selected for the survey will then proceed to the measuring site. Those not selected for the survey will turn in their biographical questionnaires. Thank them, and tell them they are free to return to their company formation and/or duties.

IN/OUT PROCESSING STATION

Subjects arriving at the measuring site will be briefed by the team supervisor on the general purposes and procedures of the survey, and proceed to a dressing room where standard shorts and T-shirts will be issued. From there, subjects go to the in/out processing station. Team members assigned to this station will be responsible for entering information from the subject's biographical form into the computer. The resulting disk will be given to the subject who will carry it around to each measuring station where dimensional data will be recorded on it. After measuring is completed, the subject will return to the in/out processing station where three additional measurements will be made: Foot Length, Ball of Foot Length, and Foot Breadth, Horizontal. A team member will make a printout of the disk and check to see that the subject has visited all other measuring stations. If not, he or she will be asked to go back to the missing station. If information is complete the subject will be thanked, routed to the debriefing station where he or she will turn in the shorts and T-shirt, and dismissed. The disk and printout will be retained at the in/out processing station.

A flow diagram for the processing of subjects is shown in Figure 12.

MEASURING STATION LAYOUT

At the measuring stations each pair of anthropometrists will alternate as measurer and recorder. The function of the measurer is, of course, to take the measurements. The recorder's primary function is to enter the measurement data into the computer and check the values of the measurements called off by the measurer.

Important additional duties of the recorder are to assist the measurer in achieving and maintaining the proper instrument orientation when taking measurements (e.g., the tape is horizontal, the anthropometer vertical), and to ensure that the subject is in the proper position for a particular measurement (e.g., looking straight ahead, shoulders relaxed). In almost all cases, this assistance involves visual checks and verbal suggestions. To accomplish these duties with minimum interference to data entry, the recorder positions himself or herself so as to get the best possible view of everything that goes on at the station. Each anthropometrist/recorder pair will work out between themselves how best to do that. The suggested layout of measuring station #2 in Figure 13 illustrates one useful arrangement. (In actual practice, only one subject will occupy a measuring station at any one time.)

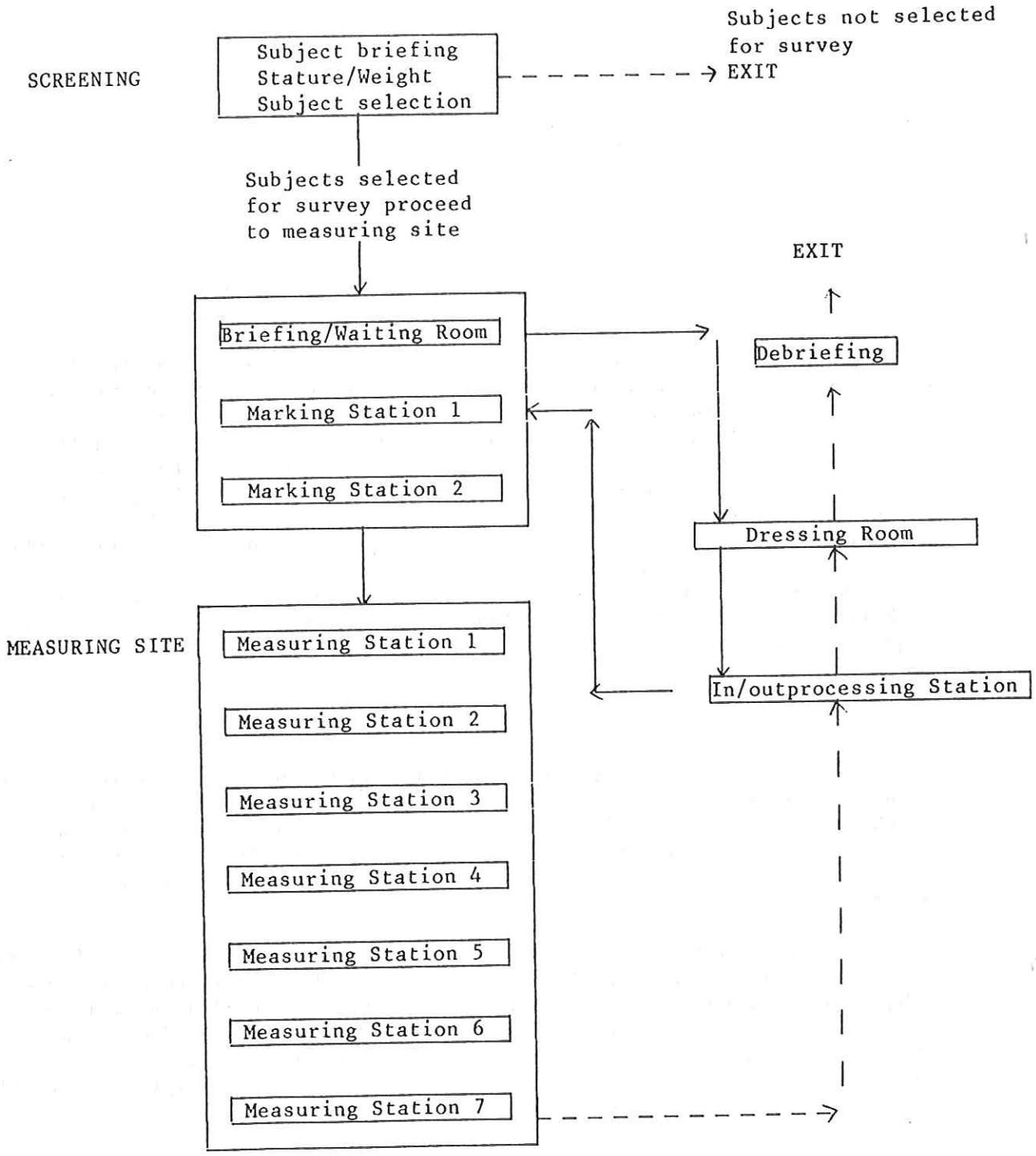


Figure 12. Flow chart for subject selection and processing.

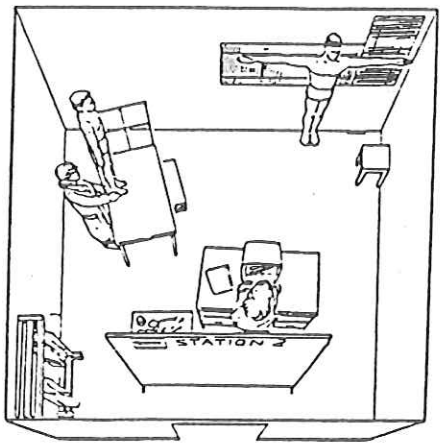


Figure 13. Suggested measuring station layout.

At station #2, the subject stands or sits in a corner for the several dimensions for which a wall-mounted scale is used. For one measurement the subject stands with the back against the wall and the arms outstretched at the sides. Other dimensions measured at this station require the subject to stand on a table where a few heights from the table to points on the leg are measured, several circumferences of the leg are taken, and three foot dimensions are measured. For these dimensions it is important for the recorder to ensure that the subject's arms are horizontal or vertical when a wall-scale is used, that the anthropometer is vertical when heights are measured, and that the tape is horizontal when circumferences are measured. With the recorder positioned as illustrated in Figure 13, only head movement is required to observe what is necessary.

THE LANDMARKS

Dimensions are measured from one point on the body (or a fixed surface such as a floor) to another, or in the case of circumferences, around a part of the body at a specified level. To ensure that each dimension is measured accurately and consistently from subject to subject, dimensions are defined in terms of body landmarks which serve as their origin, termination, or level of measurement.

Three categories of landmarks are described in this section: (1) About 65 landmarks (designated by lines, crosses, and dots) will be drawn on each subject in advance of the measuring. (2) Additional landmarks will be drawn on the face by team members operating the automated headboard at measuring station #7. (3) Some 30 easily-identified landmarks (e.g., dactylion II - the tip of the index finger) are cited in the measurement descriptions but will not actually be drawn on the subject's body.

DRAWN LANDMARKS

Many of the landmarks which serve as the starting point or endpoint of a given measurement are located with reference to underlying bones or muscles. Two men and two women will be trained in locating these points by palpation and sighting, and two marking stations will be set up for this purpose. The landmarks to be marked at the two stations are, in order of marking:

Marking Station 1

Crinion
Sellion
Tragion, right and left
Infraorbitale
Menton
Submandibular
Infrathyroid
Cervicale
Neck: right lateral, anterior, and left lateral
Trapezius point, right and left
Clavicle point, right and left
Acromion, right and left
Midshoulder
Scye, anterior on torso
Scye, anterior on upper arm
Scye: posterior horizontal on torso, right and left
Scye: posterior vertical, right and left
Scye: posterior diagonal, right and left
Midscye, right and left
Midspine
Scye level at midspine
Waist (omphalion), anterior
Deltoid point, right
Biceps point

Marking Station 2

Lateral femoral epicondyle, sitting
Trochanter
Inner thigh
Gluteal furrow point
Anterior superior iliac spine, right and left
Iliocristale
Trochanterion
Lateral femoral epicondyle standing
Suprapatella
Midpatella
Dorsal juncture of the foot and leg
First metatarsophalangeal protrusion
Fifth metatarsophalangeal protrusion
Lateral malleolus
Calf
Suprasternale
Tenth rib
Waist (natural indentation), right
Bustpoint, right and left
Radiale
Stylion
Metacarpale II
Metacarpale V
Wrist, dorsal
Olecranon, center
Deltoid point, left
Waist (omphalion): right, left, and posterior
Waist (natural indentation): posterior, left, and anterior
Buttock point, right and left lateral

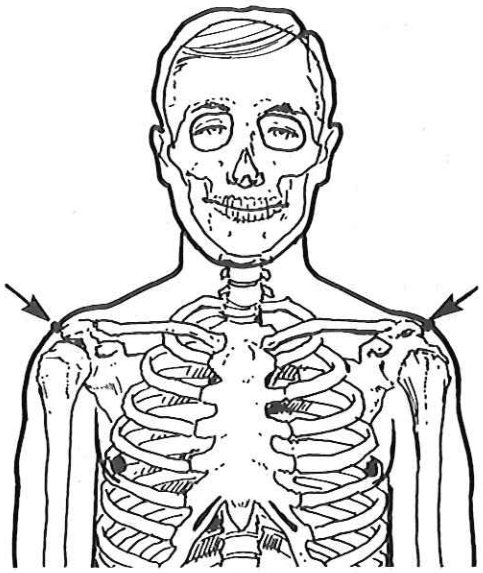
LANDMARK DESCRIPTIONS

The following pages describe the landmarks drawn on the body and give instructions for their location and marking.

Acromion, right and left

DESCRIPTION: The point of intersection of the lateral border of the acromial process and a line running down the middle of the shoulder from the neck to the tip of the shoulder.

PROCEDURE: Subject is in the anthropometric standing position. Stand behind the subject and palpate the tips of both shoulders simultaneously. Draw a line along the lateral bony border of each shoulder. Then stand at the right of the subject and lay a tape on the shoulder originating at the **trapezius point** (at the base of the neck), passing so that the front edge of the tape lies over the **clavicle** (collar bone) **point**, and crosses the drawn acromial border at the tip of the shoulder. Draw a short line along the front edge of the tape where it crosses the acromial border. Repeat the process for the left shoulder.

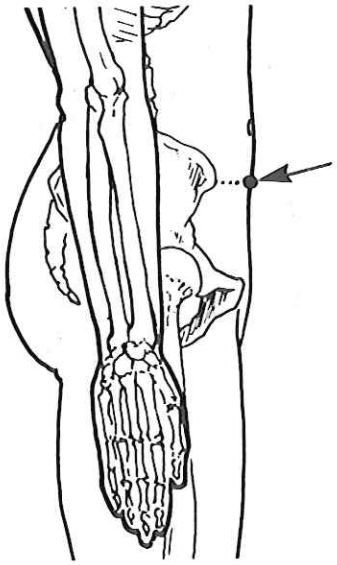


Anterior superior iliac spine, right and left

DESCRIPTION: The anterior points of the right and left iliac crests.

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject. Locate each iliac crest (the top of the pelvis) by palpation and then bring the thumb to the anterior points of the crests. Draw a cross (+) through each landmark. In most cases you will have to ask the subject to lower the waistband of the shorts somewhat to reveal these points.

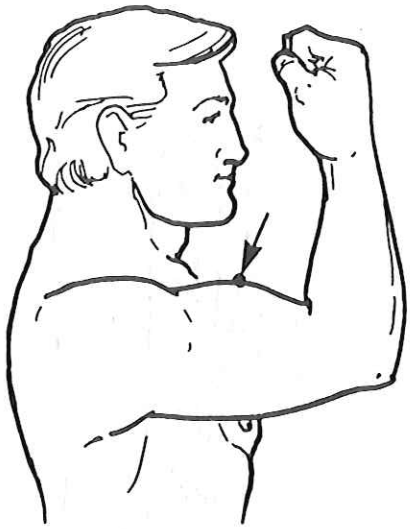
CAUTION: Do not distort the skin when drawing the cross.



Biceps point

DESCRIPTION: The highest point of the right flexed biceps as viewed from the subject's right side.

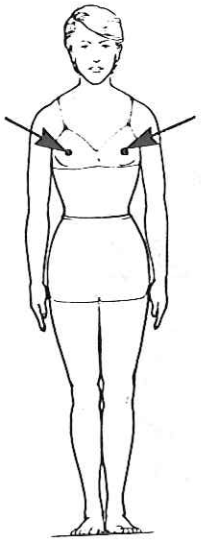
PROCEDURE: Subject stands with the right upper arm extended forward horizontally and the elbow flexed about 90 degrees. The fist is tightly clenched and held facing the head. Stand to the right of the subject and locate the highest point on the flexed biceps by inspection. Draw a short line perpendicular to the long axis of the upper arm passing through the landmark.



Bustpoint, right and left

DESCRIPTION: The anterior points of the bra cups.

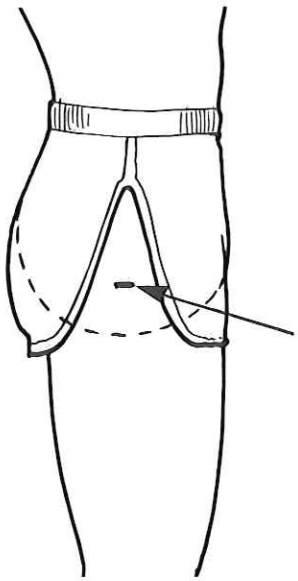
PROCEDURE: Subject is in the anthropometric standing position. Stand at the right of the subject and sight the most protruding point of the bra over each breast. Draw a dot on each landmark.



Buttock point, right lateral and left lateral

DESCRIPTION: Points at the level of the maximum protrusion of the right buttock.

PROCEDURE: Subject is in the anthropometric standing position. Stand at the right of the subject and sight the point of maximum protrusion of the right buttock (buttock point, posterior). (This landmark is not drawn.) Set the landmark transfer rod to the height of the posterior buttock landmark. Move it to the right and left sides of the subject and draw short horizontal marks on each side. On the right side mark the line with a "B".

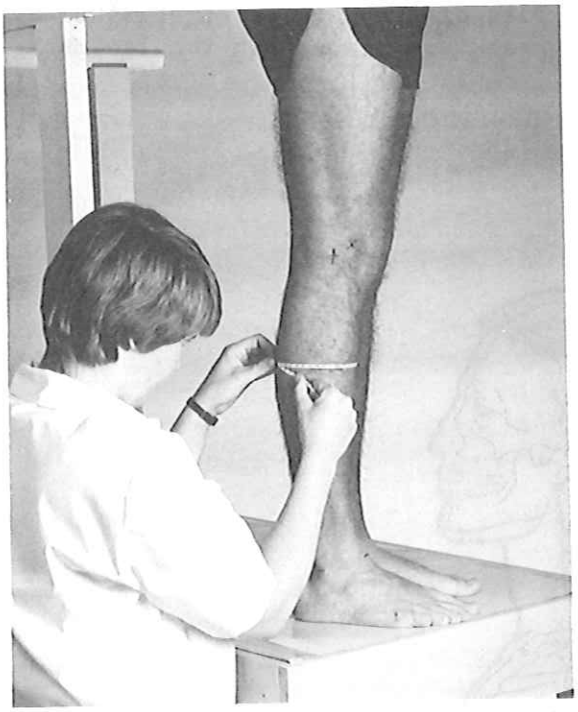


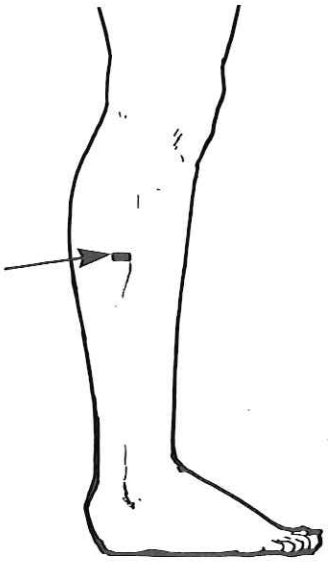
Calf

DESCRIPTION: A point on the side of the calf at the level of the maximum circumference of the right calf.

PROCEDURE: Subject stands erect on a table with the weight distributed equally on both feet. Stand behind the subject. Wrap a tape around the calf, crossing it at the back, and slide it up and down to establish the maximum circumference of the calf. Be sure the tape is in a horizontal plane. Draw a short horizontal line along the bottom of the tape on the lateral side of the calf.

CAUTION: On some subjects the level of maximum circumference of the calf may extend vertically more than 1 cm. In such cases, the landmark is drawn at the level of the lowest maximum circumference of the calf.



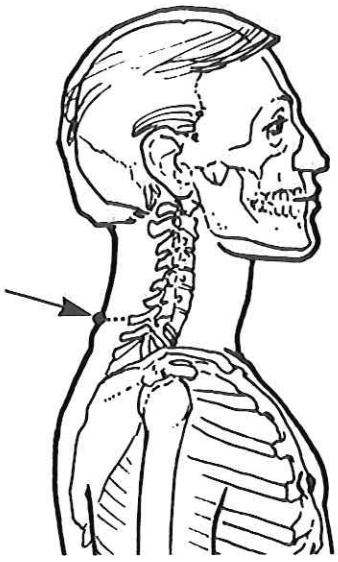


Cervicale

DESCRIPTION: The superior palpable point of the spine of the seventh cervical vertebra.

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. The spine of the seventh cervical vertebra is the most prominent vertebral spine of the back of the neck. It is best found by having the subject bend the head downwards. Stand behind the subject and with the pad of the index finger, palpate the most prominent spine. Have the subject slowly bring the head up to the Frankfort plane while intermittently touching the spine. When the head is in place, locate the superior point of the spine of the seventh cervical vertebra. Draw a cross (+) through the landmark.

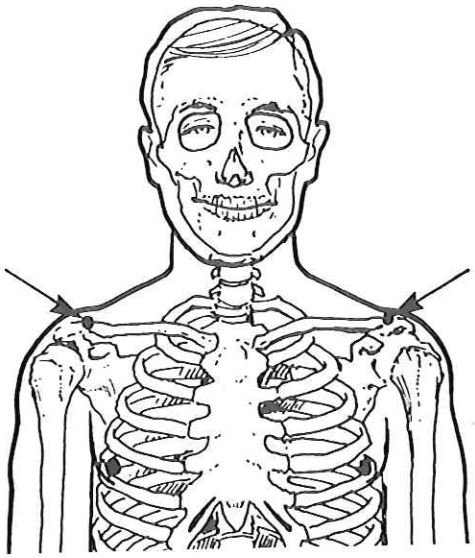
CAUTION: A few subjects will be encountered on whom no cervical spine prominence is detectable. On such subjects, estimate the point as nearly as possible with respect to the neck and shoulders. A few subjects will exhibit two or three equally prominent spinal processes. In such cases, mark the spine that is closest to the posterior base of the neck as established by a tape. Be sure that the head is in the Frankfort plane when the landmark is drawn.



Clavicle point, right and left

DESCRIPTION: The superior points of the lateral ends of the clavicles.

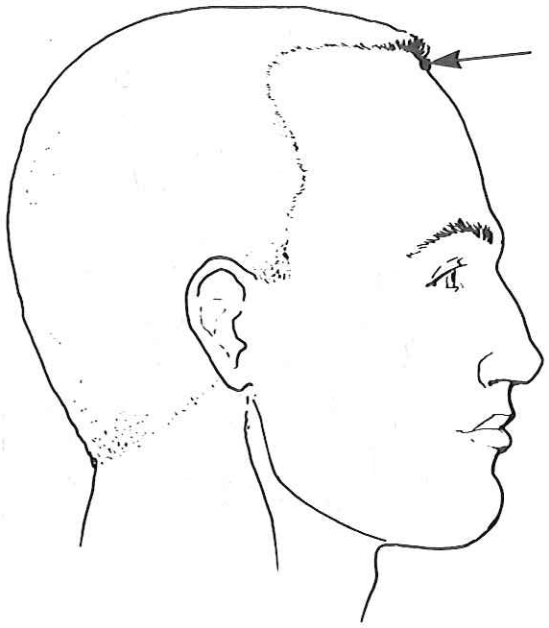
PROCEDURE: Subject is in the anthropometric standing position. Stand behind the subject and palpate the top of the lateral ends of the clavicles (collar bones) near the tips of the shoulders until you locate their most superior points. Place dots over the landmarks.



Crinion

DESCRIPTION: The lowest point of the hairline on the forehead in the midsagittal plane.

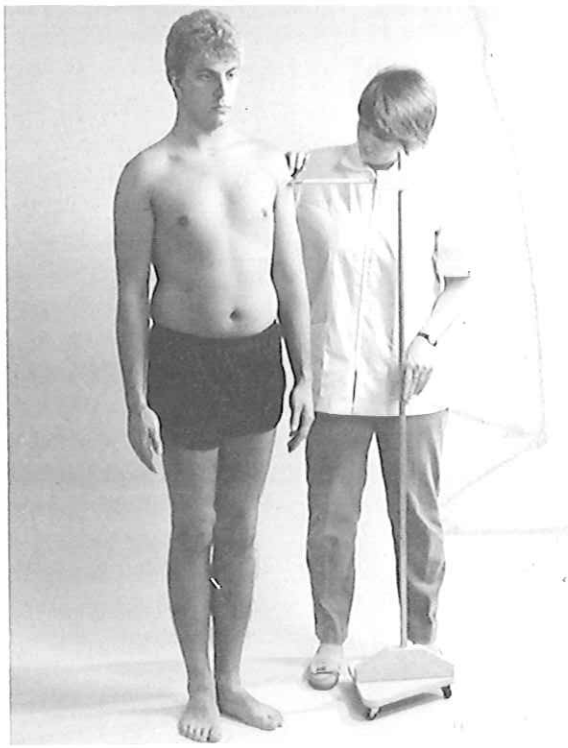
PROCEDURE: Subject stands looking straight ahead. Stand in front of the subject and locate, by inspection, the lowest point of the hairline on the forehead in the midsagittal plane (on some subjects, the widow's peak). Place a dot on the landmark. On subjects with receding hairlines, this landmark cannot be established and is, therefore, not drawn.

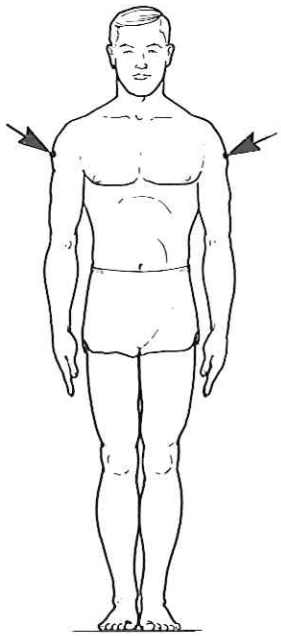


Deltoid point, right and left

DESCRIPTION: The lateral point of the right deltoid muscle, and the margin of the left deltoid muscle at the level of the right deltoid point.

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and locate, by inspection, the most protruding point of the right upper arm overlying the deltoid muscle. Draw a short horizontal mark through the landmark. Use a landmark transfer rod set at the height of the right deltoid landmark to establish the location of the left deltoid landmark. Draw a short horizontal line through the left landmark.





Dorsal juncture of the foot and leg

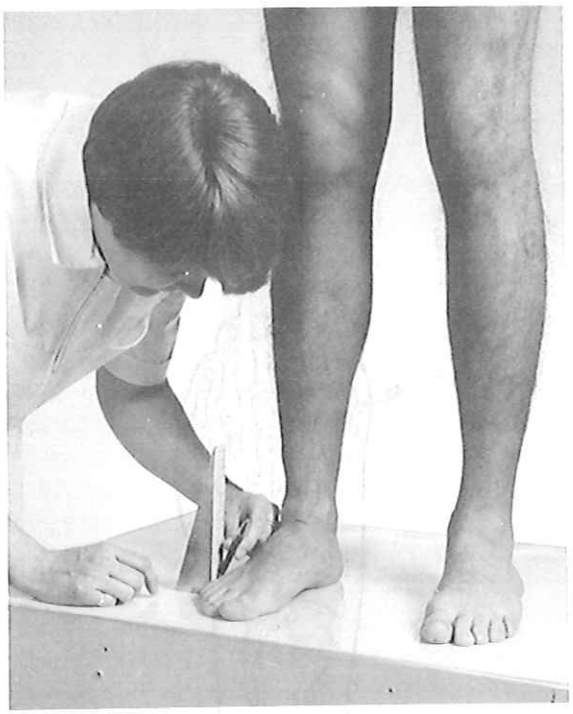
DESCRIPTION: The top of a skin crease between the foot and the front of the ankle when the knees and ankles are flexed about 30 degrees.

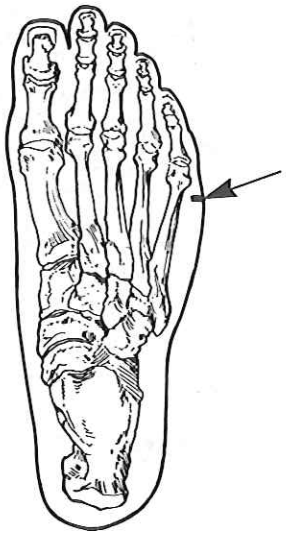
PROCEDURE: Subject stands on the table with the feet flat on the table and the knees bent so that distinct skin creases appear on the top of the foot at its juncture with the ankle. Stand in front of the subject and locate the top of the deepest and longest crease by inspection. Ask the subject to stand erect and then draw a short horizontal line through the point.

Fifth metatarsophalangeal protrusion

DESCRIPTION: The most lateral protrusion of the right foot in the region of the fifth metatarsophalangeal joint.

PROCEDURE: Subject stands on a graph paper on a table with the weight distributed equally on both feet. Position the right foot in such a way that the inside of the foot is parallel to a line on the table. Stand in front of the subject and, by inspection, locate the maximum protrusion on the outside of the foot near the little toe. If the maximum protrusion is not clearly defined, use a marking block. The landmark is at the midpoint of the surface that is in contact with the block. Draw a short vertical line through the landmark.

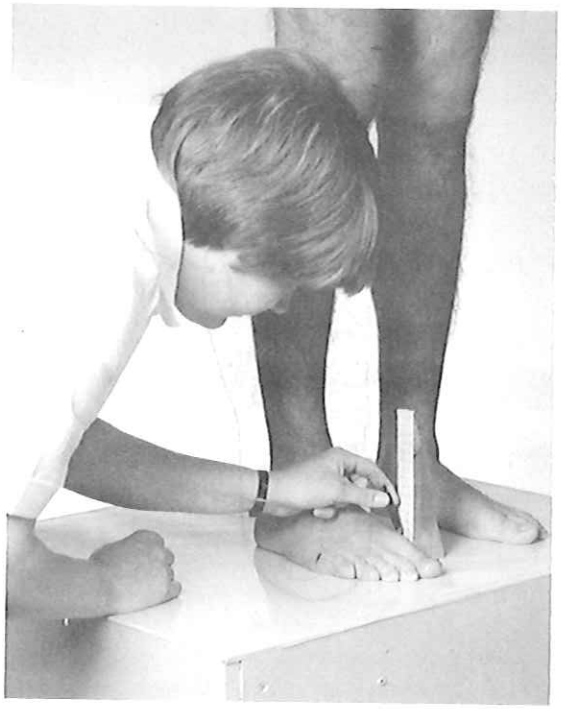




First metatarsophalangeal protrusion

DEFINITION: The most medial protrusion of the right foot in the region of the first metatarsophalangeal joint.

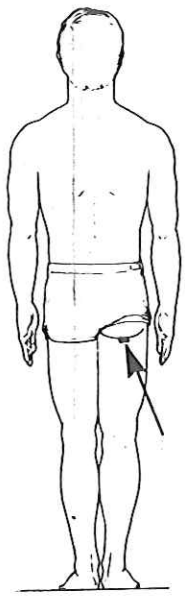
PROCEDURE: Subject stands on a table with the weight distributed equally on both feet. Position the right foot in such a way that the inside of the foot is parallel with a line on the table. Stand in front of the subject and, by inspection, locate the maximum protrusion of the inside of the foot near the big toe. If the maximum protrusion covers an area larger than a point use a marking block. The landmark is at the midpoint of the surface that is in contact with the block. Draw a short vertical line through the landmark. On some subjects the big toe will splay out. This should be ignored. Be sure the mark is placed on or near the joint on the end of the foot and not on the toe.



Gluteal furrow point

DESCRIPTION: The lowest point of the lowest furrow or crease at the juncture of the right buttock and the thigh.

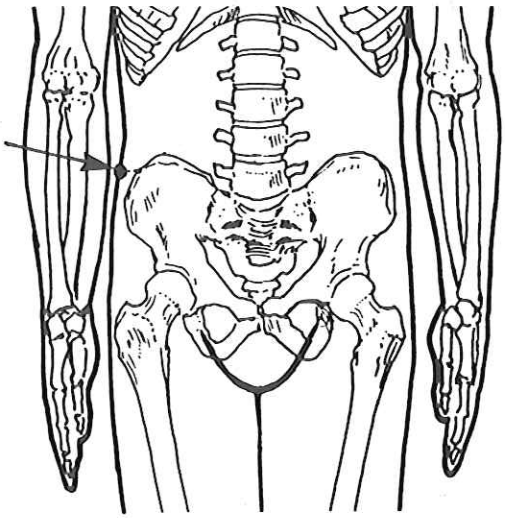
PROCEDURE: Subject is in the anthropometric standing position. Stand behind the subject and draw a short horizontal line at the top of the thigh at the lowest point of the lowest crease. Where there is a smooth continuous curve at the juncture of the thigh and buttock, view the buttock/thigh juncture from the right side and draw the landmark where you judge it to be appropriate. Even on subjects with a continuous curve, a skin crease can usually be discerned.



Iliocristale

DESCRIPTION: The highest palpable point of the right iliac crest of the pelvis, one half the distance between the anterior superior iliac and posterior superior iliac spines.

PROCEDURE: Subject stands in the anthropometric standing position. Stand in front of the subject. Use both hands to locate the anterior and posterior points of the iliac crests and note one half the distance between them. At this midpoint, use the tip of the finger to move upwards on the right side to locate the highest palpable point, and draw a short horizontal line through the landmark. Draw an "I" on the line.

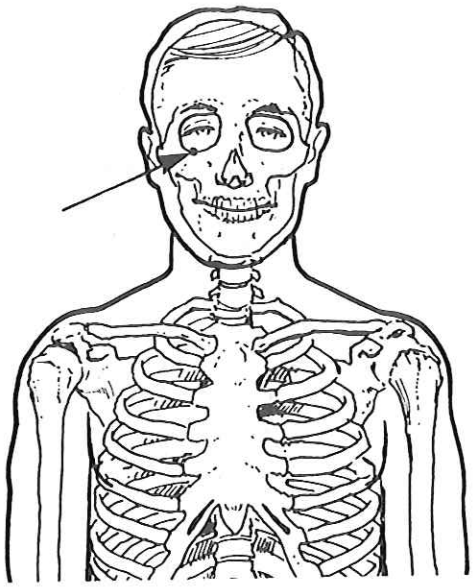


Infraorbitale

DESCRIPTION: The lowest point on the anterior border of the bony eye socket.

PROCEDURE: Subject stands, looking straight ahead. Stand in front of the subject and palpate the bony eye socket under the eye to locate its lowest point. Draw a dot on the landmark.

CAUTION: Subjects may be apprehensive when you palpate near their eyes. Care must be taken in locating this landmark to reduce the subject's concern.

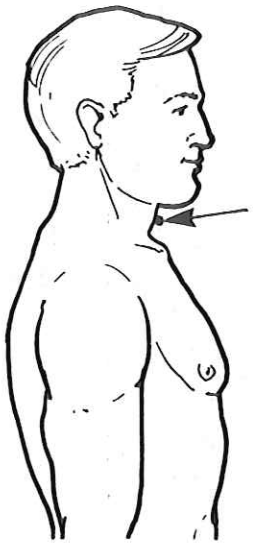


Infrathyroid

DESCRIPTION: The inferior point in the midsagittal plane of the thyroid cartilage (Adam's apple).

PROCEDURE: Subject stands with the head in the Frankfort plane. Stand in front of the subject and palpate the smooth lateral surface of the thyroid cartilage moving downwards until you feel the space between the thyroid cartilage and the cricoid cartilage just below it. Then locate the bottom point of the thyroid cartilage in the midsagittal plane. Draw a short horizontal line through the landmark.

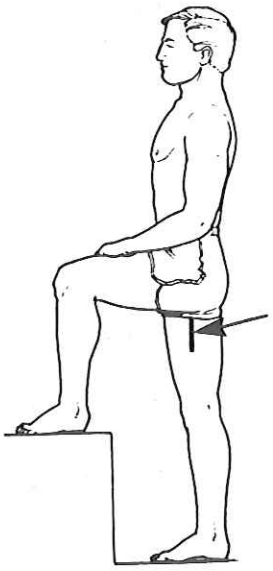
CAUTION: Be sure the subject's head is in the Frankfort plane.



Inner thigh

DESCRIPTION: A vertical line halfway between the front and back of the right inner thigh, and extending downward from the level of the gluteal furrow.

PROCEDURE: Subject stands erect, looking straight ahead with the left foot on a platform so that the left knee is flexed about 90 degrees. Stand at the left of the subject and locate the landmark by inspection. Draw a vertical line approximately 4 cm long down the middle of the inner thigh beginning at the level of the gluteal furrow (posterior juncture of the buttock and thigh).

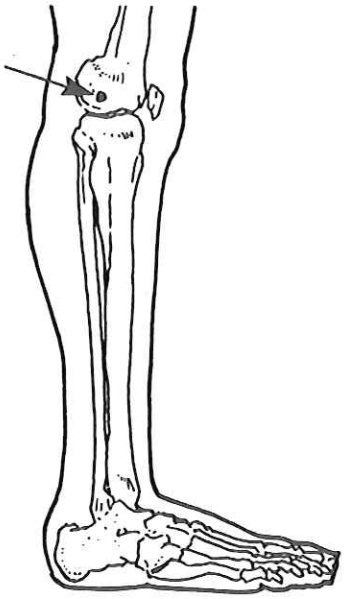


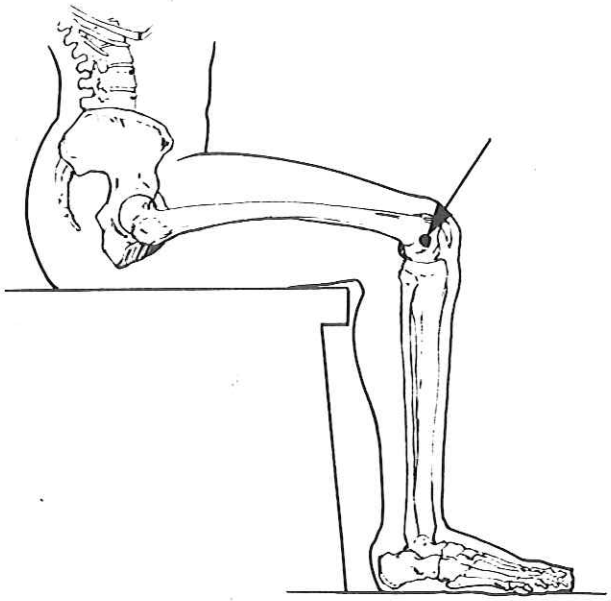
Lateral femoral epicondyle, standing and sitting

DESCRIPTION: Lateral point of the right femoral epicondyle (knee pivot point).

PROCEDURE: Subject stands erect on a table with the weight distributed equally on both feet. Stand in front of the subject and, with one hand, grasp the bony prominences of the bottom of the femur (femoral epicondyles) located to the left and right of the knee. Have the subject flex the knee to help locate these structures. The subject then straightens the knee. When you have located the lateral point of the lateral femoral epicondyle use the thumb or index finger of the other hand to mark its place and draw a cross (+) through the landmark. The subject now sits. The lateral femoral epicondyle point, sitting, is located by the same means while the subject sits. On this landmark draw an "O" about 5 mm in diameter.

CAUTION: This landmark is difficult or impossible to locate accurately in heavily muscled subjects. Use your best judgment in these cases.



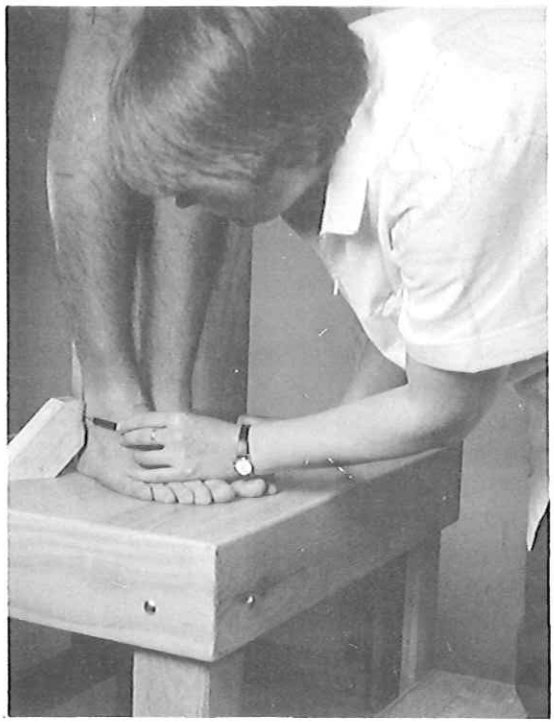


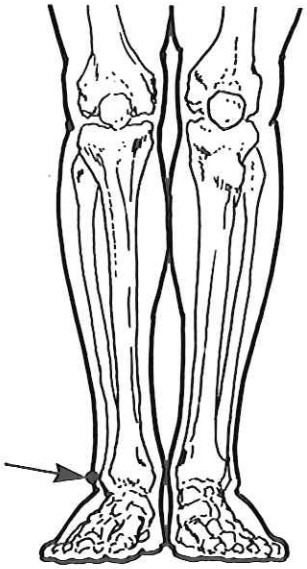
Lateral malleolus

DESCRIPTION: The lateral point of the right lateral malleolus (an ankle bone).

PROCEDURE: Subject stands on a table with the weight distributed equally on both feet. Stand at the subject's right and use a marking block to locate the protruding point on the lateral malleolus (the ankle bone on the outside of the foot). Draw a cross (+) through the point.

CAUTION: This landmark can be on a vein.



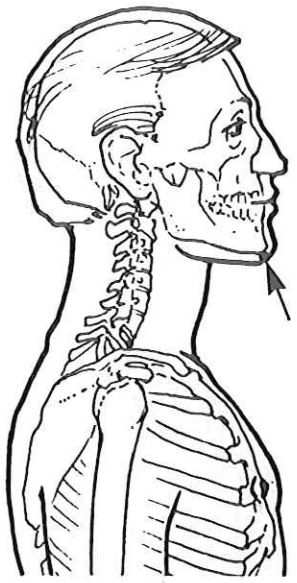


Menton

DESCRIPTION: The inferior point of the mandible in the midsagittal plane (bottom of the chin).

PROCEDURE: Subject stands, looking straight ahead, with the teeth together. Stand in front of the subject. Locate the landmark by palpation of the lower jawbone just under the chin, and draw a dot on it.

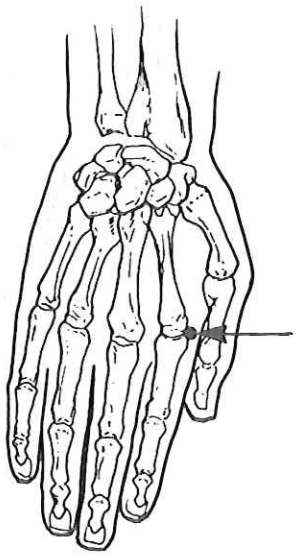
CAUTION: Be careful not to distort the sometimes soft tissue of the skin when drawing the landmark.



Metacarpale II

DESCRIPTION: The lateral point of the right metacarpophalangeal joint II (at the base of the index finger).

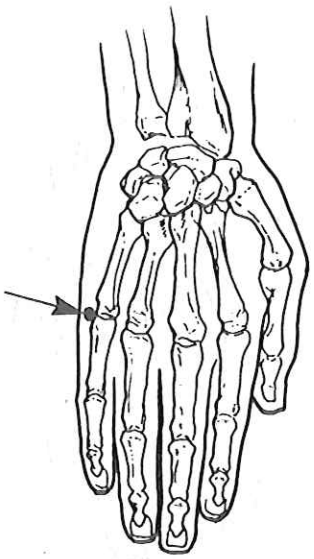
PROCEDURE: Subject stands. Stand in front of the subject. Grasp the subject's hand and palpate the metacarpophalangeal joint II to locate its most laterally protruding point. The landmark will be located on the side of the hand at the base of the index finger. Draw a short line perpendicular to the long axis of the finger through the landmark.



Metacarpale V

DESCRIPTION: The medial point of the right metacarpophalangeal joint V (at the base of the little finger).

PROCEDURE: Subject stands. Stand in front of the subject. Grasp the subject's hand and palpate the metacarpophalangeal joint V to locate its most medially protruding point. The landmark will be located on the side of the hand at the base of the little finger. Draw a short line perpendicular to the long axis of the finger through the landmark.

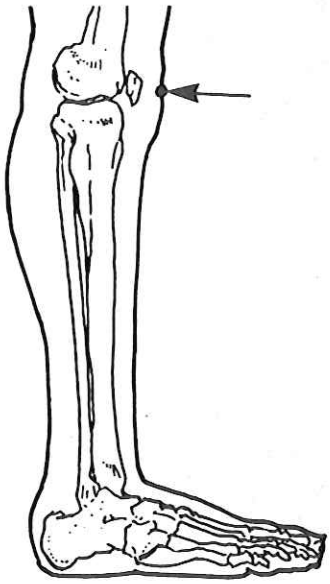


Midpatella

DESCRIPTION: The anterior point halfway between the top and bottom of the right patella (the kneecap).

PROCEDURE: Subject stands erect on a table with the knee relaxed. Stand in front of the subject. Grasp the kneecap with the forefinger on the **supra-patella** mark and the thumb on the lower edge of the patella. Establish the midpoint by sight and draw a short horizontal line through the landmark.

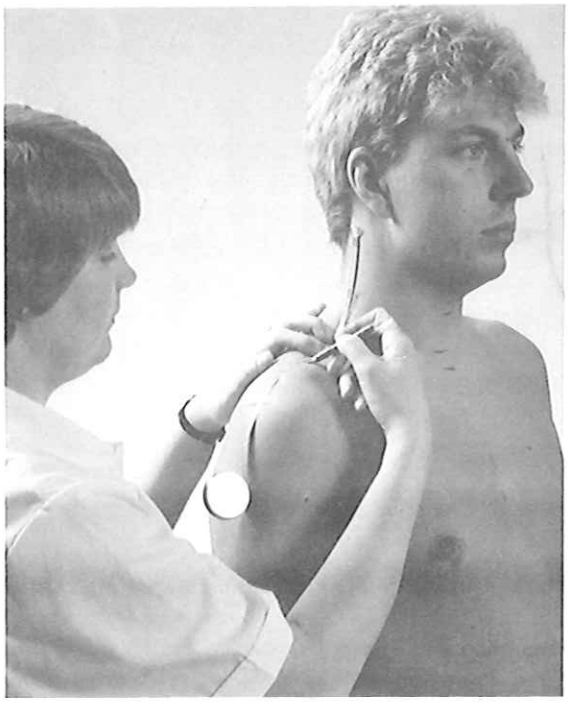
CAUTION: Subjects commonly lock their knees when this landmark is being located. If the subject has difficulty relaxing the knee, firmly grasp the subject's thigh a few inches above the knee and then let go. This usually has the effect of relaxing the patella. If the subject is still unable to relax the knee, move on to other landmarks and then try the patella landmark again.

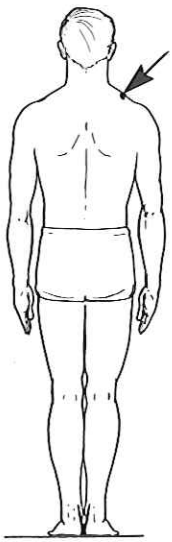


Midshoulder

DESCRIPTION: The point on top of the right shoulder midway between the neck (**right trapezius point**) and the tip of the shoulder (**acromion, right**).

PROCEDURE: Subject stands in the anthropometric standing position. Stand behind the subject and lay a tape along the top of the shoulder from the **trapezius point**, at the juncture of the neck and shoulder, to the **acromion landmark** at the tip of the shoulder. Note one-half the measured distance and draw a line from front to back across the shoulder at that point. Make sure the line crosses over the top of the trapezius muscle at that location.

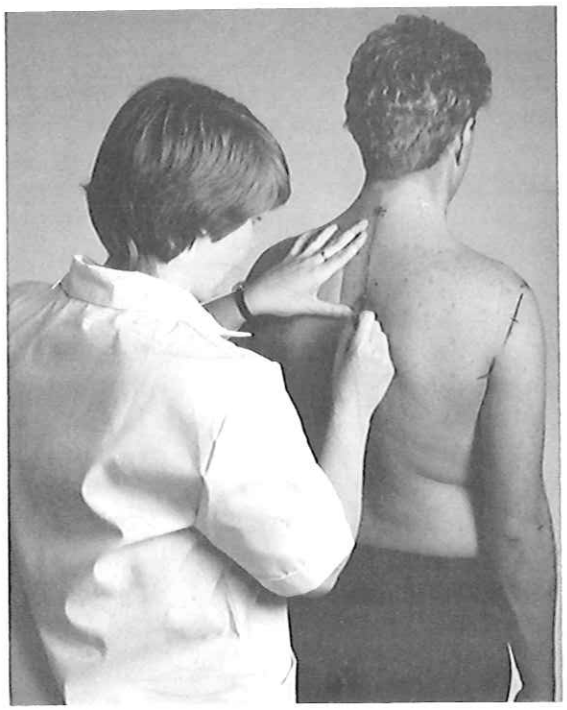


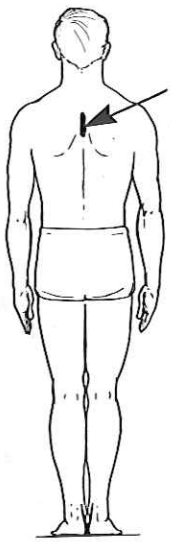


Midspine

DESCRIPTION: A line down the center of the back.

PROCEDURE: Subject is in the anthropometric standing position. Stand behind the subject. Using a plastic rule as a guide, draw a vertical line about 10 cm long down the back, in the midsagittal plane, beginning at a point about 4 cm below **cervicale** (at the base of the neck).

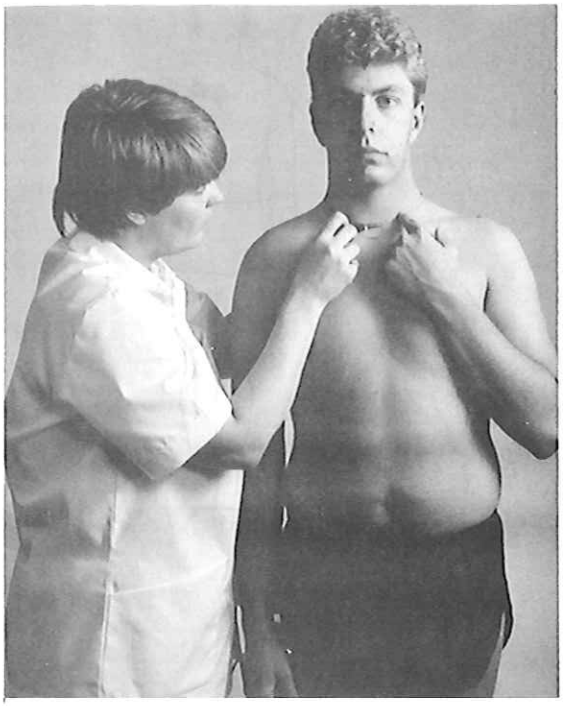


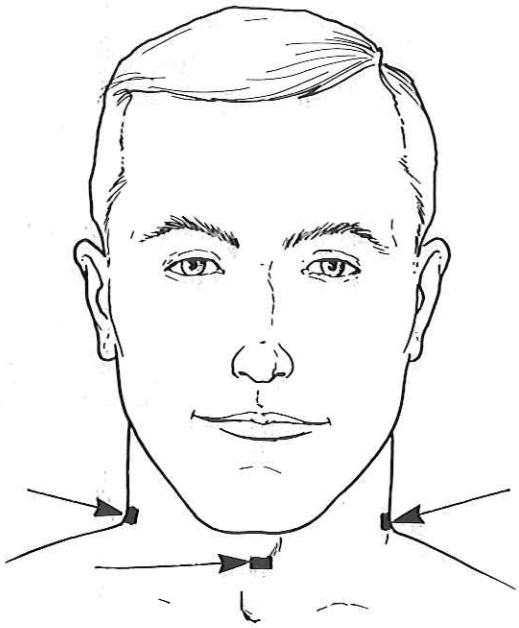


Neck: anterior, right lateral, and left lateral

DESCRIPTION: Anterior and lateral points at the base of the neck.

PROCEDURE: Subject stands looking straight ahead. Stand behind the subject. Place a tape around the base of the neck, laying it first in front, then on the sides, and finally, across the back, as if to measure NECK CIRCUMFERENCE, BASE. The anterior landmark is at the bottom of the tape, on the front of the neck in the midsagittal plane. The subject places a finger on the tape near the anterior landmark to help hold the tape in place. Draw a short horizontal line through the landmark. The right and left lateral landmarks are located at the bottom of the tape on both sides. Draw roughly 4-cm-long horizontal lines through both landmarks following the bottom of the tape.

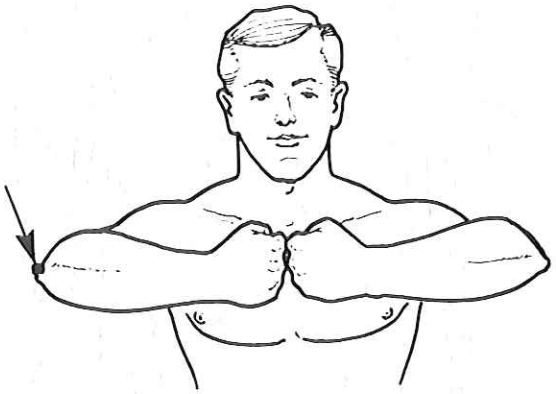




Olecranon, center

DESCRIPTION: A point on the center of the curvature of the right olecranon process (the elbow) with the elbow flexed about 115 degrees.

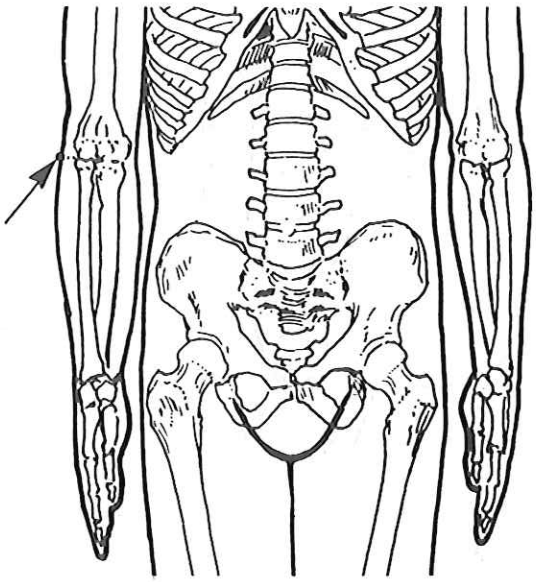
PROCEDURE: Subject stands. The subject makes fists and brings them together in such a way that the metacarpophalangeal and proximal interphalangeal knuckles are touching. With the volar surfaces of the hands facing outwards and the palm sides facing inwards, the subject raises the arms until they are in a horizontal position roughly parallel to the standing surface. The forearms and fists are in a straight line. Stand at the right of the subject. Locate the center of the curvature of the elbow by inspection and draw a short vertical line through the landmark.



Radiale

DESCRIPTION: The highest point on the outside edge of the radius.

PROCEDURE: Subject stands relaxed. Stand at the right of the subject and palpate the area of the landmark (the hollow on the lateral side of the elbow). When you have located the upper end of the radius bring the forefinger toward it horizontally and touch it gently so as not to pull the skin around it up or down. Draw a cross (+) through the point. If you have any difficulty locating this point, grasp the subject's wrist and rotate the arm back and forth while palpating the bone in the area of the landmark.



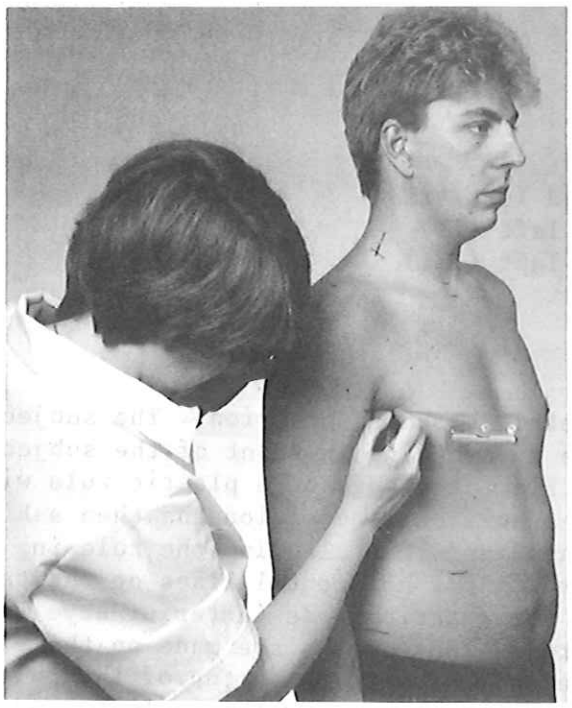
Scye

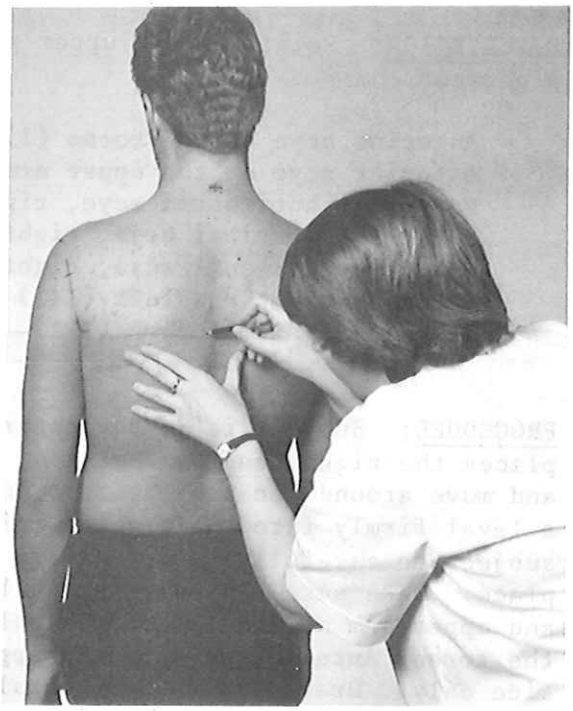
DESCRIPTION: Points on the upper arm and torso associated with the armhole of a garment.

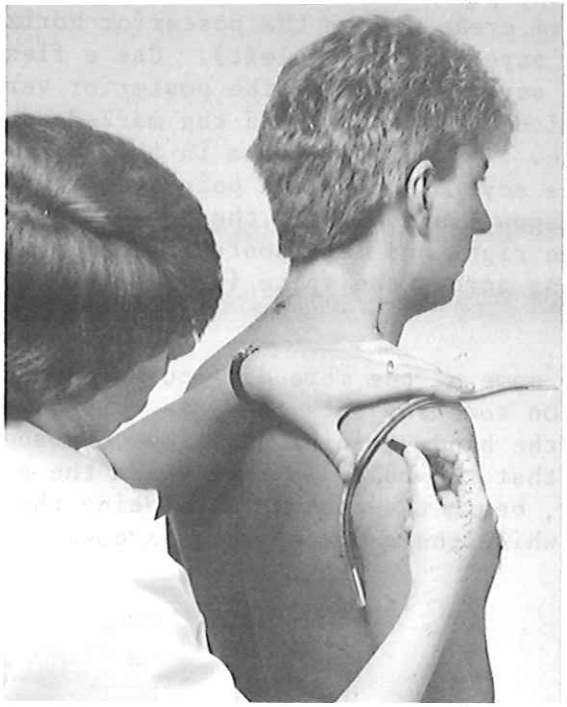
Anterior scye on the torso (I)
Anterior scye on the upper arm (I)
Posterior horizontal scye, right and left (II)
Posterior vertical scye, right and left (II)
Posterior diagonal scye, right and left (III)
Midscye, right and left (III)
Scye level at midspine (III)

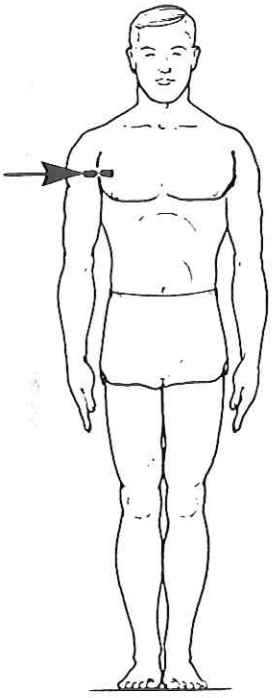
PROCEDURE: Subject is in the anthropometric standing position. The subject places the right hand on the hip. Begin by standing in front of the subject and move around the subject as needed. Place the edge of a plastic rule with a level firmly into the right armpit in a horizontal position and then ask the subject to carefully lower the arm to the side, thus clamping the rule in place. Make sure the rule is level. Draw short horizontal lines on the torso and upper arm at the top of the rule on the anterior side (**Anterior scye on the torso, Anterior scye on the upper arm**). These marks are made on the right side only. Draw a short horizontal line on the back at the top of the rule (**Posterior horizontal scye, right**). Repeat the process with the left hand on the hip and the rule in the left armpit for the **posterior horizontal scye, left.** Then remove the plastic rule and draw short vertical lines extending upwards along the arm creases from the posterior horizontal landmarks (**Posterior vertical scye, right and left**). Use a flexible rule to draw a line (**Posterior diagonal scye**) connecting the posterior vertical scye lines to the corresponding **acromion landmarks.** Hold the marked edge of the rule parallel to the coronal plane. Then place a tape in the same position, and note the distance between the scye and acromion points. Draw short horizontal lines intersecting the diagonal at one-half the noted distance (**Midscye**). With a ruler connecting the right and left posterior horizontal scye marks, draw a short horizontal line across the spine (**Scye level at midspine**).

CAUTION: These are some of the more difficult landmarks to locate accurately and consistently. On some subjects the arms will have to be held farther away from the body than the hands-on-hips position to place the ruler in its proper position. Be sure that the ruler is level when the arm is lowered to the side. If it is not, begin the process of placing the ruler again. Do not try to level the ruler while the subject's arm is down.

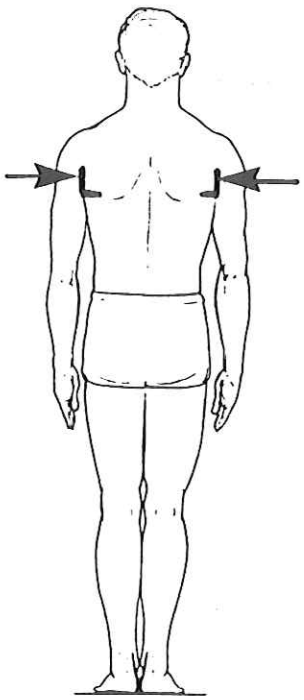




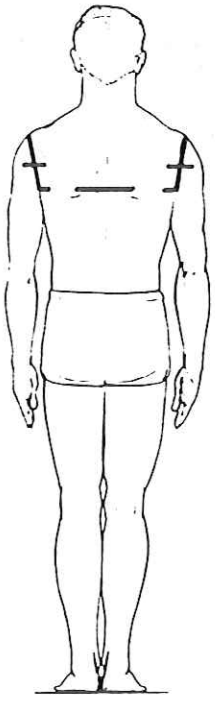




I



II

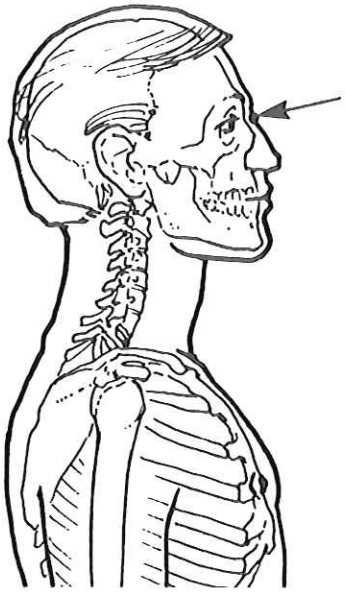


III

Sellion

DESCRIPTION: The point of the deepest depression of the nasal bones at the top of the nose.

PROCEDURE: Subject stands, looking straight ahead. Stand at the right of the subject and palpate the point of deepest depression of the bridge of the nose in the midsagittal plane. On some subjects, however, there is no distinctly deepest point and judgment will have to be used to establish its location. Draw a dot on the bridge of the nose at the landmark.

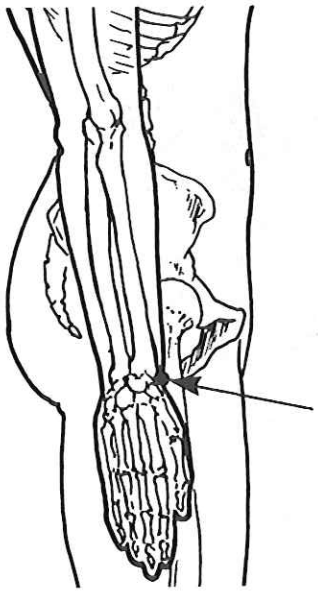


Stylion

DESCRIPTION: The lowest point of the bottom of the radius.

PROCEDURE: Subject stands. Stand in front of the subject and grasp the subject's hand. Place your thumb on the thumb side of the subject's hand and palpate up toward the wrist until you locate the end of the radius. Draw a cross (+) over the landmark.

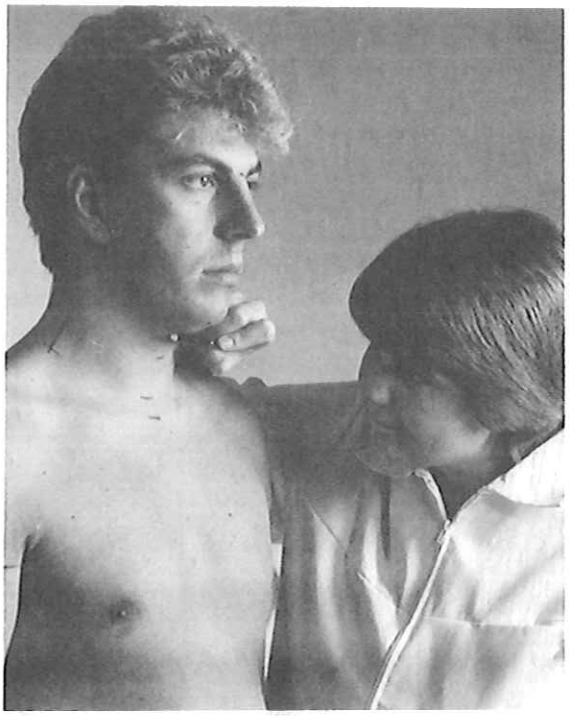
CAUTION: This area is crossed by tendons so it may be necessary to bend the hand up and down at the wrist to find the landmark.

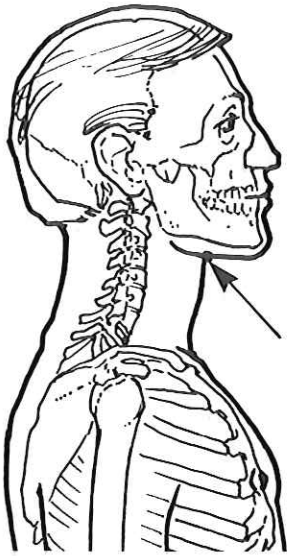


Submandibular

DESCRIPTION: The juncture, in the midsagittal plane, of the lower jaw and the neck.

PROCEDURE: Subject stands with the head in the Frankfort plane. Place a marking pencil on the underside of the jaw and lightly roll it back toward the neck until it is stopped by the neck. Draw a short horizontal line at this point.



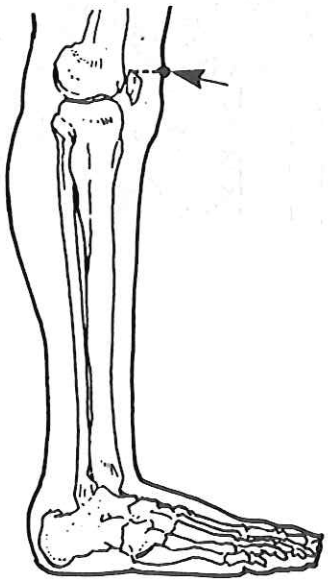


Suprapatella

DESCRIPTION: The superior point of the patella (kneecap).

PROCEDURE: Subject stands erect on a table with the patella relaxed. Stand in front of the subject and grasp the sides of the patella between the thumb and third finger, using the index finger to locate the top of the patella. In trying to locate the upper border of the patella, it may help to run your thumb and third finger up and down along its upper sides. When the top of the kneecap has been located draw a short horizontal line through the point.

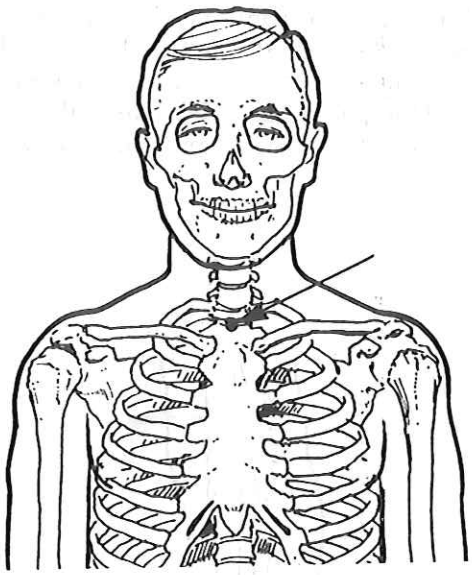
CAUTION: Subjects will tend to lock their knees when this landmark is being located. If the subject has difficulty relaxing the knee, firmly grasp the subject's thigh a few inches above the knee and then let go. This usually has the effect of relaxing the patella. If the subject is still unable to relax the knee, move on to other landmarks and then try the patella landmark again.



Suprasternale

DESCRIPTION: The inferior point of the jugular notch of the sternum (top of the breastbone).

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and locate the bottom of the notch of the sternum by palpation. Draw a short horizontal line through the landmark.

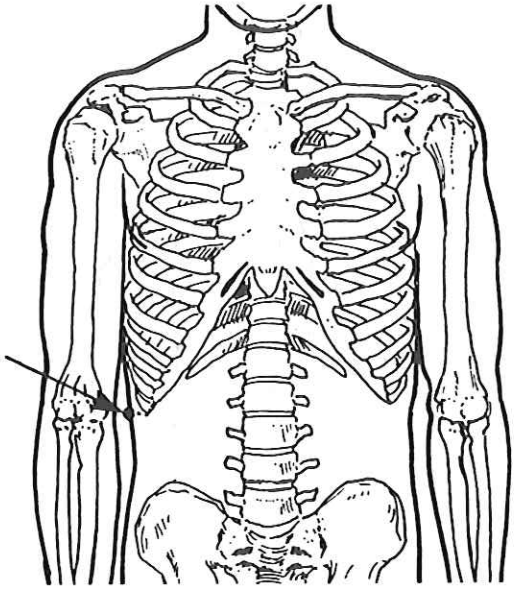


Tenth rib

DESCRIPTION: The inferior point of the right tenth rib (bottom of the rib cage).

PROCEDURE: Subject stands erect. Stand in front of the subject and begin palpating the bottom of the rib cage on the right side. Work toward the front along the bottom of the tenth rib until you locate its lowest point. Draw a short horizontal line through the landmark.

CAUTION: Subjects are often sensitive to touch in the waist area. Use firm pressure to find the deep bony structure. Avoid prolonged palpation of this area if possible.



Tragion, right and left

DESCRIPTION: The superior point on the juncture of the cartilaginous flap (tragus) of the ear with the head.

PROCEDURE: Palpate each tragus to find the superior point of attachment to the head. Place a dot on each landmark.

CAUTION: Avoid distorting the soft tissue in this area while drawing the landmark.

Trapezius point, right and left

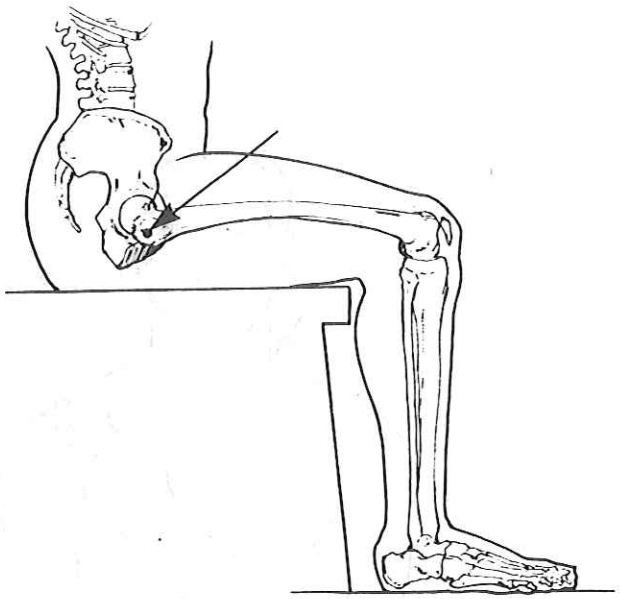
DESCRIPTION: The point at which the anterior border of the trapezius muscle crosses the **lateral neck landmark.**

PROCEDURE: Subject stands looking straight ahead. Ask the subject to place the right hand on his/her left shoulder to help outline the trapezius muscle on the right shoulder. Stand at the side of the subject. Moving from the shoulder to the neck, palpate the mass of the trapezius muscle to locate its anterior border. Draw a short line from the neck toward the shoulder at the point where the anterior border of the muscle crosses the **lateral neck landmark.** Repeat this procedure on the other side.

Trochanter

DESCRIPTION: A point at the center of the lateral surface of the right greater trochanter of the right femur of a sitting subject.

PROCEDURE: Subject sits with the knees flexed about 90 degrees. Stand at the right of the subject. Palpate the lateral surface of the greater trochanter near the hip joint and estimate its center. Draw an "O" about 5 mm in diameter on the landmark.

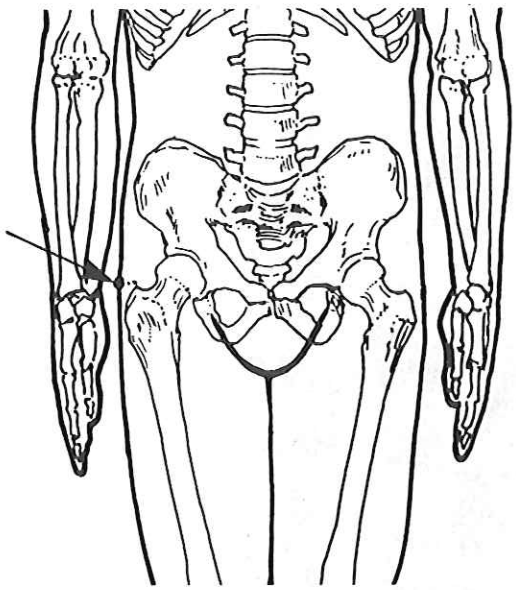


Trochanterion

DESCRIPTION: The superior point of the greater trochanter of the right femur of a standing subject.

PROCEDURE: Subject stands erect with weight distributed equally on both feet. Stand in front of the subject. Use the pads of the fingers to simultaneously locate both greater trochanters (near the hip joint). Work fingers up along the front and back of the right trochanter to find its highest point. On a number of subjects it will help to have the subject move the thigh back and forth. Draw a short horizontal line at the level of the landmark.

CAUTION: This can be a difficult landmark to locate and you may have to use your best judgment in drawing the landmark.

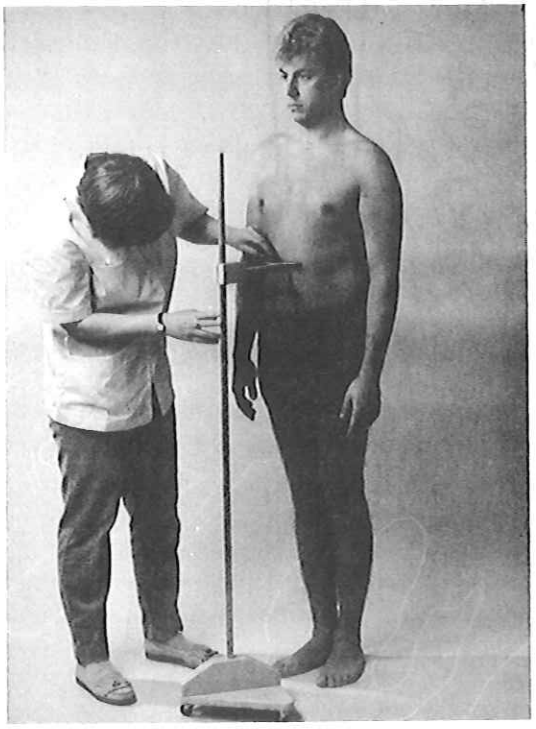


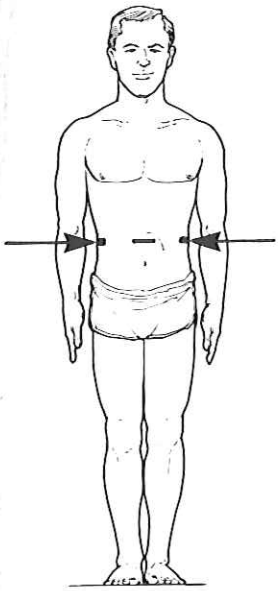
Waist (natural indentation): right and left; anterior and posterior

DESCRIPTION: The point of greatest indentation on the profile of the right side of the torso as viewed from the front of the subject, or one-half the distance between the **Tenth rib** and the **Iliocristale landmarks.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and locate the point of maximum indentation on the right side of the waist by inspection. On some subjects there will be more than one indentation that could be identified as a "natural indentation." On these subjects, the landmark is drawn one-half the distance between the **Tenth rib** and the **Iliocristale landmarks.** On these subjects, write "1/2" beside the landmark. Draw a cross (+) on the landmark. Use a landmark transfer rod set at the height of the right waist landmark to locate corresponding landmarks on the left, front and back of the subject. Draw 4-cm horizontal lines through these landmarks. The marks are drawn at the maximum point of quiet respiration.

CAUTION: The subject must not tense the abdominal muscles. Be sure to draw the landmarks at the maximum point of quiet respiration.



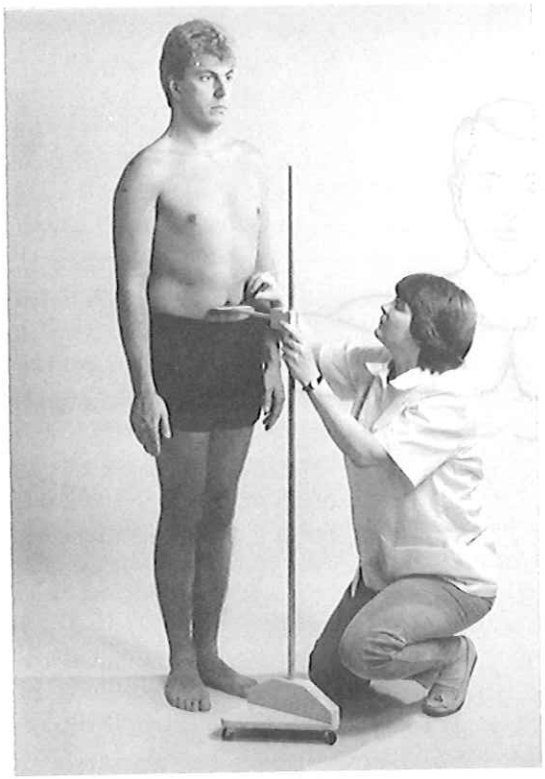


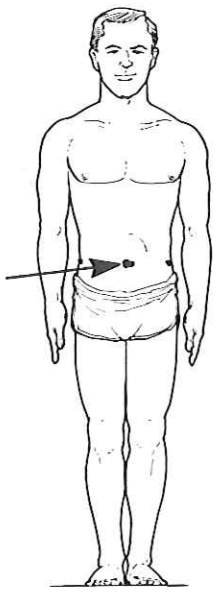
Waist (omphalion): right and left; anterior and posterior

DESCRIPTION: Center of the navel.

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and locate the landmark by inspection. Draw a 4-cm horizontal line across omphalion, and using a landmark transfer rod set at the height of omphalion, draw 4-cm horizontal lines on the right and left sides and over the spine of the subject. The landmarks are drawn at the maximum point of quiet respiration.

CAUTION: The subject must not tense the abdominal muscles or change body position while these marks are drawn.



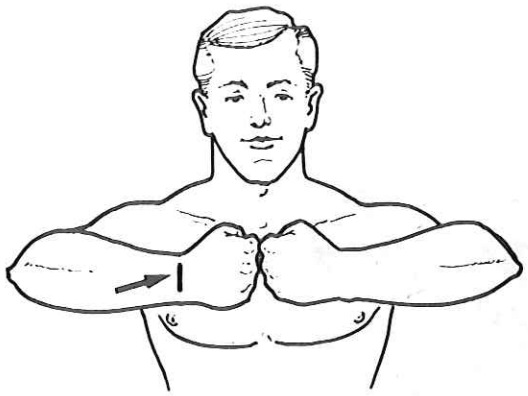


Wrist, dorsal

DESCRIPTION: A line across the back of the wrist originating at the **stylion landmark** and perpendicular to the long axis of the arm.

PROCEDURE: Subject stands. The subject makes fists and brings them together in such a way that the metacarpophalangeal and proximal interphalangeal knuckles are touching. With the volar surfaces of the hands facing outward and the palm sides facing inward, the subject raises the arms until they are in a horizontal position roughly parallel to the standing surface. The forearms and fists are in a straight line. Stand in front of the subject looking directly at the **stylion landmark** to eliminate errors in sighting. Draw a line across the dorsal (back) surface of the wrist beginning below stylion.

CAUTION: Be sure the line is vertical and that its origin is at stylion.



HEAD AND FACE LANDMARKS

Some head and face landmarks to be located and drawn at marking station #1 have already been described. They are: Crinion, Infraorbitale (right), Menton, Sellion, and Tragion (right and left).

A number of additional landmarks will be drawn on the face by measurers at measuring station #7. Ask the subject to sit on an elevated chair so the head and face are at the eye level of the marker. Locate the landmarks by palpation and visual inspection and mark each one with a dot using a fine-point marking pencil. Descriptions of the supplemental landmarks appear below. They are illustrated in Figure 14.

Alare, right and left -- the most lateral point on the flare or wing of the nose. It is located by visual inspection.

Cheilion, right and left -- the most lateral point of the juncture of the fleshy (mucosal) tissue of the lips with the facial skin at the corner of the mouth. It is located by visual inspection.

Ectoorbitale, posterior: right and left -- the posterior point on the marginal process of the zygomatic bone at the level of the outer corner of the eye **(ectocanthus)**. It is located by palpation.

Frontotemporale, right and left -- the point of deepest indentation of the temporal crest of the frontal bone above the browridges. It is located by palpation.

Glabella -- the most anterior point on the frontal bone midway between the bony browridges. It is located by inspection and palpation.

Gonion, right and left -- the most lateral point on the posterior angle of the mandible (jawbone). It is located by palpation.

Infraorbitale, left -- The lowest point on the anterior border of the bony eye socket.

Promenton -- the most anterior projection of the soft tissue of the chin in the midsagittal line. It is located by visual inspection.

Pronasale -- the point of the most anterior projection of the tip of the nose in the midsagittal line. It is located by visual inspection.

Stomion -- the point of intersection of the upper and lower lip in the midsagittal plane when the mouth is closed. It is located by visual inspection. This landmark is not drawn.

Subnasale -- the point of intersection of the philtrum (groove of the upper lip) with the inferior surface of the nose, in the midsagittal plane. It is located by visual inspection.

Zygion, right and left -- the most lateral point on the zygomatic arch. It is located by palpation and visual inspection.

Zygofrontale, right and left -- the most lateral point of the frontal bone where it forms the upper margin of the bony eye socket.

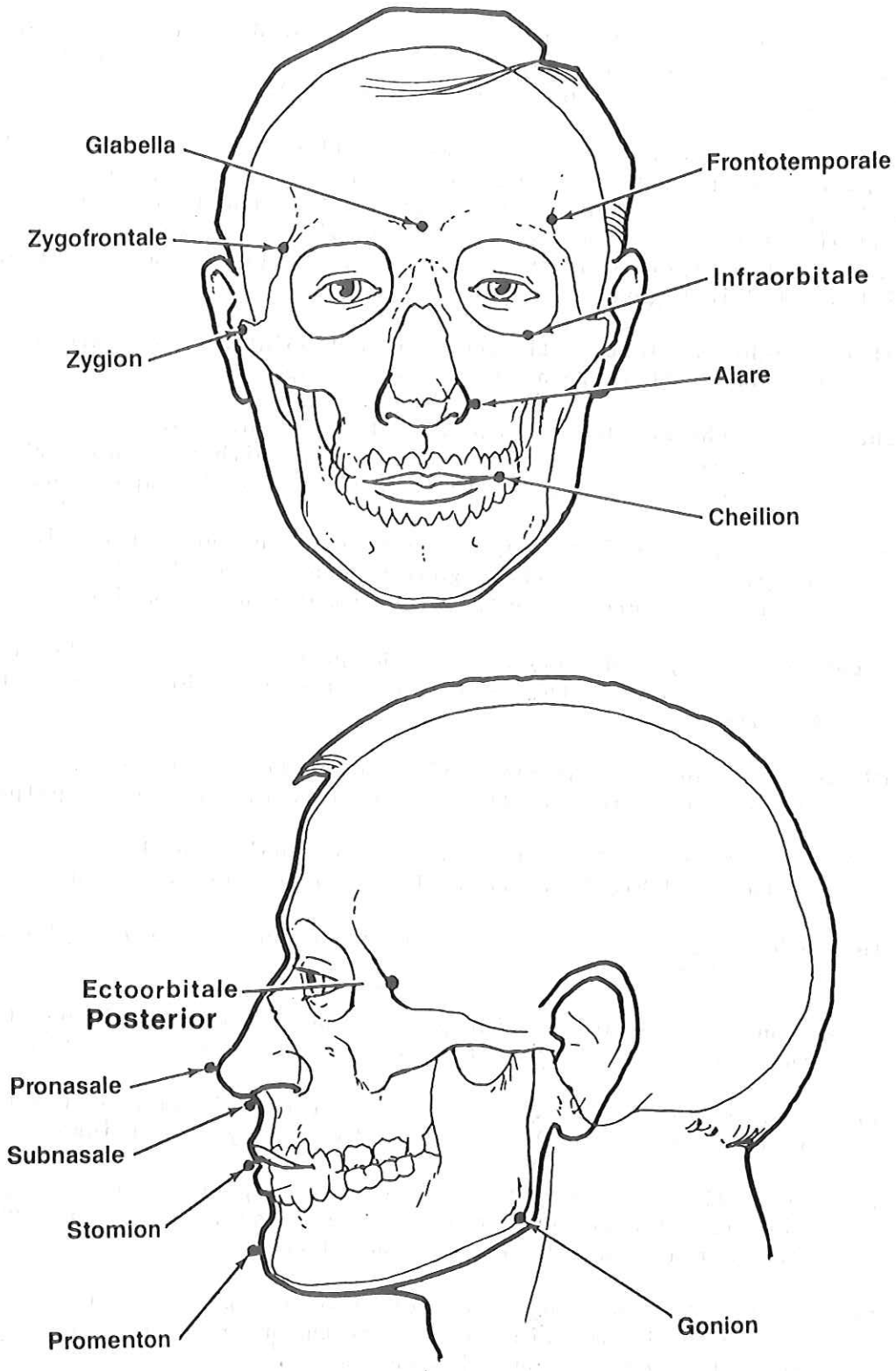


Figure 14. Head and face landmarks to be located at measuring station #7.

All these landmarks will be touched by an electronic sensor on the automated headboard to obtain three-dimensional head data. (Operation of the headboard is described in Appendix D).

UNDRAWN LANDMARKS

Some landmarks such as "the tip of the thumb," "bottom of the ear," or "the lowest point of the elbow bent 90 degrees" are obvious and easy to locate from subject to subject. Others, like a point where two body parts meet or the most protruding point of a body part, are similarly easy to locate by sight or with the measuring instrument. Some 30 landmarks will not be drawn by the markers. Rather, it will be the responsibility of the measurers to learn the definitions and locations of those undrawn landmarks that pertain to measurements at their stations. They are defined below:

Abdominal point, anterior -- the most protruding point of the relaxed abdomen of a seated subject.

Acropodion -- the tip of the first or second toe, whichever is longer.

Axillary fold, posterior: right and left -- the highest point of the right and left axillary folds on the back (see Figure 15).

Buttock point, posterior -- point of maximum protrusion of the right buttock of a standing subject.

Chin -- the most protruding point on the bottom edge of the chin, along the jawline.

Dactylion II -- the tip of the index finger.

Dactylion III, right and left -- the tip of the middle finger.

Dorsal juncture of the calf and thigh -- the juncture between the right calf and thigh behind the knee of a subject in the anthropometric sitting position.

Ear, bottom -- the lowest point of the ear on its long axis.

Ear point -- the lateral point (farthest from the head) of the right ear.

Ear, top -- the highest point of the ear on its long axis.

Ectocanthus -- the outside corner of the right eye formed by the meeting of the upper and lower eyelids.

Elbow crease -- the skin crease on the inside of the elbow joint when the elbow is flexed 90 degrees.

Heel point, lateral and medial -- the lateral and medial points of the right heel located at or behind the most protruding point of the lateral malleolus (outside ankle bone).

Inferior breast point -- the most inferior point of the juncture of the lower of the two breasts with the torso.

Knee point, anterior -- the most protruding point of the right kneecap of a seated subject.

Medial malleolus -- the medial point of the medial malleolus (inside ankle bone).

Olecranon, bottom and rear -- the lowest and rearmost points of the elbow with the elbow flexed 90 degrees.

Otobasion superior -- the anterior superior point of the juncture between the right ear and the head (see Figure 16).

Posterior Superior Iliac Spine -- the posterior point of the crest of the right ilium (see Figure 17). A dimple often overlies this point.

Pternion -- the posterior point of the right heel.

Submandibular -- the point in the midsagittal plane where the lower jaw joins the neck. (When this point is indistinct, the landmark will be drawn.)

Thelion, right and left -- center of the nipple (on males).

Thigh point, top -- the highest point of the top of the right thigh of a seated subject (in measuring THIGH CLEARANCE).

Thumbtip -- the tip of the right thumb.

Top of head -- the highest point on the head when the head is in the Frankfort plane.

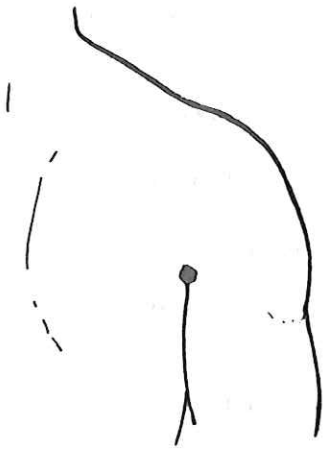


Figure 15. Axillary fold, posterior, landmark

Figure 16. Otobasion superior landmark

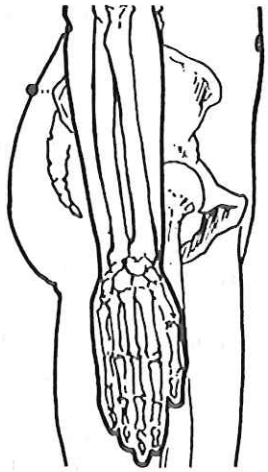


Figure 17. Posterior superior iliac spine landmark

THE MEASUREMENTS

The techniques of measuring each body dimension are described on the following pages. Included in each description is a definition of the measurement, required posture for the subject, recommended positions for the measurer, the name of the relevant instrument, and instructions for taking the measurement. Where there is a choice of right or left, all measurements are taken on the right side unless otherwise specified or in the rare cases where an anatomical abnormality makes it necessary to measure on the left side. All measurements are made to the nearest mm. Weight is taken to the nearest 0.1 kg.

SUBJECT POSTURE

The purpose of a standardized subject posture is an attempt to ensure that the differences found in body sizes within a group are just that and not variations in body posture. Most body posture descriptions are self-explanatory but the phrases "anthropometric standing" and "anthropometric sitting," so often used in these descriptions, require clarification.

For anthropometric standing, subjects are asked to stand erect, with their weight evenly distributed on both feet, heels together as much as possible, legs and trunk straight without stiffness, and the head erect and looking straight ahead. The arms are to hang relaxed with the elbows lightly touching the sides with the palms of the hands beside, but not touching, the thighs. This posture is similar to that of the position of military attention but without the stiffness and bracing with which it is often associated.

In the position of anthropometric sitting, the subject sits on a cushionless flat surface with the long axes of the thighs parallel. The feet are on an adjustable foot rest, and the knees are flexed 90 degrees. This position is established using a scored plastic right angle and the two seated landmarks on the thigh (trochanter and lateral femoral epicondyle, sitting). (See Figure 18.) Rest one inside edge of the plastic right angle on the table surface beside the right thigh. The other arm of the angle will hang over the front edge of the table. Using an adjustable footrest, move the feet up and down until the two landmarks are on a line with each other. The trunk is erect without stiffness; the head is also erect and the subject looks straight ahead. The shoulders are relaxed and the upper arms are hanging loosely at the sides with elbows flexed 90 degrees and hands straight. Deviations from these standardized positions are indicated where appropriate.

A number of dimensions require that the subject's head be in the Frankfort plane (also known as the Frankfort horizontal). This head position is quite similar to "head is...erect and...subject looks straight ahead." However, when the Frankfort plane is called for, the anthropometrist will position the subject's head so that an imaginary line connecting the drawn landmarks at right tragion and right infraorbitale is horizontal.

PARALLAX

Parallax is the apparent displacement of an object owing to the angle from which it is viewed. A common example of this is misreading time when looking

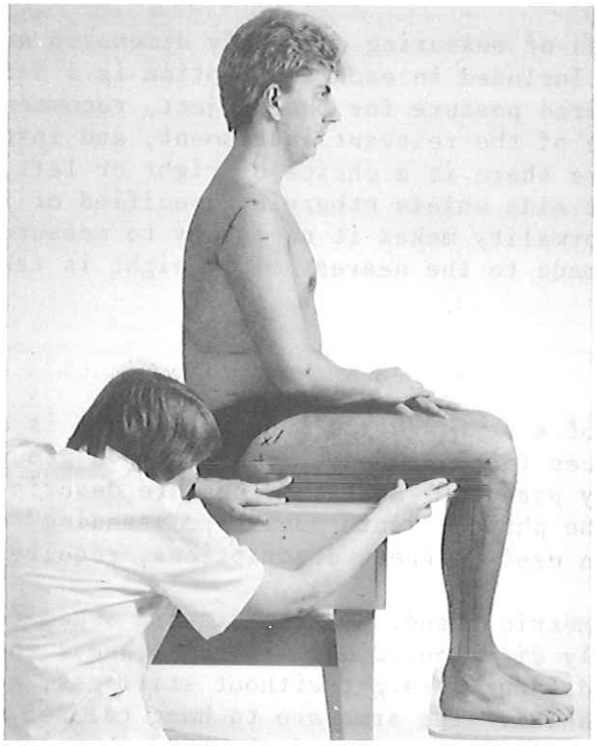


Figure 18. Establishing the anthropometric sitting position.

at the minute hand of a clock from any position except directly in front of it. Parallax can be a significant source of error in anthropometry and must be avoided. To guard against this kind of error, the anthropometrist must have his or her eyes at the same level as the measurement termination landmark or the level at which the measurement is being taken. For measurements taken on the lower body, subjects will be standing on a platform but it will still be necessary for you to do some bending or stooping to bring your eyes in line with a landmark, the blade of an instrument, or a tape measure. A stool or ladder will be supplied for taking overhead reach measurements.

MEASUREMENT ACCURACY

It is axiomatic that the data from any anthropometric study are only as good as the reliability with which the body dimensions were measured. However, measuring the body consistently is difficult and often impossible. Body positions, the amount of pressure exerted on the instruments, and breathing cycles are only a few of the sources of variation which can seriously affect the reliability of the measurement. Some examples are listed below.

Whether a subject is inhaling or exhaling when a measurement is recorded affects many dimensions. Those most affected are circumferences, breadths, and depths of the shoulders and torso, and heights from the floor or sitting surface to the shoulders and points on the torso and arms.

Few individuals can stand or sit erect without swaying. This is because the muscles that hold us in these positions are continuously adjusting to the effects of gravity. Stature, for example, will vary a measurable amount if the subject is slightly tilted when the measurement is made.

For a number of dimensions you will be cautioned not to let the subject tense the abdominal muscles. WAIST CIRCUMFERENCE is a good example of a dimension whose measurement can be drastically changed by the tension or relaxation of the abdominal muscles. A few dimensions require effort on the part of the subject to achieve the required body position. These include such dimensions as WALL-WRIST LENGTH, EXTENDED in which the subject is required to reach as far forward as possible while keeping one shoulder against a wall, and BICEPS CIRCUMFERENCE, FLEXED in which the subject is asked to "make a muscle" as hard as possible. Variability in the motivation of the subject can be a problem here and subjects should be urged to make a maximum effort.

You will learn to use about the same amount of tension on the tape when measuring body circumferences and arcs. However, it is more difficult to achieve consistency when measuring such dimensions as SCYE CIRCUMFERENCE, UPPER THIGH CIRCUMFERENCE, and AXILLARY ARM CIRCUMFERENCE where the tissue may often be relatively soft or compressed by an adjacent body segment, than when measuring such dimensions as ANKLE CIRCUMFERENCE where the flesh is usually firm.

It is the object of the handbook instructions, and the goal of the practical training you will undergo, to standardize the way these dimensions will be measured and minimize the effect of these and other variations.

DIMENSION DESCRIPTIONS

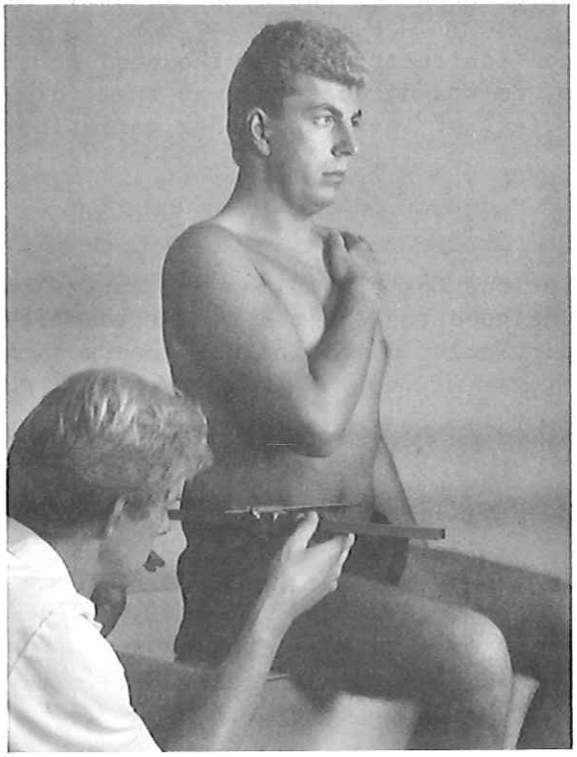
Illustrated measurement descriptions for each dimension appear on the following pages. A visual index, designed to help the reader identify the anthropometric term(s) used for a particular dimension or dimensions of interest, appears in Appendix E.

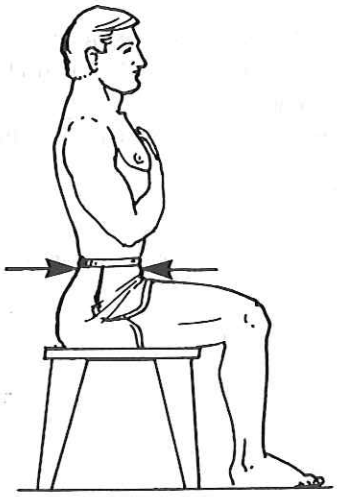
ABDOMINAL EXTENSION DEPTH, SITTING

ORIGIN-TERMINATION: **Abdominal point, anterior** -- plane of the back.

PROCEDURE: Subject is in the anthropometric sitting position but the right hand is placed on the chest. Stand at the subject's right and use a beam caliper to measure the horizontal distance between the anterior point of the abdomen and the back at the same level. The fixed blade of the caliper is placed on the back. The measurement is made at the maximum point of quiet respiration, with the blades of the instrument just touching the skin.

CAUTION: Make sure the subject does not tense the abdominal muscles.



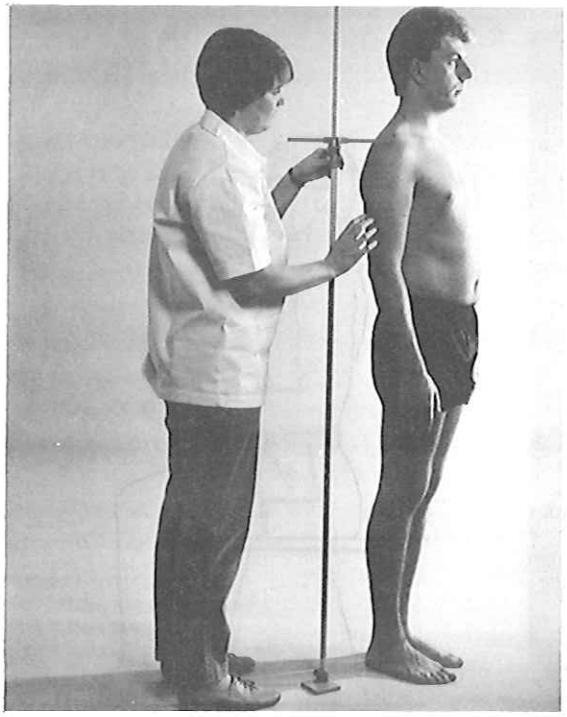


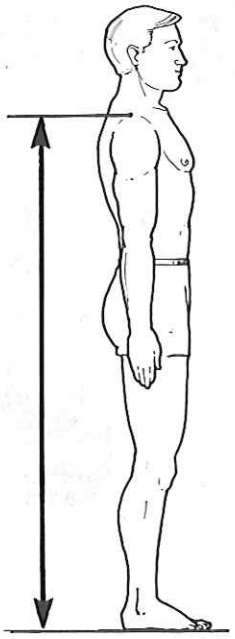
ACROMIAL HEIGHT

ORIGIN-TERMINATION: Standing surface -- **acromion, right.**

PROCEDURE: Subject is in the anthropometric standing position. Stand to the right of the subject, and use an anthropometer to measure the vertical distance between the standing surface and the drawn **acromion landmark** on the tip of the right shoulder. The measurement is made at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.



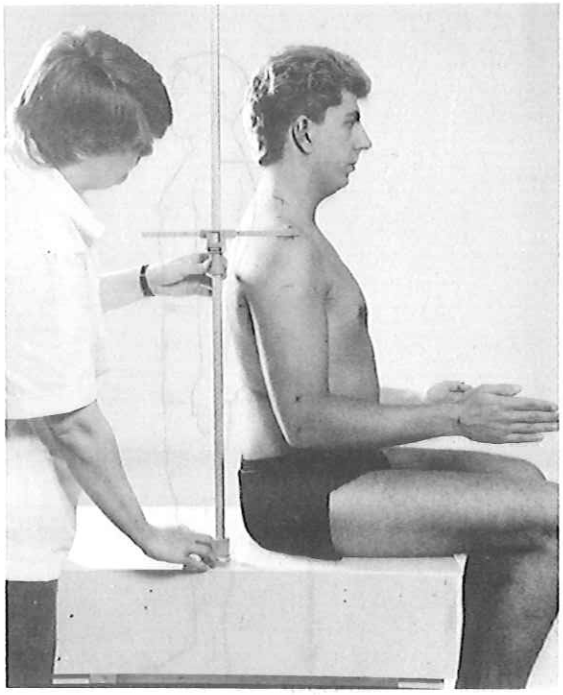


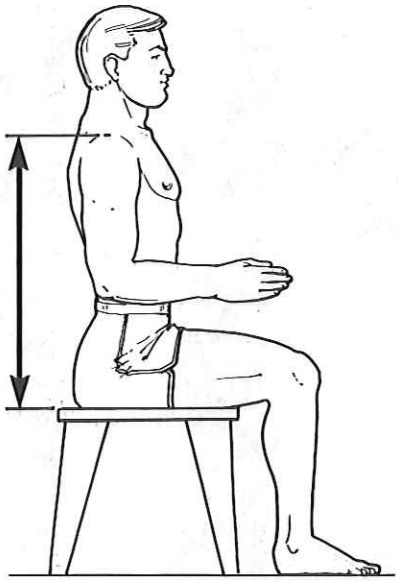
ACROMIAL HEIGHT, SITTING

ORIGIN-TERMINATION: Sitting surface -- **acromion, right.**

PROCEDURE: Subject is in the anthropometric sitting position. Stand behind the subject, and use an anthropometer to measure the vertical distance between the sitting surface and the drawn **acromion landmark** on the tip of the right shoulder. The measurement is made at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.



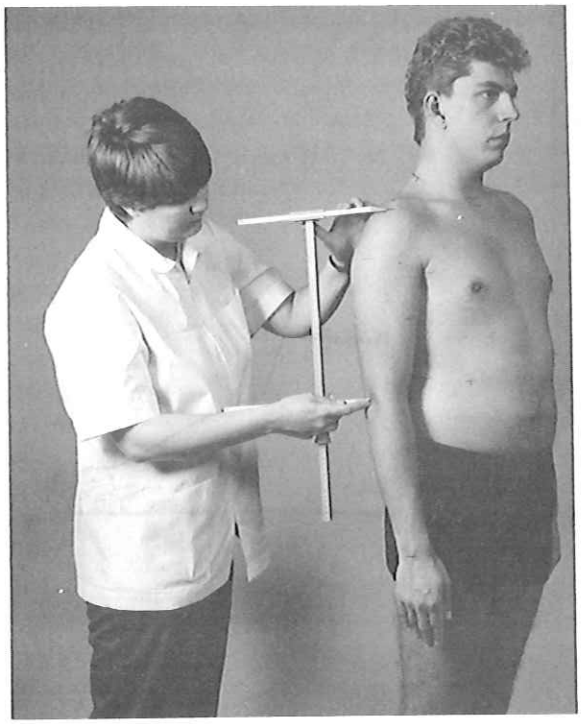


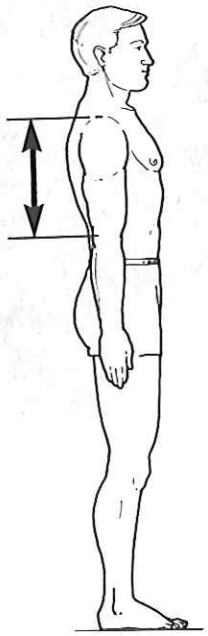
ACROMION-RADIALE LENGTH

ORIGIN-TERMINATION: **Acromion, right - radiale.**

PROCEDURE: Subject is in the anthropometric standing position. Stand to the right of the subject, and use a beam caliper to measure the distance between the drawn **acromion landmark** on the tip of the right shoulder and the drawn **radiale landmark** on the elbow. It is important that the beam of the caliper be parallel to the long axis of the arm, and that the fixed blade of the caliper remain on the tip of the shoulder during this measurement. Both blades of the instrument just touch the body.

CAUTION: Care should be taken not to distort the skin.

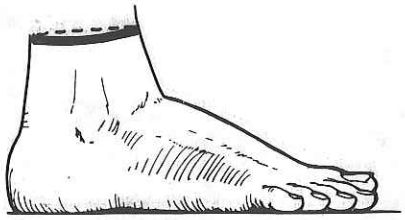




ANKLE CIRCUMFERENCE

DESCRIPTION: Minimum circumference of the ankle.

PROCEDURE: Subject stands on a table with the feet about 10 cm apart and the weight distributed equally on both feet. Stand at the right of the subject and, with a tape, measure the minimum horizontal circumference of the ankle. Exert only enough tape tension to maintain contact between the tape and the skin.

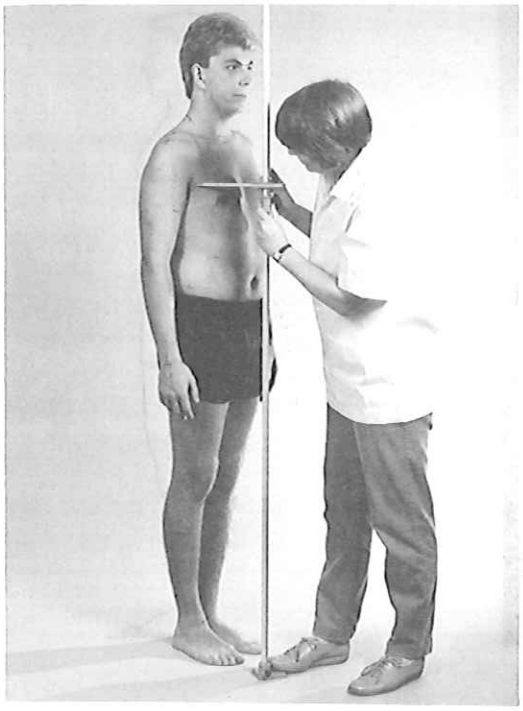


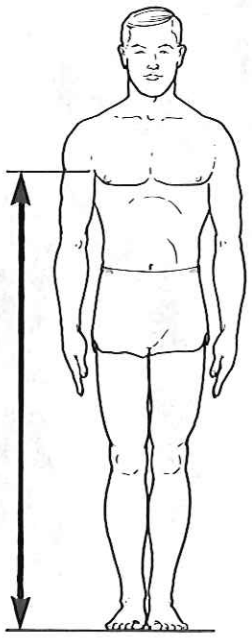
AXILLA HEIGHT

ORIGIN-TERMINATION: Standing surface -- **anterior scye on the torso, right.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use an anthropometer to measure the vertical distance between the standing surface and the axillary fold as designated by the drawn **anterior-scye-on-the-torso landmark.** The measurement is taken at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.

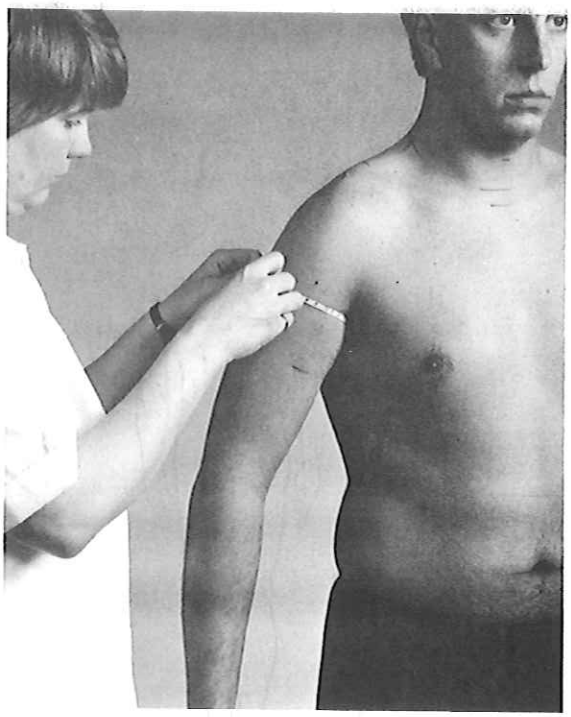




AXILLARY ARM CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Anterior Scye on the Upper Arm.**

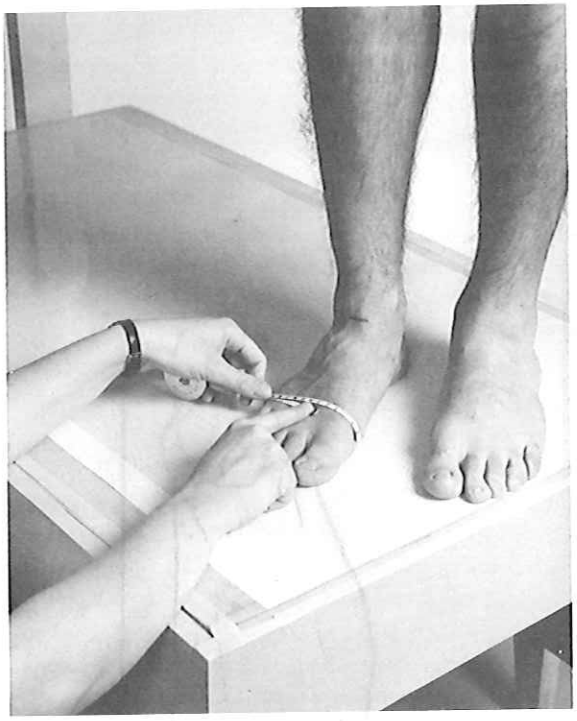
PROCEDURE: Subject stands erect looking straight ahead with both fists resting on the tops of the hips to allow placement of a tape in the armpit. When the tape is placed, the arms are dropped to hang relaxed at the side. Stand at the right of the subject and measure the circumference of the upper arm perpendicular to its long axis at the level of the **anterior scye on the upper arm landmark.** Exert only enough pressure on the tape to maintain contact between the tape and the skin.

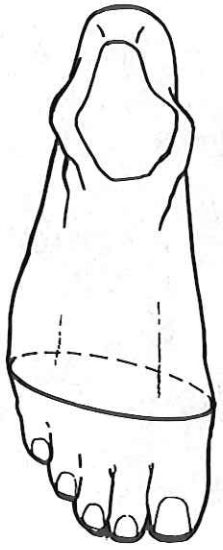


BALL OF FOOT CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **First metatarsophalangeal protrusion -- fifth metatarsophalangeal protrusion.**

PROCEDURE: Subject stands on a table with the feet about 10 cm apart and the weight distributed equally on both feet. Stand in front of the subject and use a tape to measure the circumference of the foot at the drawn **first** and **fifth metatarsophalangeal landmarks** on the ball of the foot. Exert only enough tension on the tape to maintain contact between the tape and the skin.

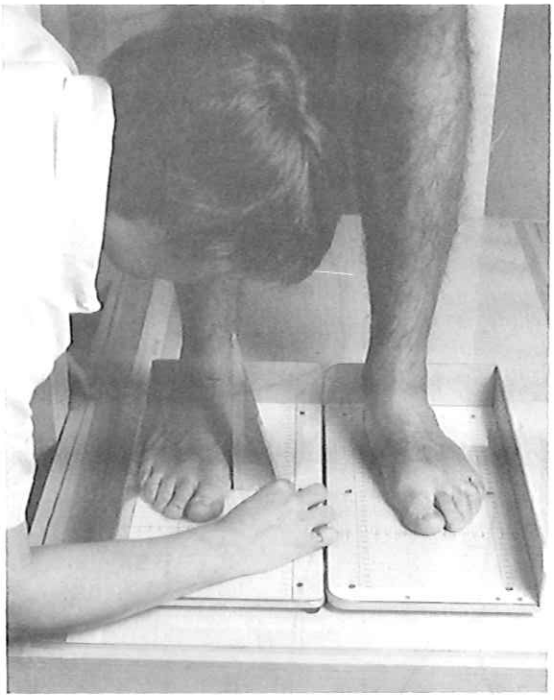


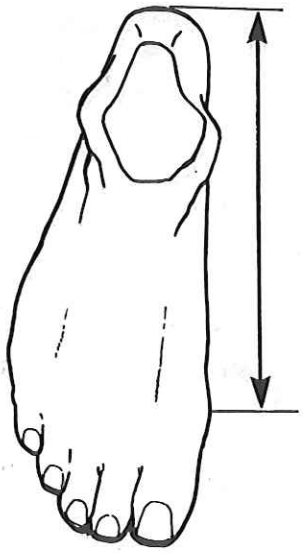


BALL OF FOOT LENGTH

ORIGIN-TERMINATION: **Pternion -- First metatarsophalangeal protrusion.**

PROCEDURE: Subject stands erect on a table with each foot in a footbox and the weight distributed equally on both feet. Stand behind the subject to make sure the right foot is properly positioned in the box. The back of the heel (**pternion**) should be lightly touching the back of the box, with the lateral point of the foot (as designated by the drawn **fifth metatarsophalangeal landmark**) lightly touching the side of the box. The medial side (inside) of the foot should be parallel with the long axis of the box. When the foot is correctly positioned, move to the front of the subject. Measure the distance between the back of the heel and the ball of the foot by placing a block on the drawn landmark at the **first metatarsophalangeal protrusion** and reading the measurement at that point from the footbox scale.



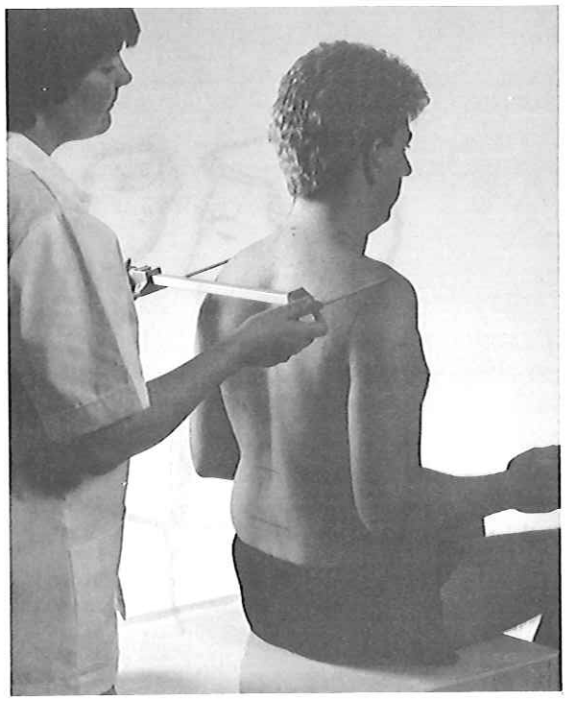


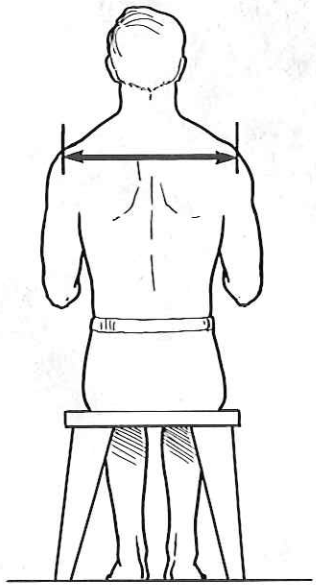
BIACROMIAL BREADTH

ORIGIN-TERMINATION: **Acromion, right -- acromion, left**

PROCEDURE: Subject is in the anthropometric sitting position. Stand behind the subject and use a beam caliper to measure the distance between the drawn right and left **acromion landmarks** at the tips of the shoulders. If the acromial landmarks cannot be seen from behind, stand in front of the subject. The measurement is taken at the maximum point of quiet respiration. Use sufficient pressure to maintain firm contact with the skin.

CAUTION: The subject must not be allowed to change the position of the shoulders.

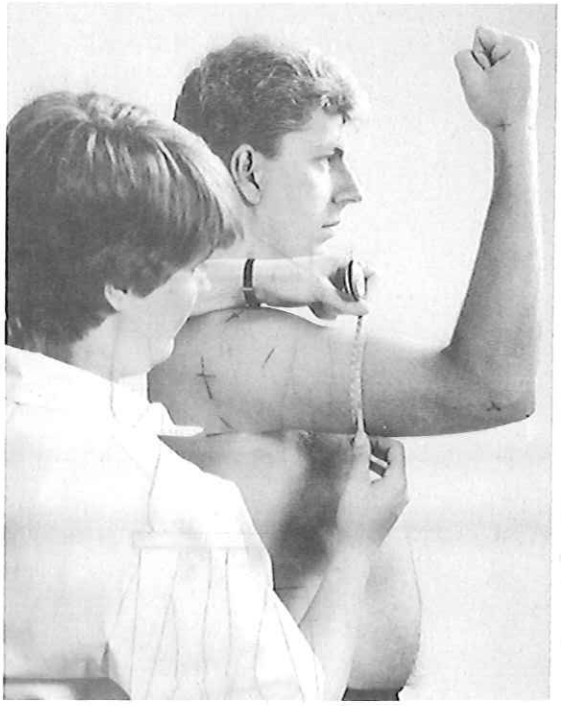


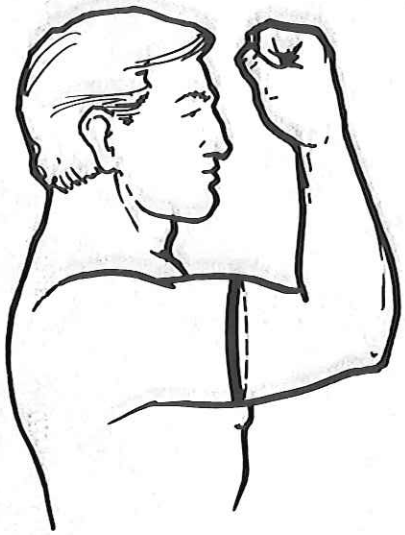


BICEPS CIRCUMFERENCE, FLEXED

LANDMARK(S) ENCOMPASSED: **Biceps point.**

PROCEDURE: Subject stands. The right upper arm is extended forward horizontally and the elbow is flexed about 90 degrees. Place a tape around the upper arm at the level of the drawn **biceps point landmark.** The fist is clenched and held facing the head. The subject is urged to exert maximum effort in "making a muscle." Stand at the right of the subject and use a tape to measure the circumference of the upper arm. The tape should be in a plane perpendicular to the long axis of the upper arm. Exert only enough tension on the tape to maintain contact between the tape and the skin.



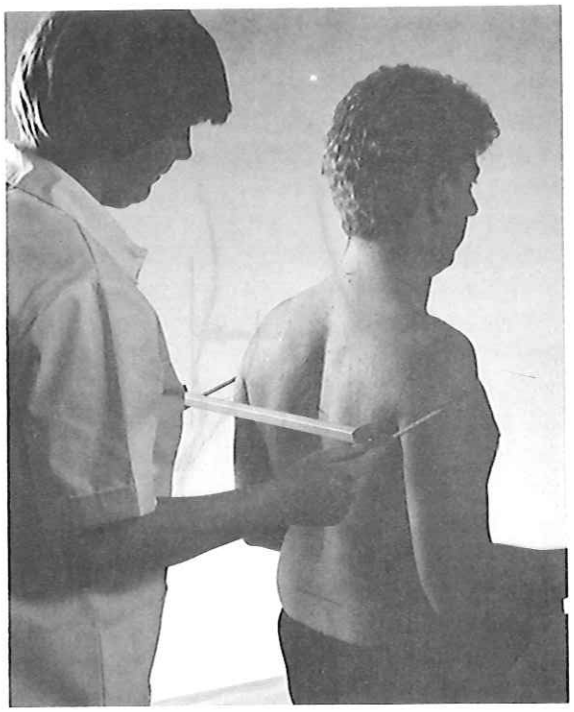


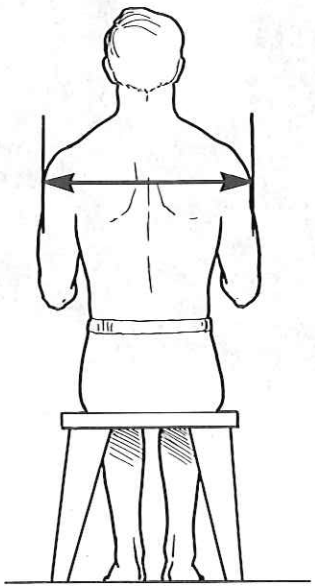
BIDELTOID BREADTH

DESCRIPTION: The maximum horizontal distance between the lateral margins of the upper arms on the deltoid muscles.

PROCEDURE: Subject is in the anthropometric sitting position. Stand behind the subject and use a beam caliper to locate the greatest horizontal distance between the outside edges of the deltoid muscles on the upper arms. This is done by brushing the caliper blades up and down the upper arms. When the blades lightly touch the skin on both sides, withdraw the instrument to read off the measurement. The measurement is made at the maximum point of quiet respiration. Note that the **deltoid landmarks** are NOT used for this dimension.

CAUTION: The subject must not be allowed to change the position of the shoulders.

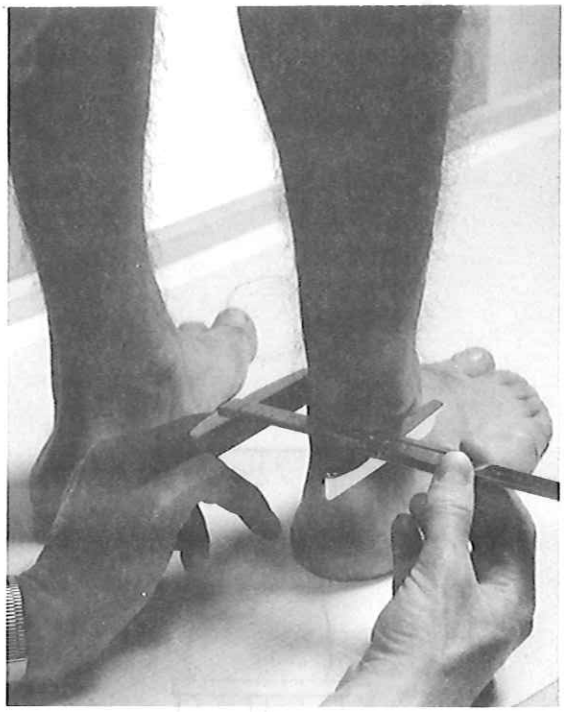


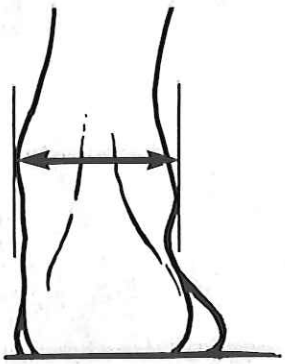


BIMALLEOLAR BREADTH

ORIGIN-TERMINATION: **Lateral malleolus -- medial malleolus.**

PROCEDURE: Subject stands on a table with the weight distributed equally on both feet. The feet are about 10 cm apart with the toes pointing forward. Stand behind the subject and use a Holtain caliper to measure the horizontal distance between the maximum protrusions of the ankle bones (**lateral** and **medial malleoli**) of the right foot. Holding the fixed blade of the caliper parallel to the long axis of the foot, place it on the **medial malleolus.** Hold the beam of the caliper parallel to the floor. Both blades of the instrument should just touch the skin.



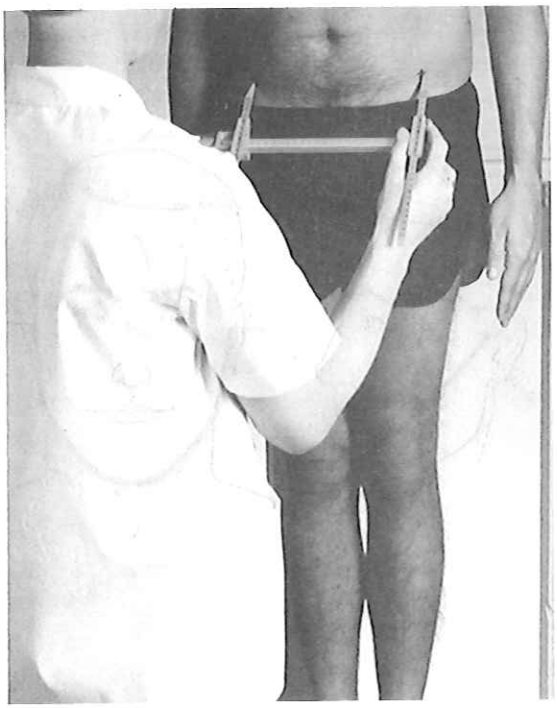


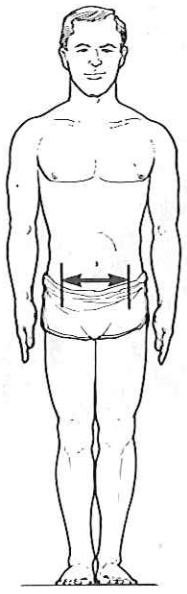
BISPINOUS BREADTH

ORIGIN-TERMINATION: **Anterior superior iliac spine, right -- anterior superior iliac spine, left.**

PROCEDURE: Subject stands on a table in the anthropometric standing position. Stand in front of the subject and use a beam caliper to measure the distance between the drawn **right** and **left anterior superior iliac spine landmarks.**

CAUTION: On some subjects, one iliac spine will be located farther forward than the other. Do not measure diagonally across the body from the "outside" point to the "inside" point; rather, hold the beam of the caliper so that it extends straight across the body at the level of the more protruding point. Note, also, that the beam will not necessarily be parallel to the floor since the two iliac spines are not always located directly across from each other, but it must be parallel to the coronal plane.

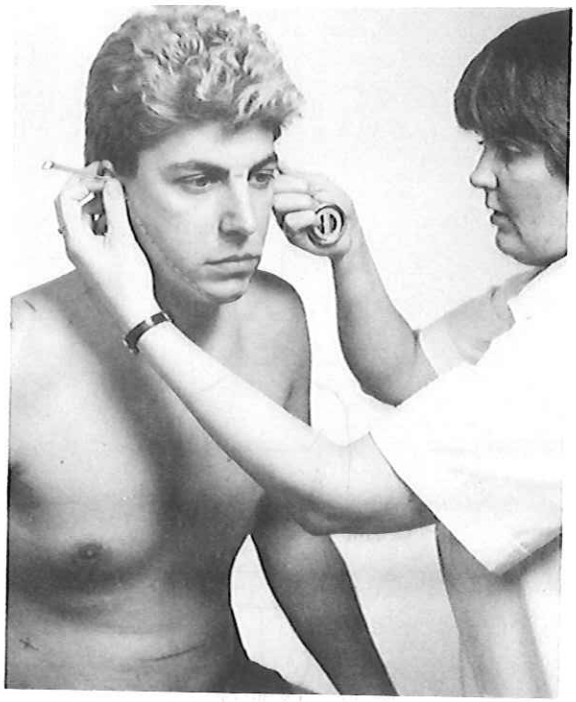


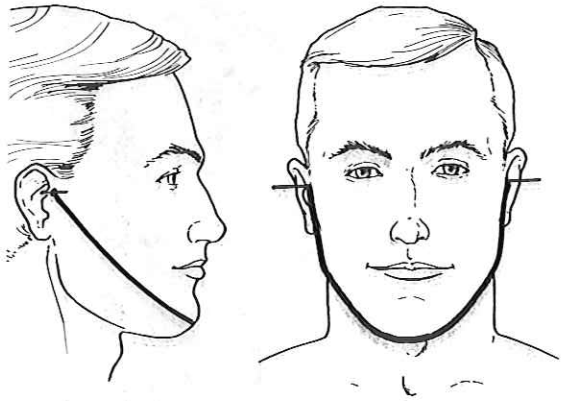


BITRAGION CHIN ARC

DESCRIPTION: The surface distance between the **right** and **left tragion** across the anterior point of the chin.

PROCEDURE: Subject sits with the teeth together (lightly occluded). Stand in front of the subject and use a tape to measure the surface distance from the drawn **right tragion landmark** to the drawn **left tragion landmark** across the tip of the chin (**chin landmark**). Exert enough tension on the tape to maintain contact between the tape and the skin, and be sure that the zero point of the tape remains on a **tragion landmark**. The chin will be slightly compressed.

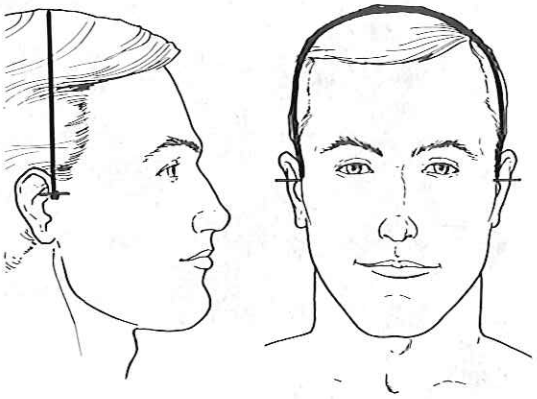




BITRAGION CORONAL ARC

DESCRIPTION: The surface distance between the **right** and **left tragion** across the top of the head in a coronal plane.

PROCEDURE: Subject sits with the head in the Frankfort plane. Stand in front of the subject and use a tape to measure the surface distance between the drawn **right** and **left tragion landmarks** across the top of the head in the coronal plane. Exert sufficient pressure to compress the hair, and be sure the zero point of the tape remains on a **tragion landmark** for the measurement.

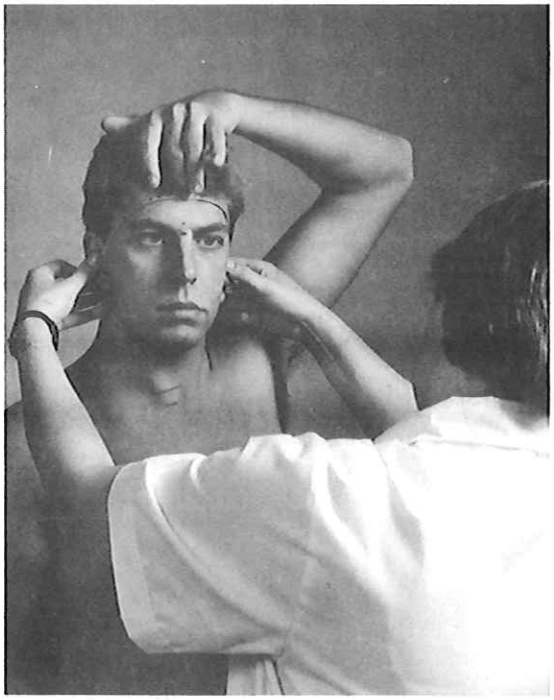


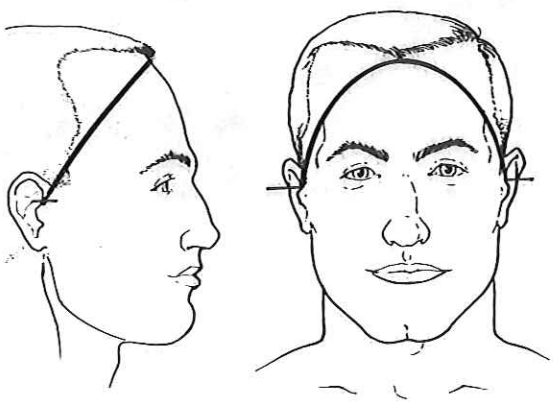
BITRAGION CRINION ARC

DESCRIPTION: The surface distance between the **right** and **left tragion** across the top of the forehead at **crinion.**

PROCEDURE: Subject sits. Stand in front of the subject and use a tape to measure the surface distance between the drawn **right** and **left tragion landmarks** across the top of the forehead. The top edge of the tape crosses the forehead at the lowest point of the hairline (**crinion**). Ask the subject to help you keep the tape in position by holding it in place on the forehead. Be sure that the zero point of the tape remains on a **tragion landmark.**

CAUTION: This point can be indistinct or altogether absent on balding males. In such cases, the landmark will not be drawn, and this dimension is not measured.

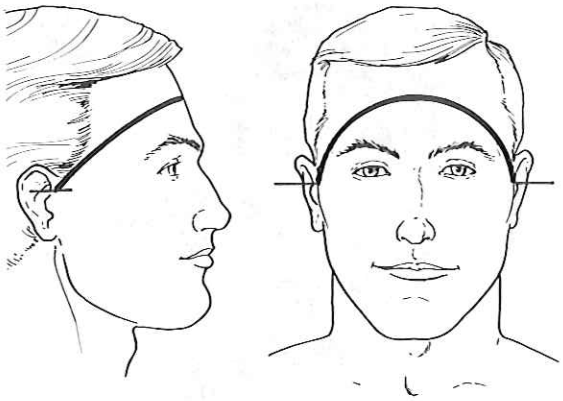




BITRAGION FRONTAL ARC

DESCRIPTION: The surface distance between the **right tragion** and the **left tragion** across the forehead.

PROCEDURE: Subject sits. Stand in front of the subject and use a tape to measure the surface distance between the drawn **right tragion landmark** and the drawn left tragion landmark with the tape passing across the forehead just above the ridges of the eyebrows (supraorbital ridges). Be sure that the zero point of the tape remains on a tragion landmark, and exert just enough pressure on the tape to maintain contact between the tape and the skin.

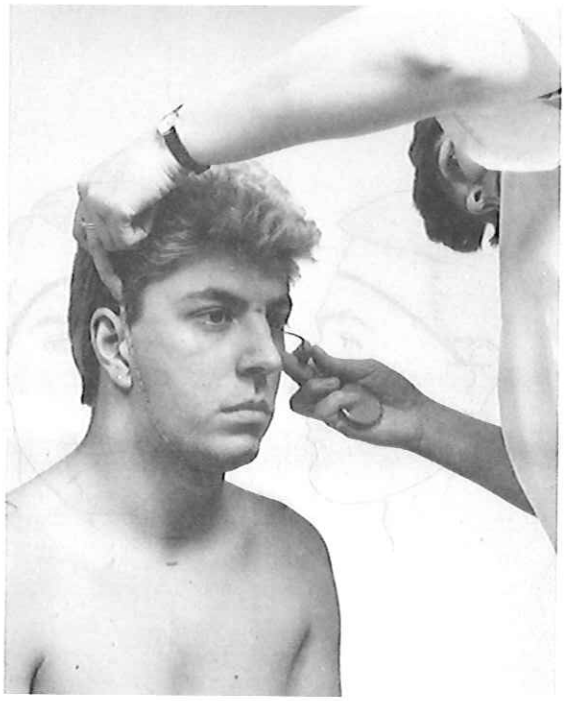


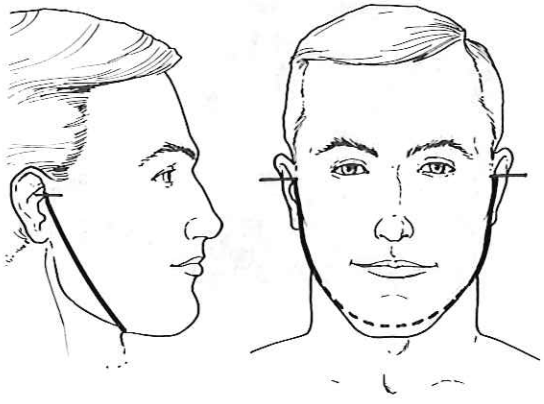
BITRAGION SUBMANDIBULAR ARC

DESCRIPTION: The surface distance between the **right** and **left tragion** across the **submandibular landmark** at the juncture of the jaw and the neck.

PROCEDURE: Subject sits with the head in the Frankfort plane. Stand in front of the subject and use a tape to measure the surface distance from the drawn **right tragion landmark** to the drawn **left tragion landmark** across the **submandibular landmark.** Be sure the zero point of the tape is on a **tragion landmark**, and exert only enough tension on the tape to maintain light contact between the tape and the skin.

CAUTION: Take care not to compress the soft tissue of the lower jaw.



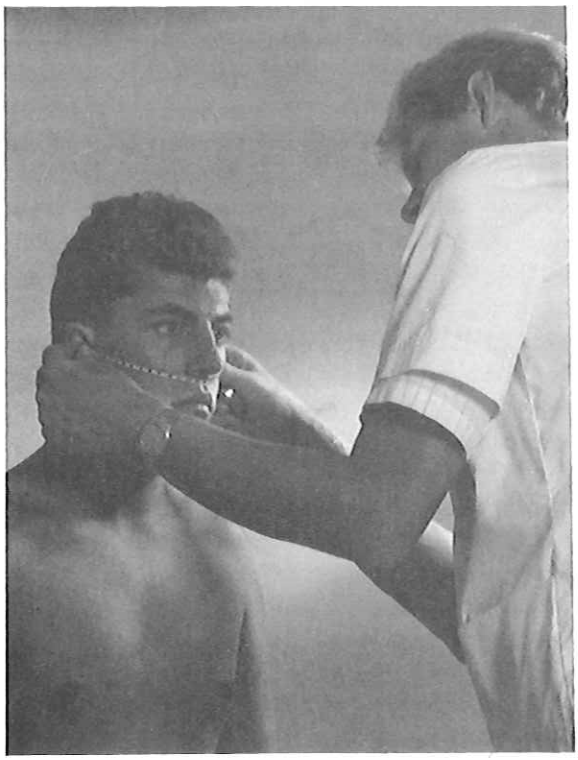


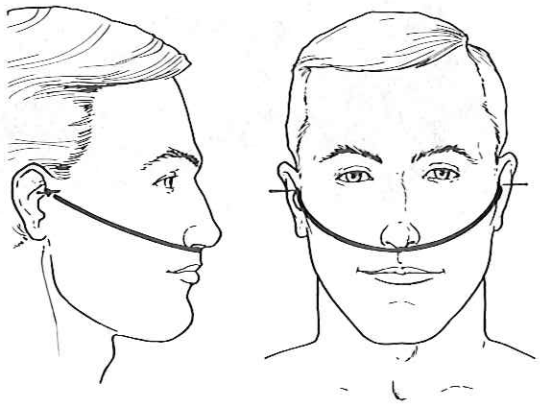
BITRAGION SUBNASALE ARC

DESCRIPTION: The surface distance between the **right** and **left tragion** across the bottom of the nose (**subnasale**).

PROCEDURE: Subject sits. Stand in front of the subject and use a tape to measure the surface distance between the drawn **right** and **left tragion landmarks** with the top edge of the tape crossing the lowest point of the bottom of the nose (**subnasale**). Exert only enough pressure to maintain contact between the tape and the skin, and be sure the zero point of the tape is on a **tragion landmark.**

CAUTION: Be careful not to compress the soft tissue under the nose.

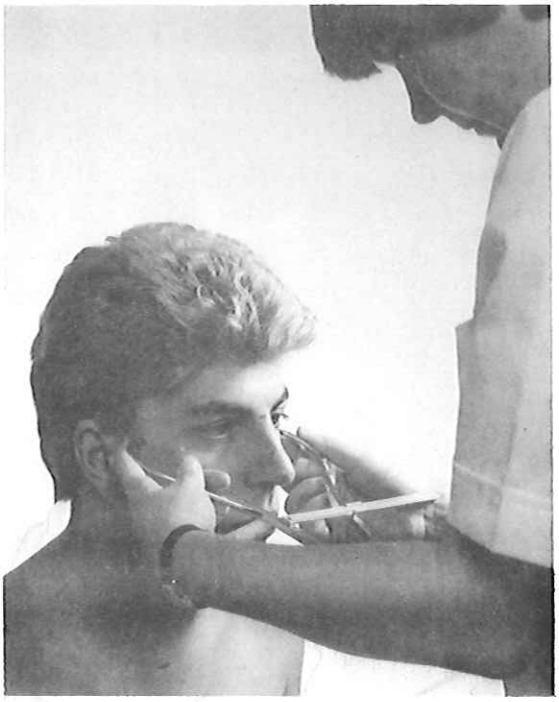


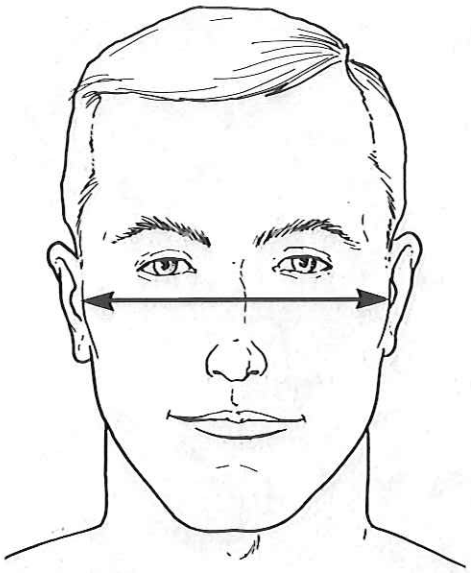


BIZYGOMATIC BREADTH

DESCRIPTION: The maximum horizontal breadth of the face between the zygomatic arches.

PROCEDURE: Subject sits. Stand in front of the subject and use a spreading caliper to measure the maximum horizontal breadth of the face between the cheekbones (zygomatic arches). Exert only enough pressure to ensure that the caliper tips are on the zygomatic arches.

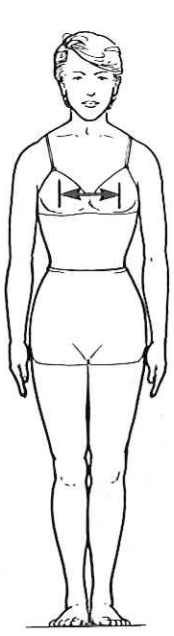


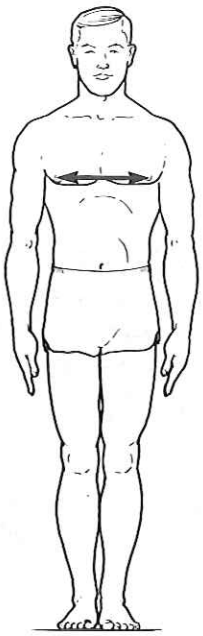


BUSTPOINT/THELION - BUSTPOINT/THELION BREADTH

ORIGIN-TERMINATION: **Bustpoint/thelion, right -- bustpoint/thelion, left.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use a beam caliper to measure the distance between the right and left bustpoints on women and the center of the nipples on men **(bustpoint/thelion).** On women, the landmark will be drawn on the bra. They are not drawn on male subjects. The measurement is taken at the maximum point of quiet respiration.



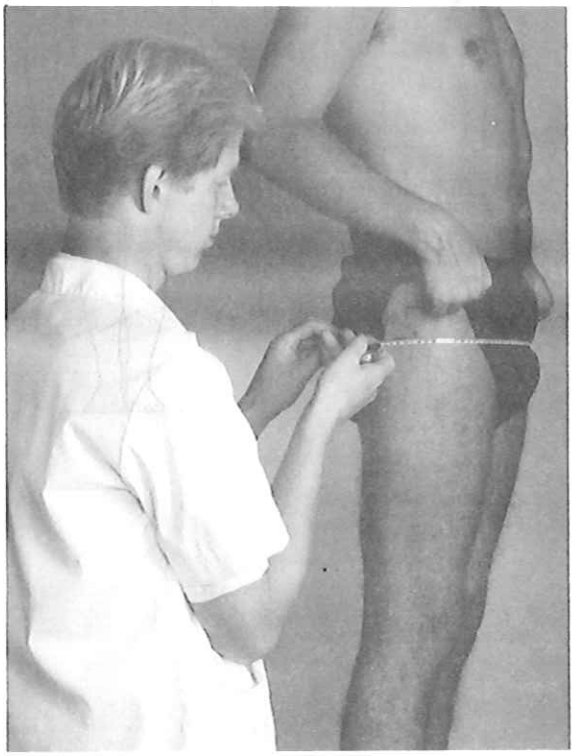


BUTTOCK CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Buttock point: right lateral, left lateral,** and **posterior.**

PROCEDURE: Subject stands erect on a table with heels together. Ask the subject to hold up the right leg of the shorts to expose the landmark. Stand at the subject's right and use a tape to measure the horizontal circumference of the trunk at the level of the maximum protrusion of the right buttock. The tape should pass over the **posterior buttock point** (not drawn) and the **buttock point landmarks** drawn on the right and left hips. (On the right hip this landmark is a horizontal line with a "B" drawn beside it.) If necessary, ask male subjects to adjust the genitalia so as to interfere as little as possible with the tape. Exert only enough tension on the tape to maintain contact between the tape and the skin.

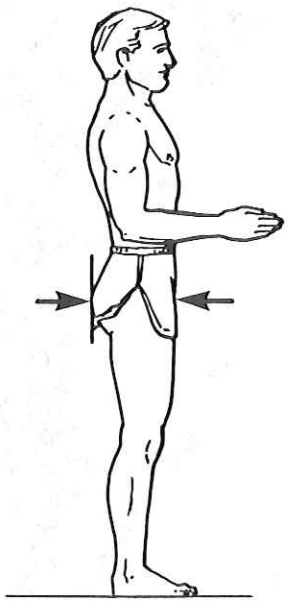
CAUTION: The tape must be maintained in a horizontal plane.



BUTTOCK DEPTH

ORIGIN-TERMINATION: **Buttock point, posterior** -- abdomen.

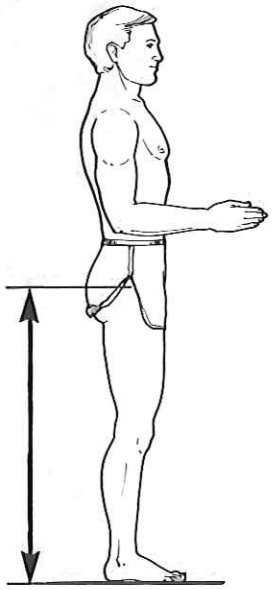
PROCEDURE: Subject stands on a table in the anthropometric standing position but with the right elbow flexed. Stand at the subject's right and use a beam caliper with a fixed paddle blade to measure the horizontal depth of the torso at the level of the maximum protrusion of the right buttock. The fixed paddle blade is placed on the **posterior buttock point**; the other blade is placed on the abdomen so that it crosses the midsagittal plane at the same level. If necessary, ask male subjects to adjust genitalia so as to interfere as little as possible with the caliper blade. Exert only enough pressure on the instrument to attain contact between the caliper blades and the skin.



BUTTOCK HEIGHT

ORIGIN-TERMINATION: Standing surface -- **buttock point, right lateral.**

PROCEDURE: Subject stands on a table in the anthropometric standing position but with the right elbow flexed. In some cases the subject will have to hold up the right leg of the shorts to expose the landmark. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the standing surface and the level of the maximum protrusion of the buttock as drawn on the right side of the right thigh (**buttock point, right lateral,** marked with a "B").

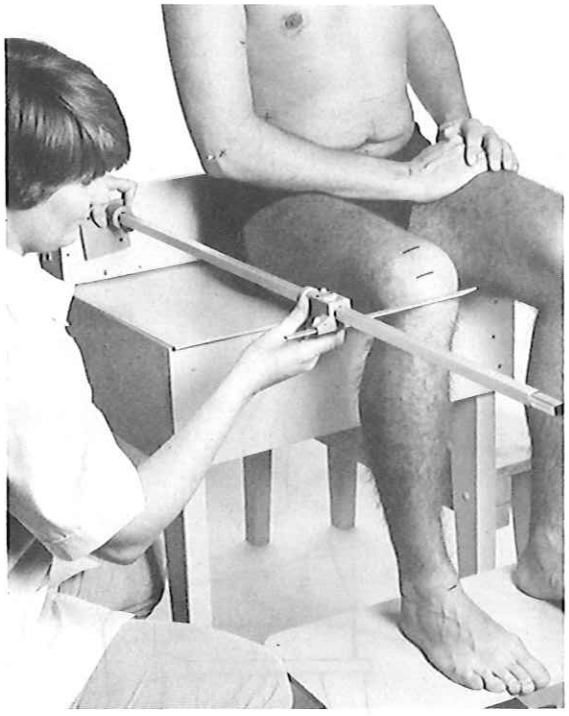


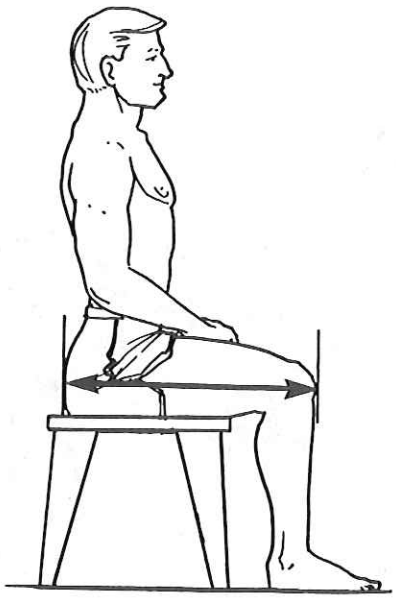
BUTTOCK-KNEE LENGTH

ORIGIN-TERMINATION: Buttock plate -- **knee point, anterior.**

PROCEDURE: Subject is in the anthropometric sitting position but with arms relaxed on the lap. Stand at the right of the subject and slide the buttock plate toward the subject until it makes light contact with the most posterior point on either buttock. When the plate is in position lock it in place. Use an anthropometer to measure the horizontal distance between the buttock plate and the front of the knee (**knee point, anterior**). The base of the anthropometer is anchored on the buttock plate. Exert only enough pressure on the instrument to attain contact between the anthropometer blade and the knee.

CAUTION: To ensure that the anthropometer is horizontal, be sure that the base of the anthropometer is fully against the buttock plate.



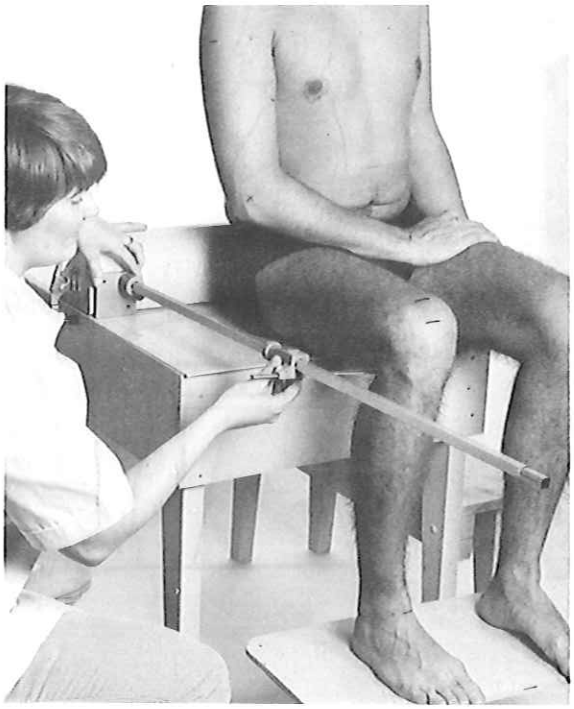


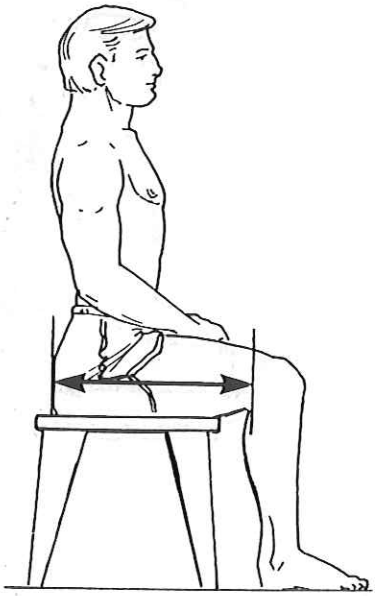
BUTTOCK-POPLITEAL LENGTH

ORIGIN-TERMINATION: Buttock plate -- **dorsal juncture of the calf and thigh.**

PROCEDURE: Subject is in the anthropometric sitting position with the arms relaxed on the lap. Stand at the right of the subject and slide the buttock plate toward the subject until it makes light contact with the most posterior point on either buttock. When the plate is in position, lock it in place. Use an anthropometer to measure the horizontal distance from the buttock plate to the back of the knee. This is done in such a way that the blade of the anthropometer is placed as high and as far forward as possible in the popliteal fossa behind the knee (**dorsal juncture of the calf and thigh**) without compressing tissue. Exert only enough pressure on the instrument to attain contact between the anthropometer blade and the skin.

CAUTION: To ensure that the anthropometer is horizontal, be sure that the base of the anthropemter is fully against the buttock plate. The computer will add 1 cm to the recorded dimension to account for the width of the anthropometer blade.

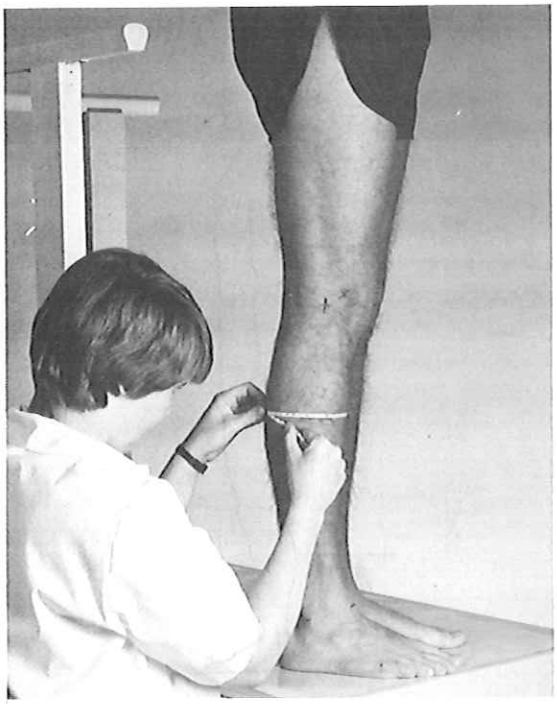


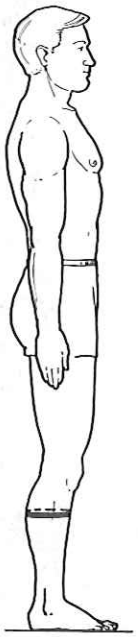


CALF CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Calf.**

PROCEDURE: Subject stands erect on a table with the heels approximately 10 cm apart and the weight distributed equally on both feet. Stand at the right of the subject. With a tape held in the horizontal plane measure the circumference of the calf at the level of the drawn **calf landmark.** Exert only enough tension on the tape to maintain contact between the tape and the skin.

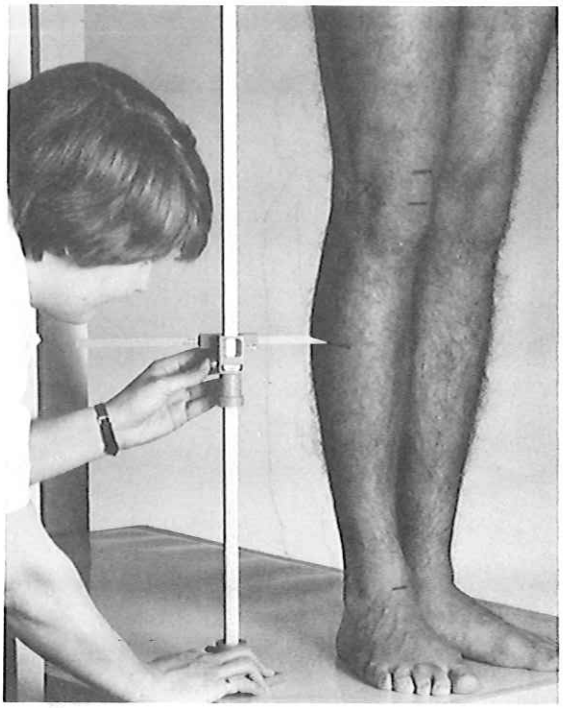


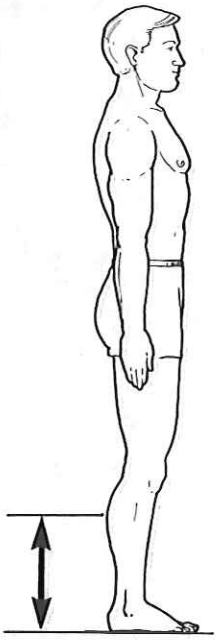


CALF HEIGHT

ORIGIN-TERMINATION: Standing surface -- **calf.**

PROCEDURE: Subject stands erect on a table with the heels together and the weight distributed equally on both feet. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **calf landmark** on the side of the leg.



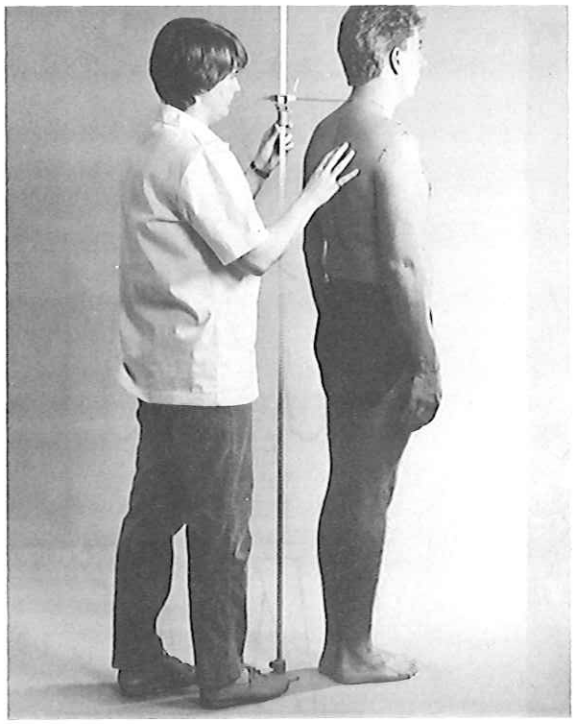


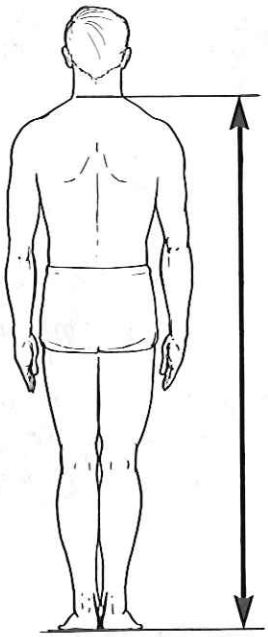
CERVICALE HEIGHT

ORIGIN-TERMINATION: Standing surface -- **cervicale.**

PROCEDURE: Subject is in the anthropometric standing position with the head held in the Frankfort plane. Stand behind the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **cervicale landmark.** The measurement is taken at the the maximum point of quiet respiration.

CAUTION: Be sure the subject's head remains in the Frankfort plane while the measurement is taken.



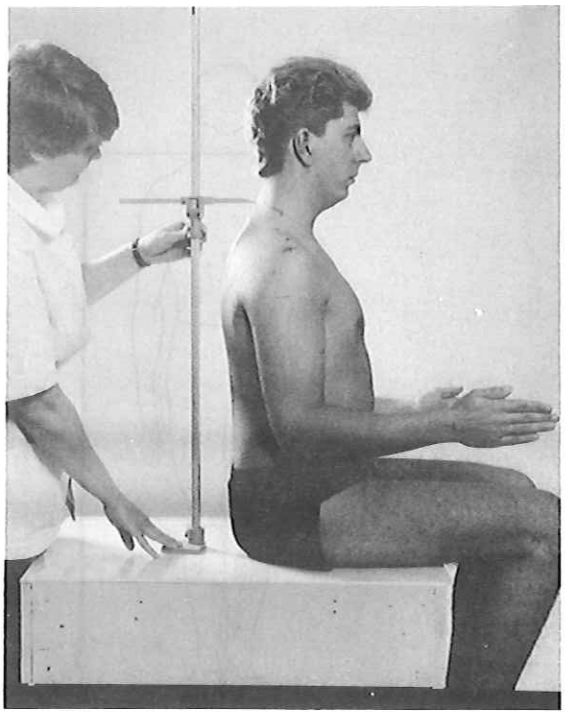


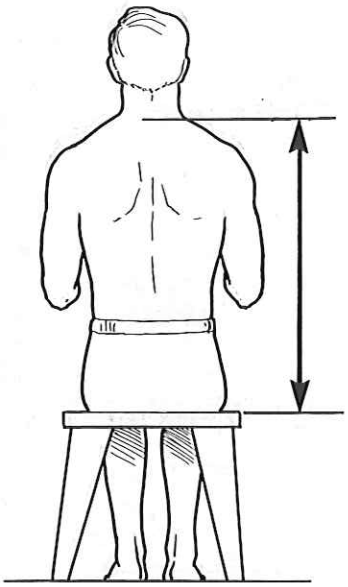
CERVICALE HEIGHT, SITTING

ORIGIN-TERMINATION: Sitting surface -- **cervicale.**

PROCEDURE: Subject is in the anthropometric sitting position with the head held in the Frankfort plane. Stand behind the subject and use an anthropometer to measure the vertical distance between the sitting surface and the drawn **cervicale landmark.** The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure the subject's head remains in the Frankfort plane while the measurement is taken.



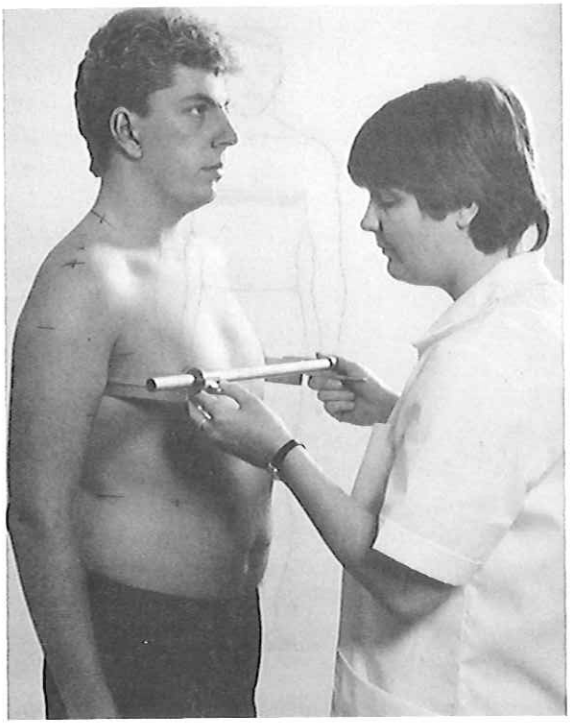


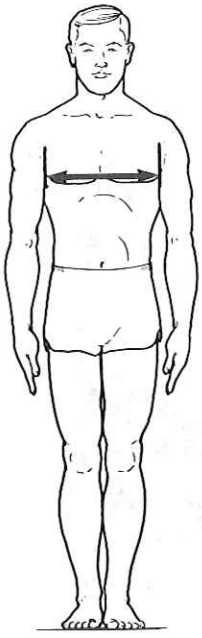
CHEST BREADTH

DESCRIPTION: The maximum horizontal breadth of the chest at the level of the right **bustpoint/thelion landmark.**

PROCEDURE: Subject stands erect looking straight ahead with the heels together and the weight distributed on both feet. The arms are held away from the body just enough to allow clearance between the arms and a beam caliper used to make the measurement. Stand in front of the subject and measure the maximum horizontal breadth of the chest at the level of the drawn **right bustpoint landmark** (women) or nipple (men). The measurement is made at the maximum point of quiet respiration. Exert only enough pressure to attain contact between the caliper and the skin (or bra).

CAUTION: Breast tissue should NOT be included in this measurement. This can be avoided, when necessary, by tilting the blades of the caliper upwards and approaching the bony sides of the chest from below the breasts. On some male subjects the latissimus dorsi, heavy muscles at the back of the armpit, bulge beyond the bony sides of the chest. These muscles should not be included in the measurement either.



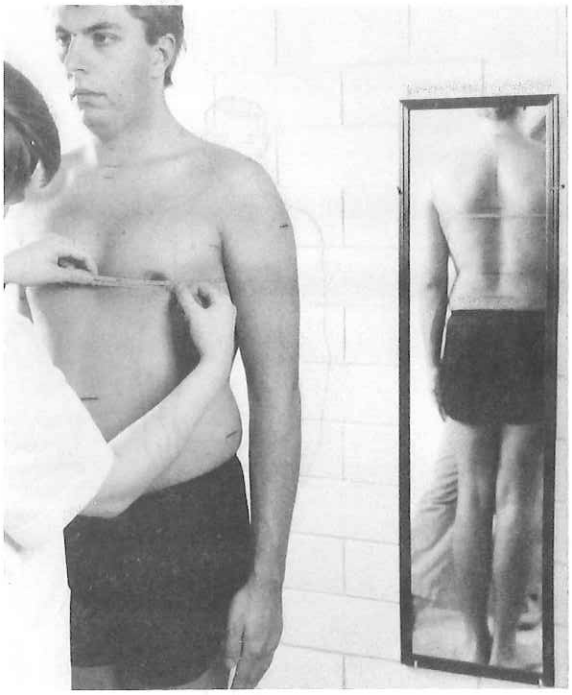


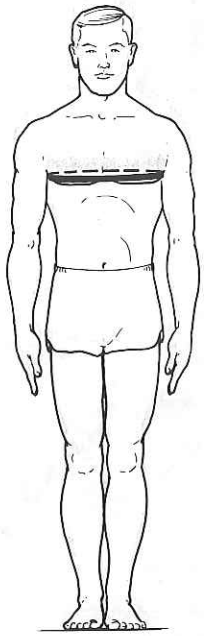
CHEST CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Bustpoint/thelion, right.**

PROCEDURE: Subject is in the anthropometric standing position in front of a mirror. Stand in front of the subject and use a tape to measure the horizontal circumference of the chest at the level of the bustpoint on women and the nipple on men (**bustpoint/thelion, right**). For women, the landamrk is drawn on the bra. It is not drawn on male subjects. Use the mirror to check the position of the tape as it crosses the subject's back. This dimension will cross very soft tissue at the armpit and bust, and some compression of the tissue will inevitably occur. Be sure, however, to keep this to a minimum. Exert only enough tension on the tape to maintain contact between the tape and the skin. The tape will span body hollows in this measurement. The measurement is taken at the maximum point of quiet respiration.

CAUTION: This must be a horizontal measurement. It will not necessarily cross the **left bustpoint/thelion landmark.**

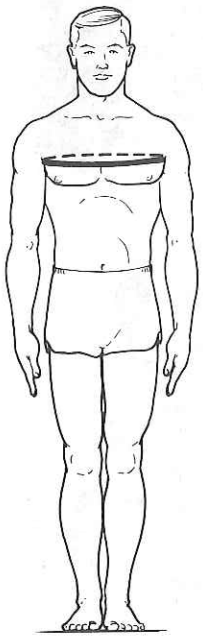




CHEST CIRCUMFERENCE AT SCYE

LANDMARK(S) ENCOMPASSED: **Scye at midspine.**

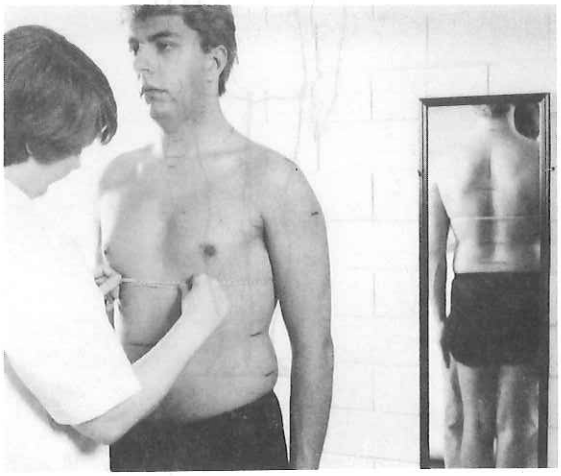
PROCEDURE: Subject stands erect looking straight ahead in front of a mirror. The heels are together and the weight is equally distributed on both feet. The subject puts both fists on the tops of the hips. Place a tape around the torso, passing over the drawn **scye level at midspine landmark.** Use the mirror to check the position of the tape as it crosses the subject's back. After the tape is in place, the subject drops the arms to the sides with the palms facing the thighs. Stand in front of the subject and use the tape to measure the horizontal circumference of the chest at the level of the landmark. This dimension will cross very soft tissue at the armpit and bust, and some compression of the tissue will inevitably occur. Be sure, however, to keep this to a minimum. Exert only enough tension on the tape to maintain contact between the tape and the skin. The tape will span body hollows in this measurement. The measurement is taken at the maximum point of quiet respiration.

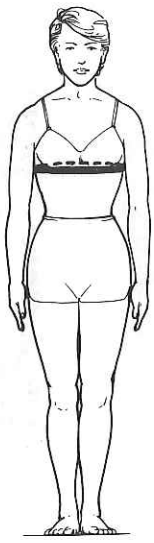


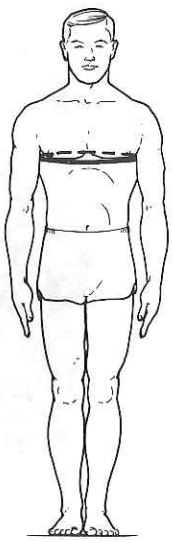
CHEST CIRCUMFERENCE BELOW BREAST

LANDMARK(S) ENCOMPASSED: **Inferior breast point.**

PROCEDURE: Subject is in the anthropometric standing position in front of a mirror. Stand in front of the subject and use a tape to measure the horizontal circumference of the chest at the level of the inferior juncture of the lowest breast with the rib cage (**inferior breast point**). On women, the tape may lie on the bra. Use the mirror to check the position of the tape as it crosses the subject's back. Exert only enough tension on the tape to maintain contact between the tape and the skin (or bra). The tape will span the hollows of the spine. The measurement is taken at the maximum point of quiet respiration.





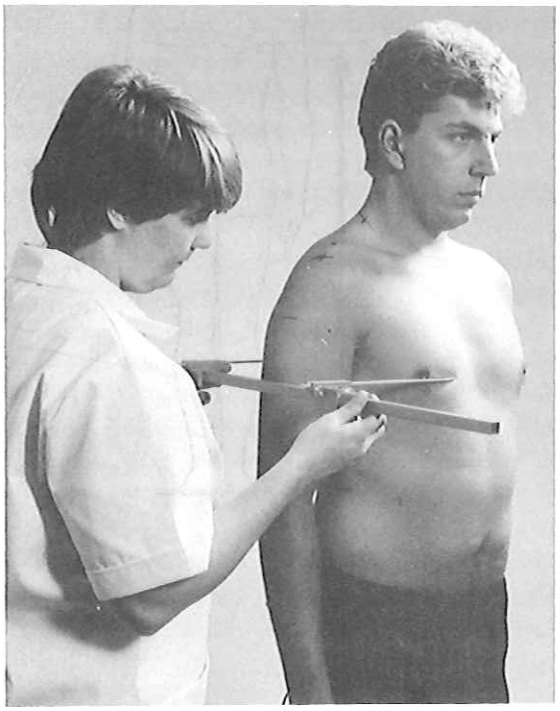


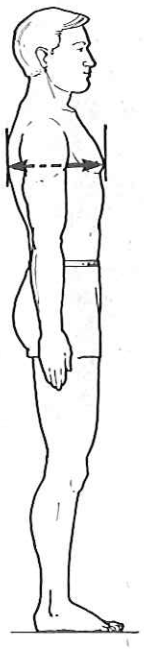
CHEST DEPTH

ORIGIN-TERMINATION: Plane of the back -- **bustpoint/thelion, right.**

PROCEDURE: Subject is in the anthropometric standing position. Stand at the right of the subject and use a beam caliper to measure the horizontal distance between the chest at the level of the right bustpoint on women and nipple on men (**bustpoint/thelion, right**) and the back at the same level. Place the fixed blade of the caliper on the back. The **bustpoint/thelion landmark** is drawn on the bra for female subjects; it is not drawn on male subjects. This measurement is taken at the maximum point of quiet respiration. Exert only enough pressure to maintain contact between the caliper and the skin (or bra).

CAUTION: Subject must not be allowed to change the position of the shoulders.

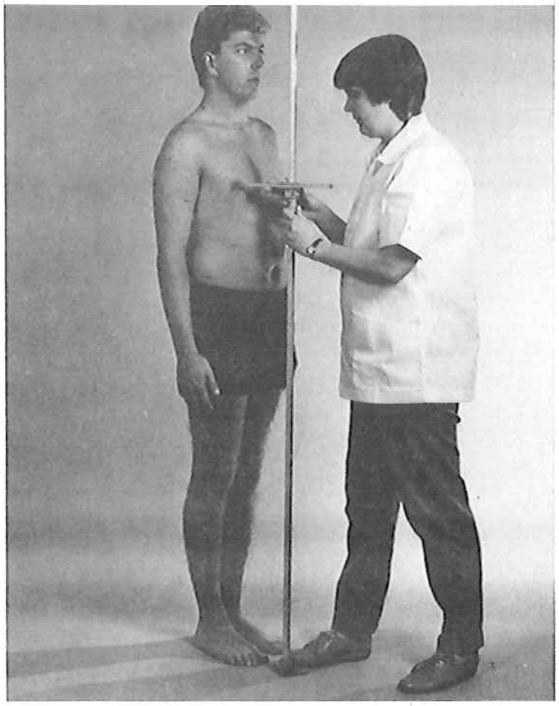


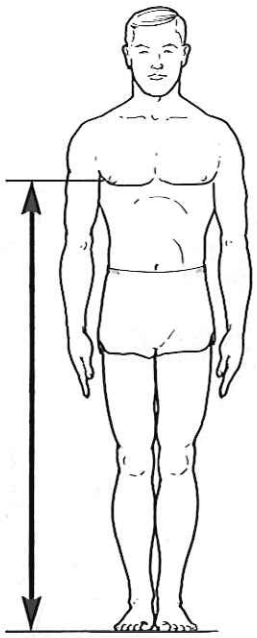


CHEST HEIGHT

ORIGIN-TERMINATION: Standing surface -- **bustpoint/thelion, right.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use an anthropometer to measure the vertical distance between the standing surface and the right bustpoint on women and the nipple on men (**bustpoint/thelion, right**). The landmark is drawn on the bra for female subjects; it is not drawn on men. The measurement is taken at the maximum point of quiet respiration.



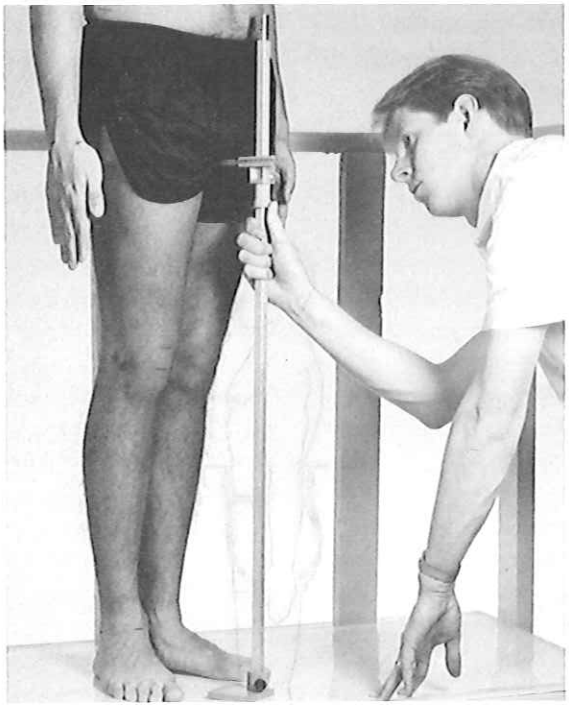


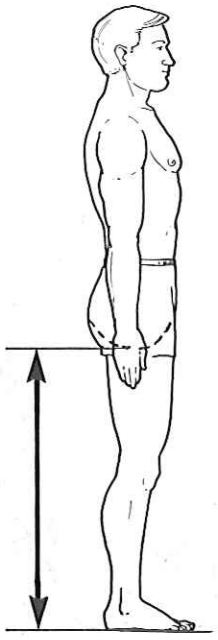
CROTCH HEIGHT

ORIGIN-TERMINATION: Standing surface -- **crotch.**

PROCEDURE: Subject stands on a table in the anthropometric standing position. Stand in front of the subject. The subject spreads the legs apart enough to allow placement of the blade of an anthropometer near the crotch. The subject then brings the heels back together and raises the blade until it is in firm contact with the crotch. (Place the blade to the right of the genitalia.) The measurer then exerts additional upward pressure on the slide of the anthropometer to achieve firm and uniform placement. Measure the vertical distance between the standing surface and the **crotch.**

CAUTION: The computer will add 1 cm to the recorded dimension to account for the width of the anthropometer blade.



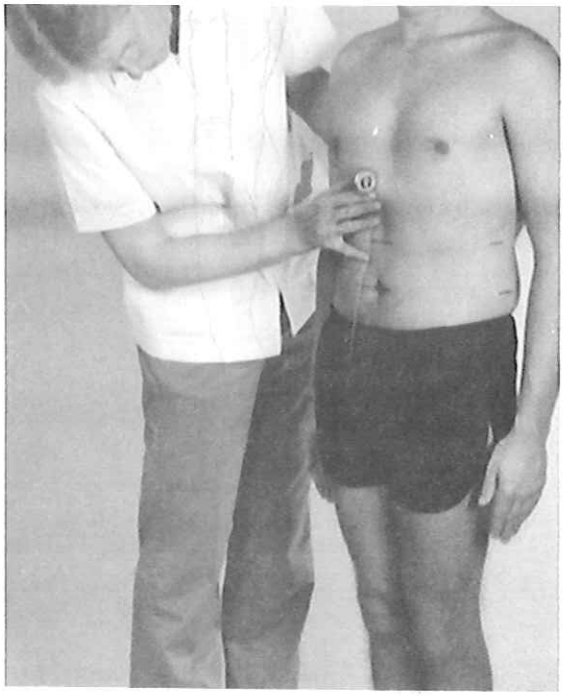


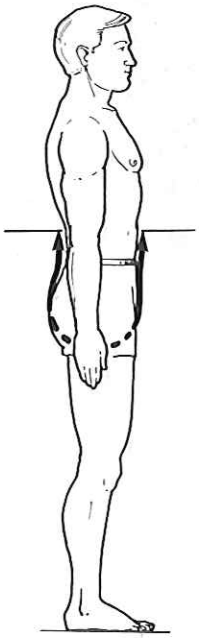
CROTCH LENGTH (NATURAL INDENTATION)

ORIGIN-TERMINATION: **Waist (natural indentation), anterior -- waist (natural indentation), posterior.**

PROCEDURE: Subject stands erect looking straight ahead with the feet sufficiently apart to allow passing a tape through the crotch. When the tape is in place, the subject brings the heels together for the measurement. Stand at the right of the subject and measure the distance between the drawn landmarks on the abdomen [**waist (natural indentation), anterior**] and at the same waist level in back [**waist (natural indentation), posterior**]. The tape passes through the crotch (on males to the right of the scrotum), and between the buttocks. The zero point of the tape is placed on the **posterior waist landmark.** After passing through the crotch the tape should be brought vertically to the **anterior waist landmark.** On men this will be somewhat to the right of the navel. Exert only enough tension on the tape to maintain contact between the tape and the surface of the body. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure the subject does not tense the abdominal muscles and that the tape lies on the skin.



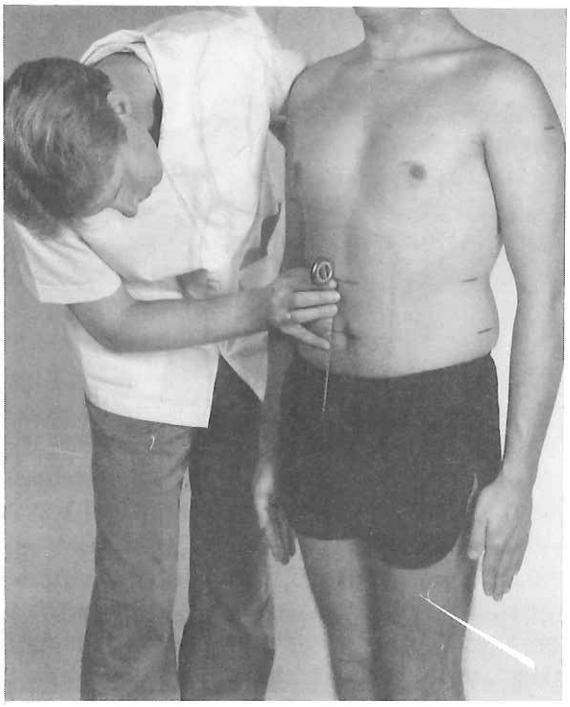


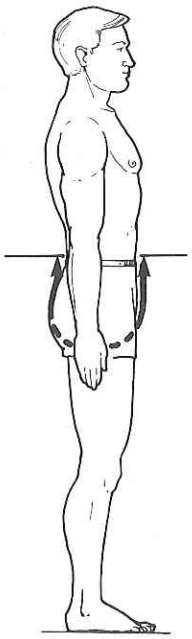
CROTCH LENGTH (OMPHALION)

ORIGIN-TERMINATION: **Waist (omphalion), anterior -- waist (omphalion), posterior.**

PROCEDURE: Subject stands erect looking straight ahead with the feet sufficiently apart to allow passing a tape through the crotch. When the tape is in place, the subject brings the heels together for the measurement. Stand at the right of the subject and measure the distance between the drawn landmarks on the navel [**waist (omphalion), anterior**] and at the same waist level in back [**waist (omphalion), posterior**]. The tape passes through the crotch (on males to the right of the scrotum) and between the buttocks. The zero point of the tape is placed on the **posterior waist landmark.** After passing through the crotch the tape should be brought vertically to the **anterior waist landmark.** On men this will be somewhat to the right of the navel. Exert only enough tension on the tape to maintain contact between the tape and the surface of the body. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure the subject does not tense the abdominal muscles and that the tape lies on the skin.



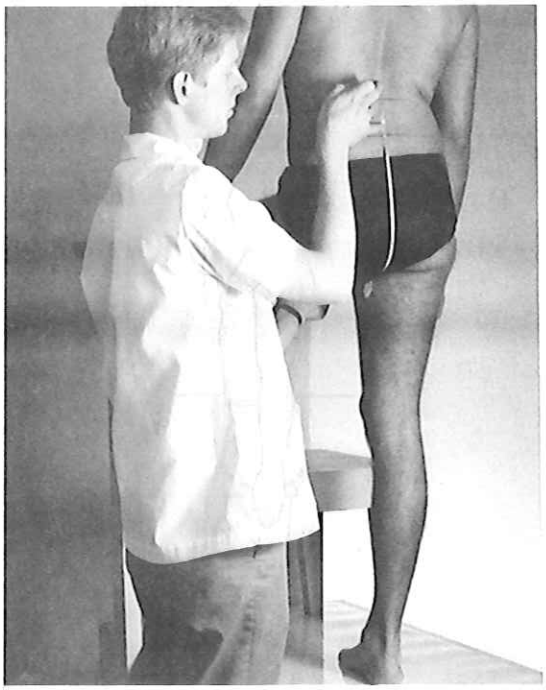


CROTCH LENGTH, POSTERIOR (NATURAL INDENTATION)

ORIGIN-TERMINATION: **Inner thigh -- waist (natural indentation), posterior**

PROCEDURE: Subject stands on a table with the left foot on a platform so that the knee is flexed. Stand to the left rear of the subject and use a specially modified tape to measure the surface distance from the crotch at the drawn **inner thigh landmark** to the back of the waist at the drawn **waist (natural indentation) posterior landmark.** To take the measurement, grasp the zero end of the tape by the dowel, place the leading edge of the pennant on the inner thigh landmark, and bring the tape up between the buttocks to the back of the waist, exerting only enough pressure to maintain contact between the tape and the body. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Do not let the subject tense the abdominal muscles; make sure that the tape lies on the surface of the body.

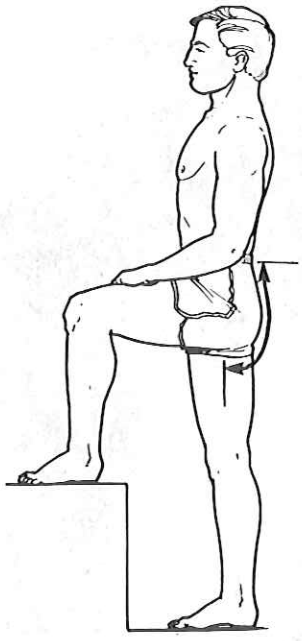


CROTCH LENGTH, POSTERIOR (OMPHALION)

ORIGIN-TERMINATION: **Inner thigh -- waist (omphalion), posterior**

PROCEDURE: Subject stands on a table with the left foot on a platform so that the knee is flexed. Stand to the left rear of the subject and use a specially modified tape to measure the surface distance from the crotch at the drawn **inner thigh landmark** to the back of the waist at the drawn **waist (omphalion), posterior landmark.** To take the measurement, grasp the zero end of the tape by the dowel, place the leading edge of the pennant on the inner thigh landmark, and bring the tape up between the buttocks to back of the waist, exerting only enough pressure to maintain contact between the tape and the body. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Do not let the subject tense the abdominal muscles and be sure that the tape lies on the surface of the body.

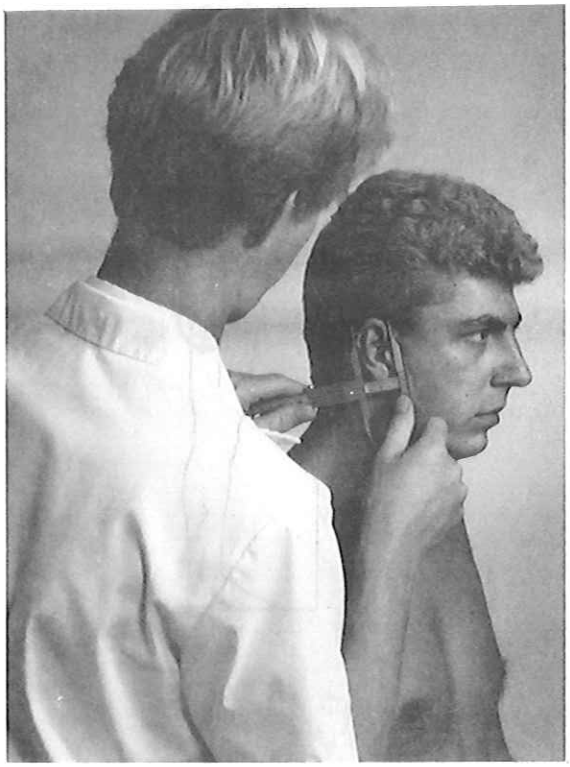


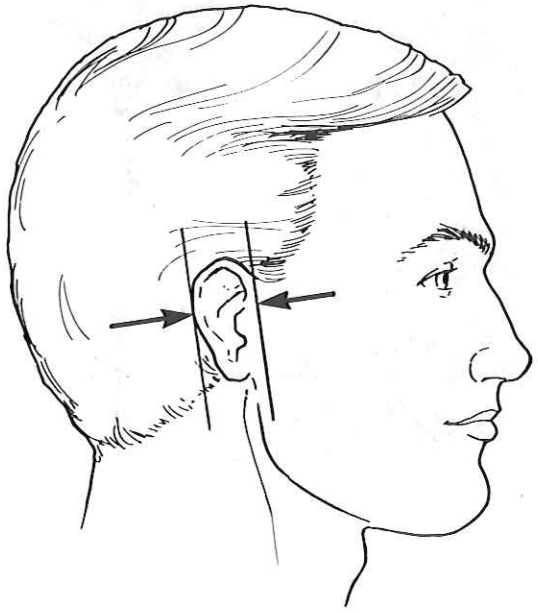
EAR BREADTH

DESCRIPTION: The greatest breadth of the ear between **Otobasion, superior** and a point on the outside edge of the ear in a line perpendicular to the long axis of the ear.

PROCEDURE: Subject sits looking straight ahead. Stand at the subject's right and use a sliding caliper to measure the maximum breadth of the ear perpendicular to its long axis. The fixed blade of the caliper is placed in front of the ear at the juncture of the top of the ear with the head (**otobasion superior**), and oriented in a line parallel to the long axis of the ear. The other blade of the instrument is touching the outer edge of the ear at its widest point. Exert only enough pressure to attain contact between the caliper and the skin.

CAUTION: Care must be taken not to distort the soft tissue of the ear.



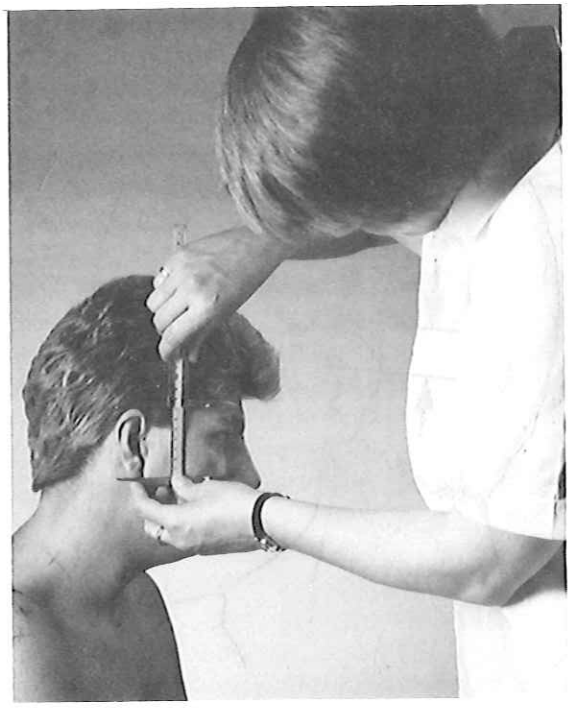


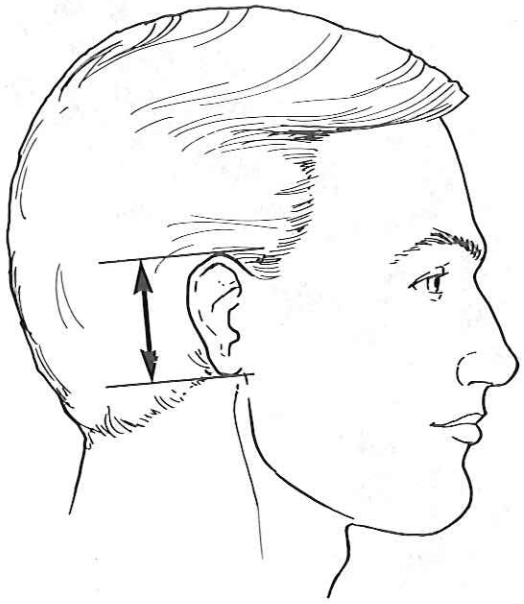
EAR LENGTH

ORIGIN-TERMINATION: **Ear, top -- ear, bottom.**

PROCEDURE: Subject sits looking straight ahead. Stand at the right of the subject and use a sliding caliper to measure the length of the ear from its highest to lowest points on a line parallel to the long axis of the ear. The fixed blade of the caliper is placed on the bottom of the earlobe. Exert only enough pressure to attain contact between the caliper and the skin.

CAUTION: Care must be taken not to distort the ear with the caliper.



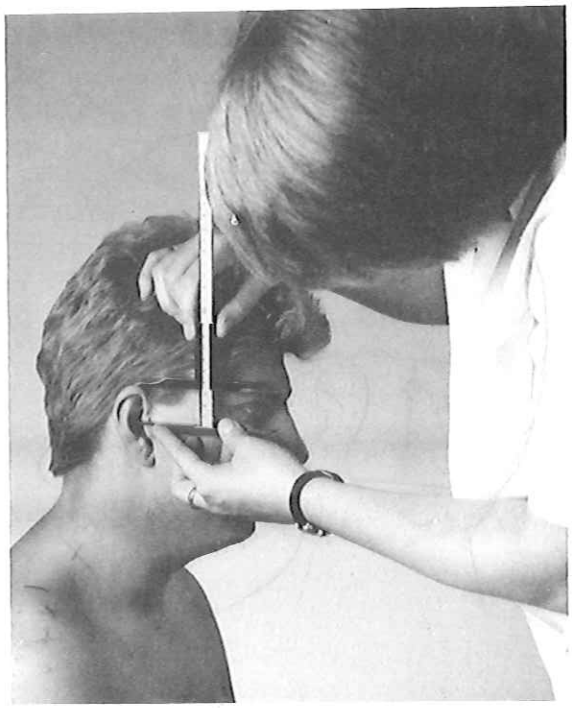


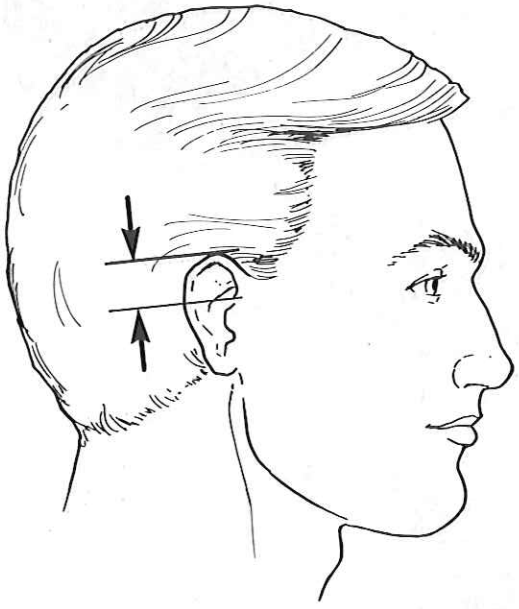
EAR LENGTH ABOVE TRAGION

ORIGIN-TERMINATION: **Tragion, right -- ear top.**

PROCEDURE: Subject sits looking straight ahead. Stand at the right of the subject and use a sliding caliper to measure the distance from the drawn **tragion landmark** to the top of the ear on a line parallel to the long axis of the ear. The fixed blade of the caliper is placed on **tragion.** Exert only enough pressure to attain contact between the caliper and the skin.

CAUTION: Take care not to compress the soft tissue of the ear.



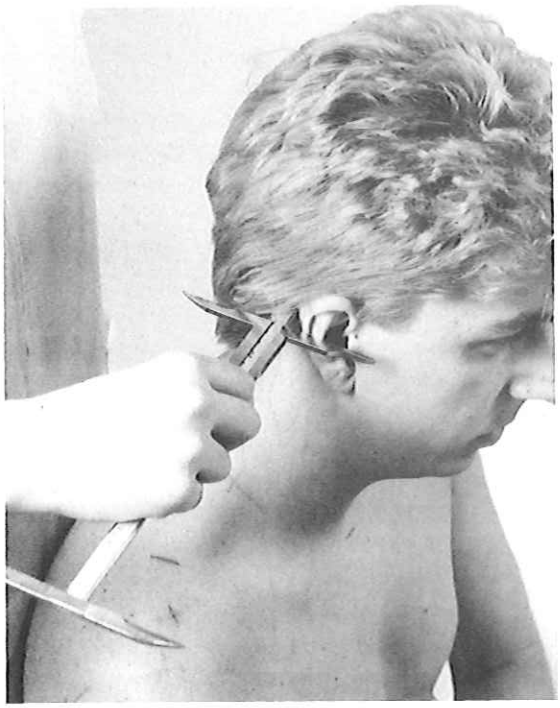


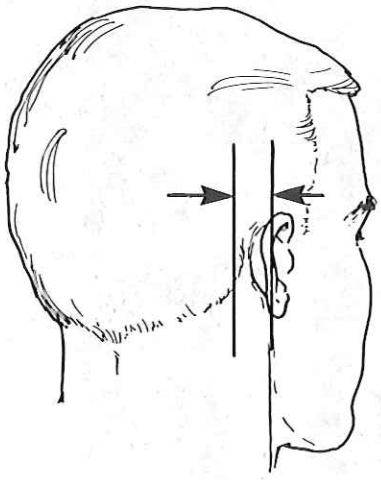
EAR PROTRUSION

ORIGIN-TERMINATION: Mastoid process -- **ear point.**

PROCEDURE: Subject sits looking straight ahead. Stand at the right of the subject and use a sliding caliper with the slide reversed to measure the horizontal distance between the mastoid process (the bony area behind the ear) and the outside edge of the ear at its most lateral point. The base of the caliper is placed on the mastoid process. Exert only enough pressure to ensure that the caliper blade is on the lateral point of the ear.

CAUTION: Care must be taken not to distort the ear and that the beam of the caliper is perpendicular to the head.



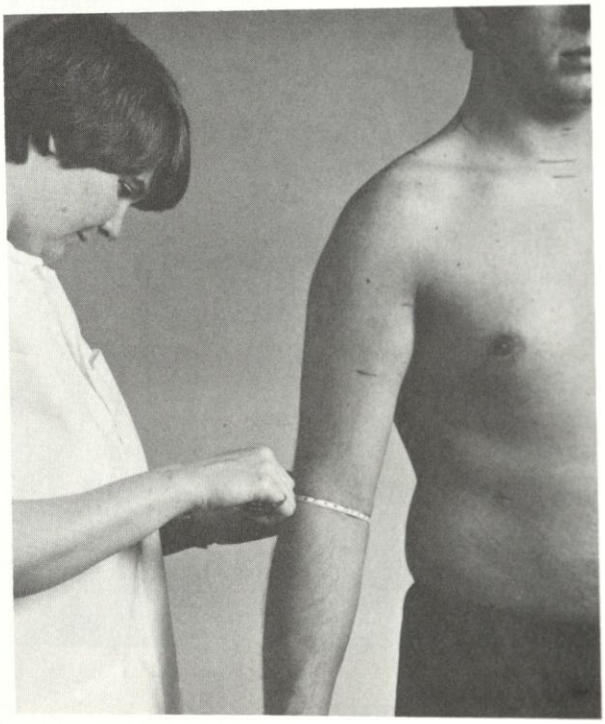


ELBOW CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Olecranon, center.**

PROCEDURE: Subject stands with the arm straight and held away from the body at about a 30-degree angle. Stand at the right of the subject and use a tape to measure the circumference of the elbow in a plane perpendicular to the long axis of the arm. The tape goes around the elbow at the level of the drawn **olecranon, center landmark.** Use only enough pressure to maintain contact between the tape and the skin.

CAUTION: Do not permit the subject to hyperextend the elbow. Women in particular will tend to do this.

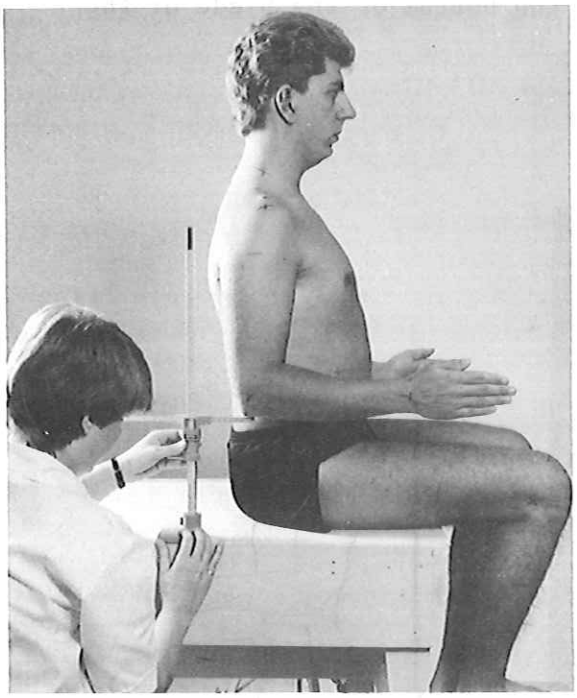


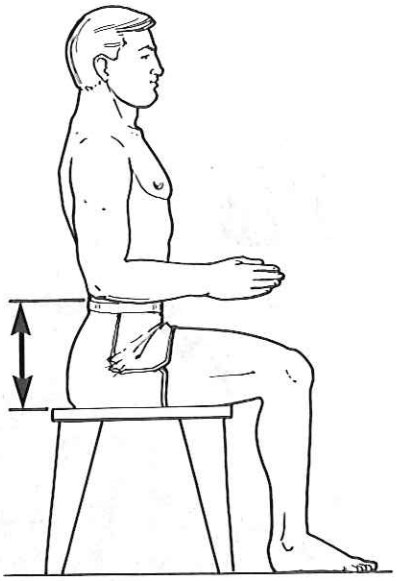
ELBOW REST HEIGHT

ORIGIN-TERMINATION: Sitting surface -- **olecranon, bottom.**

PROCEDURE: Subject is in the anthropometric sitting position. Stand behind the subject and use an anthropometer to measure the vertical distance between the sitting surface and the bottom of the flexed elbow (olecranon bottom). The measurement is taken at the maximum point of quiet respiration.

CAUTION: This dimension is difficult to measure with a high degree of reliability. Check the subject's posture, position of the shoulders, upper arms, and forearms, and be sure to make the measurement at the required point of respiration. The computer will add 1 cm to the recorded dimension to account for the width of the anthropometer blade.



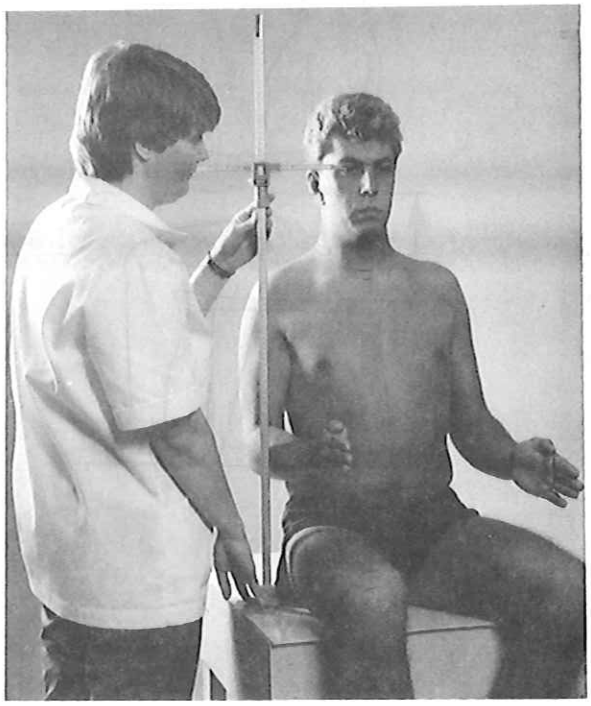


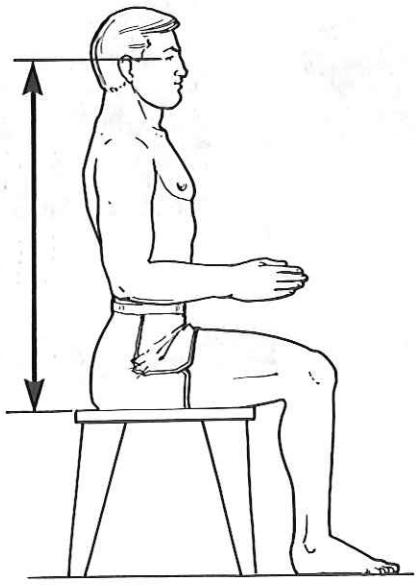
EYE HEIGHT, SITTING

ORIGIN-TERMINATION: Sitting surface -- **ectocanthus, right.**

PROCEDURE: Subject is in the anthropometric sitting position with the head in the Frankfort plane. Use an anthropometer to measure the vertical distance between the sitting surface and the outer corner of the eye (**ectocanthus, right**). Begin by placing the anthropometer on the sitting surface just behind and somewhat to the right of the subject with the blade directed away from the subject. Move the blade to a position approximately level with the subject's eyes. Then swivel it around toward the subject bringing it close to the corner of the eye without actually touching it. On some larger and heavier subjects, the anthropometer may have to be brought around to the side or even to the front of the subject in order for the blade to reach the area close to the corner of the eye. Sight along the bottom of the blade at the level of **ectocanthus.** The measurement is taken at the maximum point of quiet respiration.

CAUTION: The point of the anthropometer blade must never be directed toward the subject's eye. Be sure the subject's head is in the Frankfort plane and that your eye is at the same level as the bottom of the blade of the anthropometer.



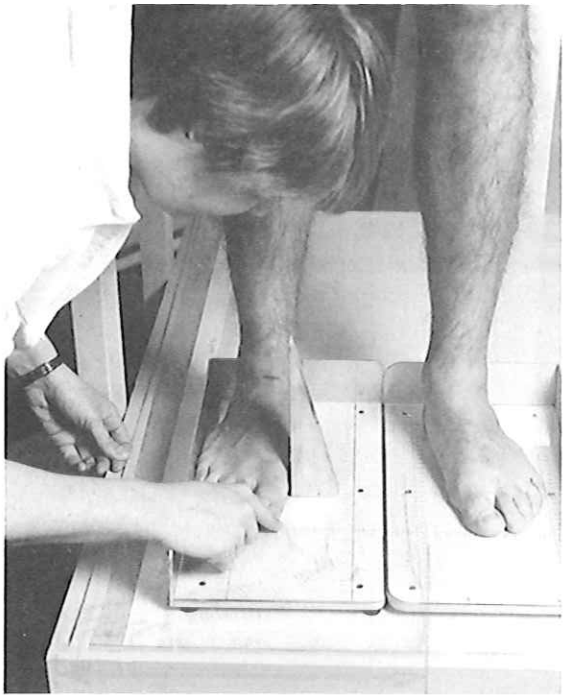


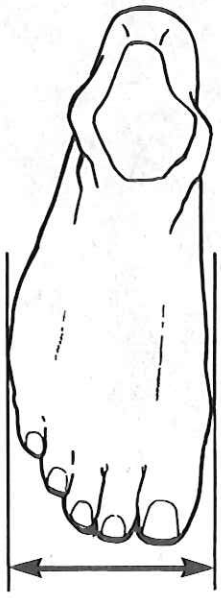
FOOT BREADTH, HORIZONTAL

ORIGIN-TERMINATION: **First metatarsophalangeal protrusion -- fifth metatarsophalangeal protrusion.**

PROCEDURE: Subject stands on a table with each foot in a footbox. Stand in front of the subject, and position the right foot in the box with the back of the heel lightly touching the back of the box, and the side of the foot at the drawn **fifth metatarsophalangeal protrusion landmark** lightly touching the side of the box. The medial side (inside) of the right foot is parallel to the long axis of the box. Place a block against the drawn landmark at the **first metatarsophalangeal protrusion** to establish the horizontal breadth of the foot on the foot box scale.

CAUTION: Be sure the foot is correctly positioned before taking the measurement.



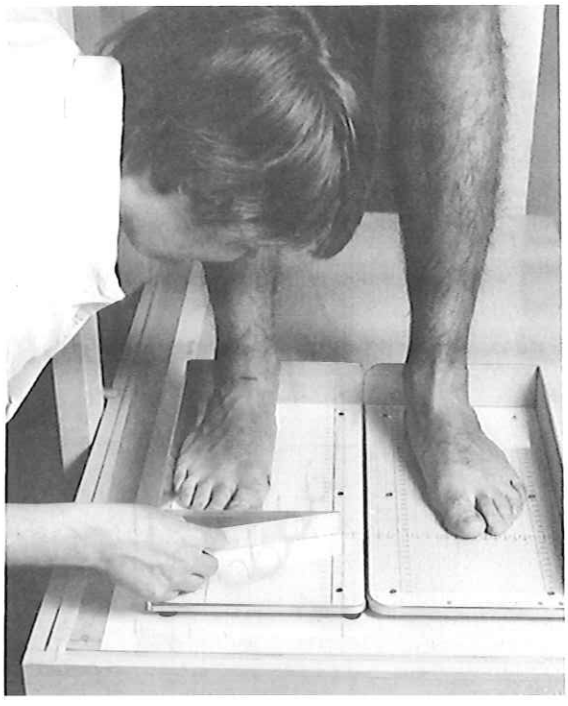


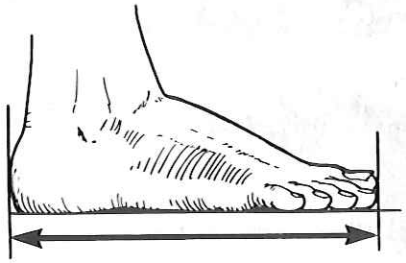
FOOT LENGTH

ORIGIN-TERMINATION: **Acropodion — pternion.**

PROCEDURE: Subject stands on a table with each foot in a footbox. Stand behind the subject to position the right foot in the box with the back of the heel (**pternion**) lightly touching the rear of the box and the **fifth metatarsophalangeal protrusion** (a drawn landmark) lightly touching the side of the box. The medial side (inside) of the right foot is parallel with the long axis of the box. Move to the right side of the subject to take the measurement. Place a block against the tip of the longest toe (**acropodion**) to establish the length of the foot on the footbox scale. Use only enough pressure to ensure that the block touches the toe.

CAUTION: Be sure the foot is correctly positioned before taking the measurement.



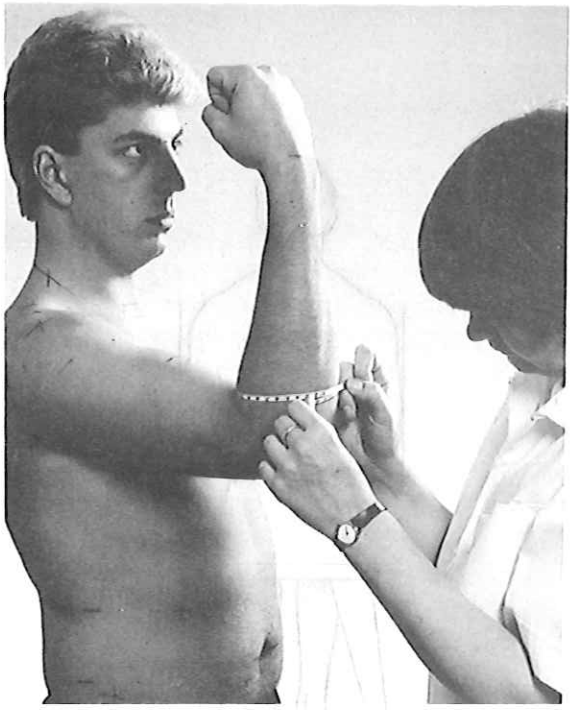


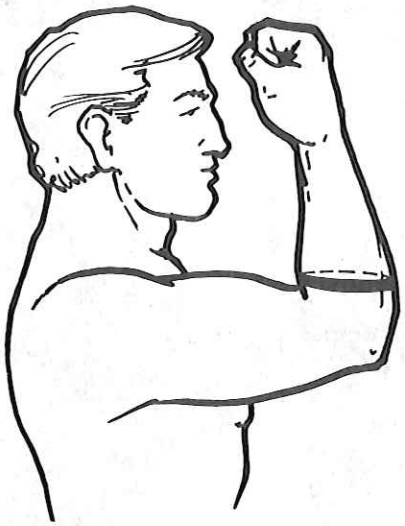
FOREARM CIRCUMFERENCE, FLEXED

LANDMARK(S) ENCOMPASSED: **Elbow crease.**

PROCEDURE: Subject stands with the upper arm extended forward horizontally, the elbow flexed 90 degrees, and the fist tightly clenched. Stand at the right of the subject and use a tape to measure the circumference of the forearm at the level where the bottom edge of the tape passes across the crease at the juncture between the upper arm and forearm (**elbow crease**). The measurement is made in a plane perpendicular to the long axis of the forearm. Exert only enough tension on the tape to maintain contact between the tape and the skin.

CAUTION: Urge the subject to clench the fist tightly.



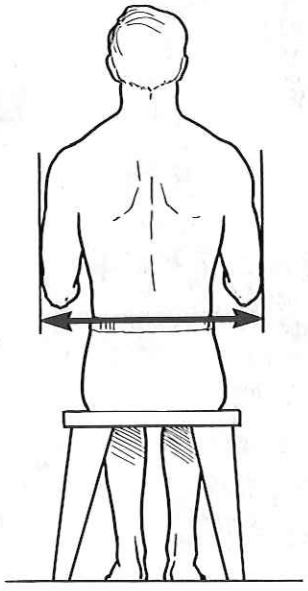


FOREARM-FOREARM BREADTH

DESCRIPTION: The maximum horizontal distance between the lateral right forearm and the lateral left forearm.

PROCEDURE: Subject is in the anthropometric sitting position. Stand behind the subject and use a beam caliper to measure the maximum horizontal distance across the upper body between the outsides of the forearms. Brush the blades back and forth to ensure that the maximum breadth is attained. Exert only enough pressure to ensure that the caliper blades are on the lateral points of the forearms. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure that the arms are in the required position and the subject is at the required point of respiration.

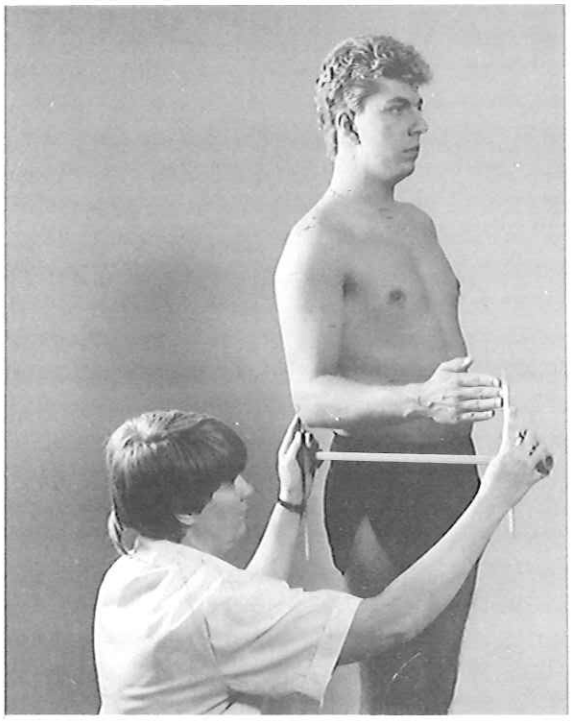


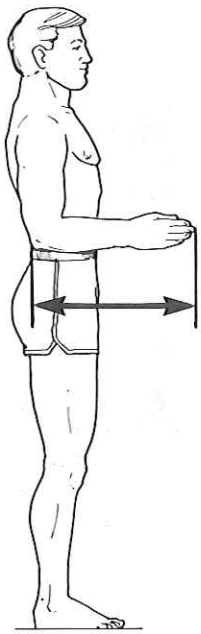
FOREARM-HAND LENGTH

ORIGIN-TERMINATION: **Olecranon, rear -- dactylion III, right.**

PROCEDURE: Subject stands erect with the upper arms hanging at the side and the right elbow flexed 90 degrees. The hand is held out straight with the palm facing inward. Stand to the right of the subject and use a beam caliper to measure the horizontal distance between the back of the tip of the elbow (**olecranon, rear**) to the tip of the middle finger (**dactylion III**). Place the fixed blade on **olecranon, rear.** Exert only enough pressure to attain contact between the caliper and the skin.

CAUTION: Measure to the tip of the finger, not the fingernail.



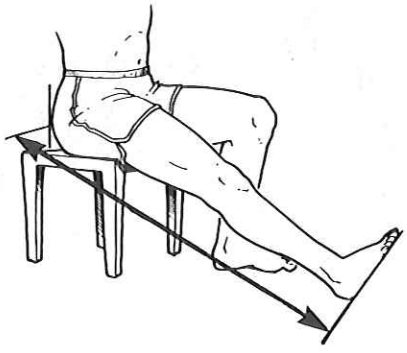


FUNCTIONAL LEG LENGTH

ORIGIN-TERMINATION: Footrest surface of the anthropometer base -- plane of the back.

PROCEDURE: Subject sits erect on the edge of a seat with the right leg extended and the foot on the base plate of an anthropometer which rests on the floor. The subject brings the left foot under the seat to enhance stability. Stand at the right of the subject and measure the straight-line distance between the footrest surface of the base of the anthropometer and the back surface of the body. The shaft of the anthropometer passes over the drawn **trochanter landmark.** The foot should be in firm contact with the base plate of the anthropometer; the blade should be in light contact with the back.

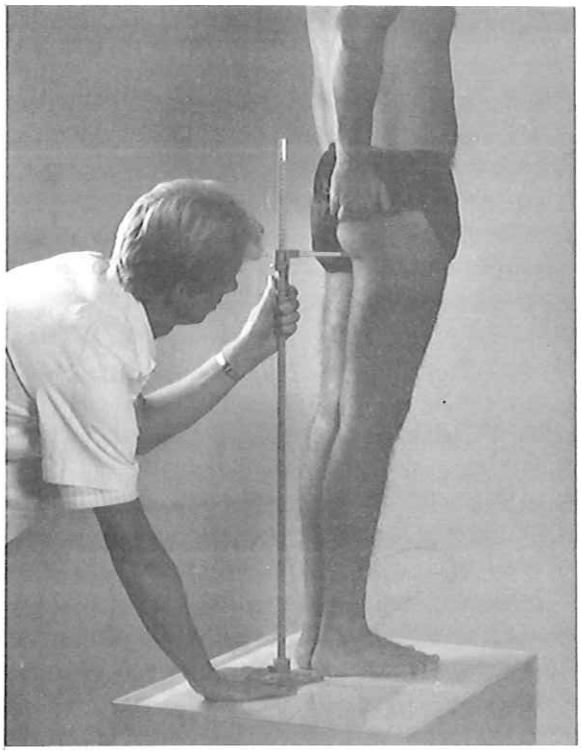
CAUTION: Urge the subject to fully extend the knee. Be sure that the anthropometer is properly aligned with the **trochanter landmark.**

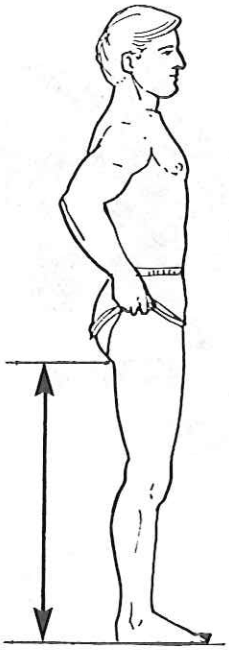


GLUTEAL FURROW HEIGHT

ORIGIN-TERMINATION: Standing surface -- **gluteal furrow point.**

PROCEDURE: Subject stands on a table in the anthropometric standing position. Ask the subject to hold up the right leg of the shorts to expose the landmark. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn landmark at the lowest point of the gluteal furrow under the buttocks.

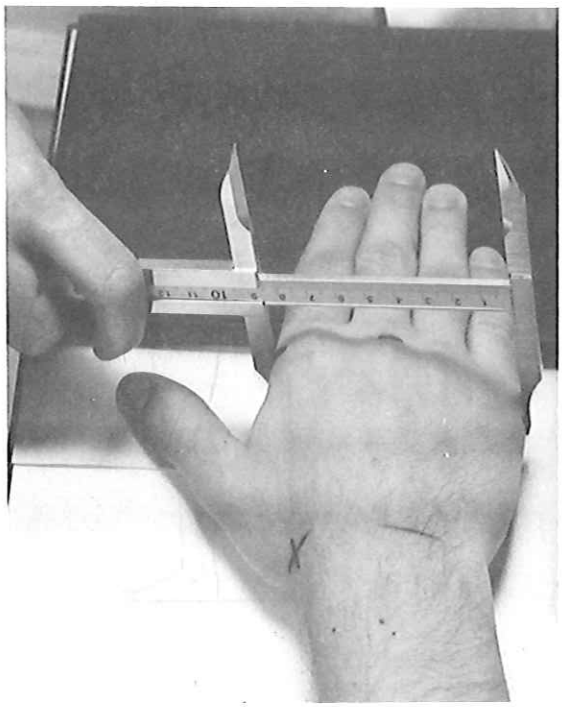


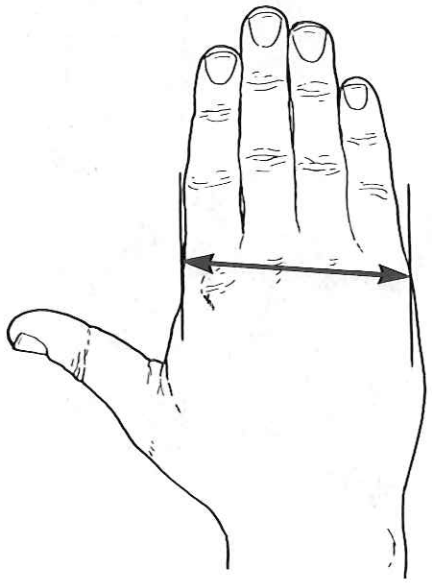


HAND BREADTH

ORIGIN-TERMINATION: **Metacarpale II -- metacarpale V.**

PROCEDURE: Subject sits with the palm on a table and the fingers on a flat surface 8 mm higher. The fingers are together and the thumb is held away from the hand at about a 45-degree angle. The measurer presses the hand into firm contact with the table and instructs the subject to hold this position. The middle finger is parallel to the long axis of the forearm. Stand in front of the subject and use a sliding caliper to measure the breadth of the hand between the drawn landmarks at **metacarpale II** and **metacarpale V.** Exert only enough pressure to ensure that the caliper blades are on the landmarks.

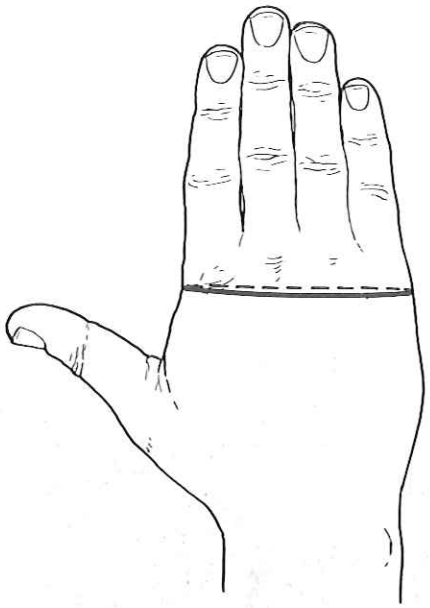




HAND CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Metacarpale II; metacarpale V.**

PROCEDURE: Subject sits with the palm on a table and the proximal phalanges on a flat surface 8 mm higher. The fingers are together and the thumb is held away from the hand at about a 45-degree angle. The measurer presses the hand into firm contact with the table and instructs the subject to hold this position. The middle finger is parallel to the long axis of the forearm. Place the tape under the hand before positioning the subject. Stand in front of the subject and pass the tape over the drawn landmarks at **metacarpale II** and **metacarpale V** to measure the circumference of the hand. Exert only enough tension on the tape to maintain contact between the tape and the skin.

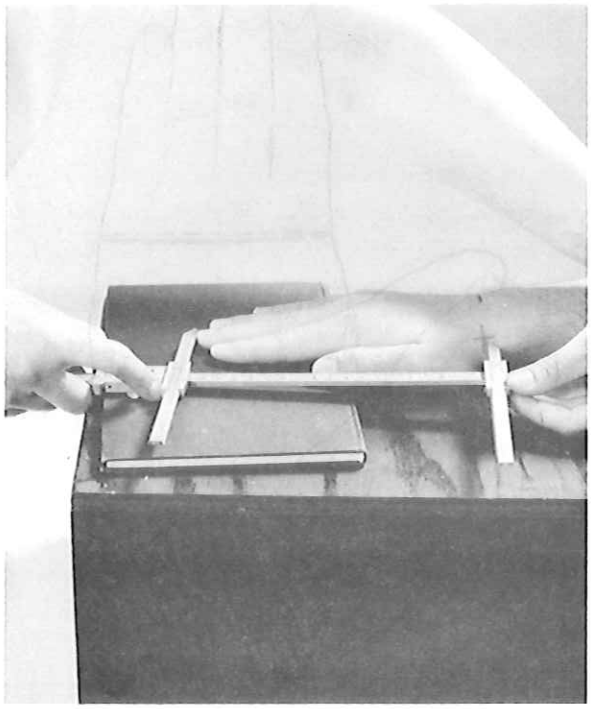


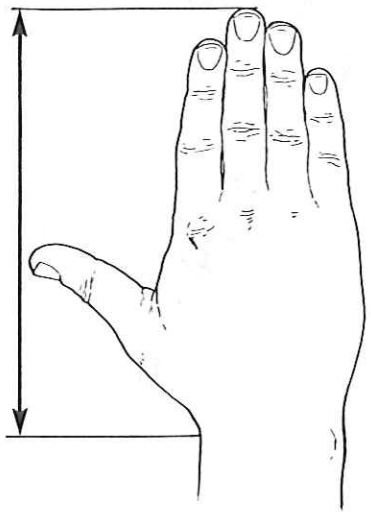
HAND LENGTH

ORIGIN-TERMINATION: **Stylion -- dactylion III, right.**

PROCEDURE: Subject sits with the palm on a table and the fingers on a flat surface 8 mm higher. The fingers are together and the thumb is held away from the hand at about a 45-degree angle. The measurer presses the hand into firm contact with the table and instructs the subject to hold this position. The middle finger is parallel to the long axis of the forearm. Stand at the left of the subject and use a Poech sliding caliper to measure the length of the hand between the drawn **stylion landmark** on the wrist and the tip of the middle finger (**dactylion III**). Place the fixed blade of the caliper on **stylion.** The beam of the caliper is parallel to the long axis of the arm. Exert only enough pressure to ensure that the tips of the caliper are on the landmarks.

CAUTION: Subject must not be allowed to flex or hyperextend the fingers.

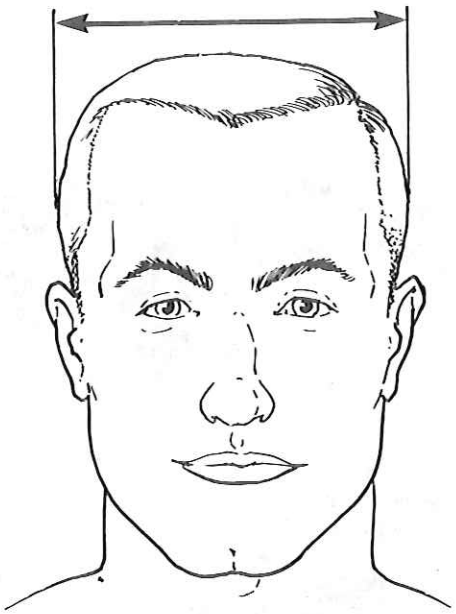




HEAD BREADTH

DESCRIPTION: The maximum horizontal breadth of the head above the ears.

PROCEDURE: Subject sits. Stand behind the subject and use a spreading caliper to measure the maximum horizontal breadth of the head above the ears. Exert sufficient pressure to obtain contact between the caliper and the skin.

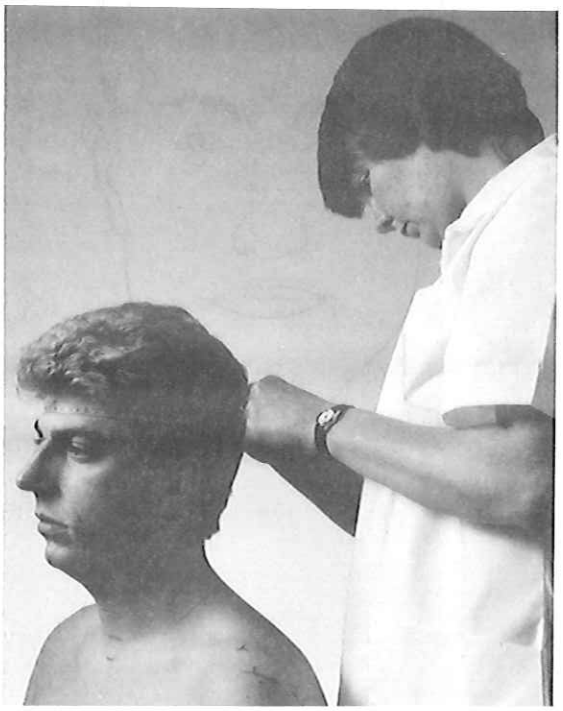


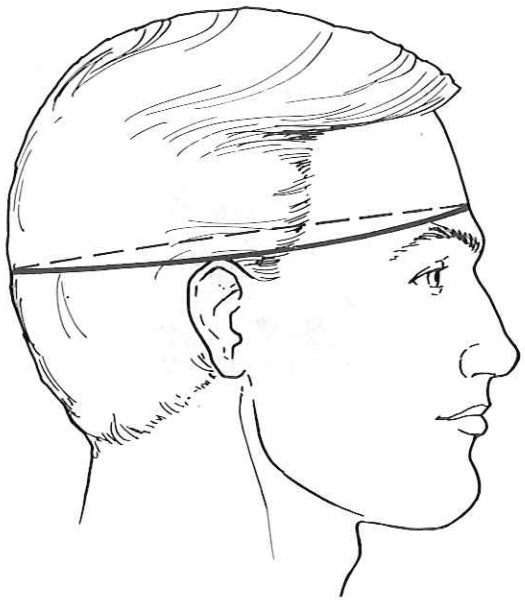
HEAD CIRCUMFERENCE

DEFINITION: The maximum circumference of the head above the supraorbital ridges and ears.

PROCEDURE: Subject sits. Stand to the right of the subject and use a tape to measure the maximum circumference of the head above the attachment of the ears to the head. The bottom of the tape should pass just above the ridges of the eyebrows (supraorbital ridges) and around the back of the head. Use enough tension to compress the hair.

CAUTION: The plane of the tape will be higher in front than it is in the back but it should not be tilted to either side.

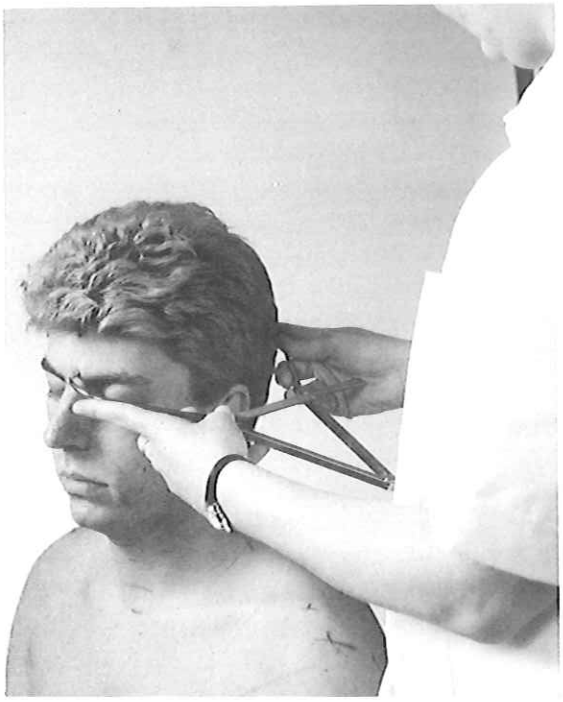


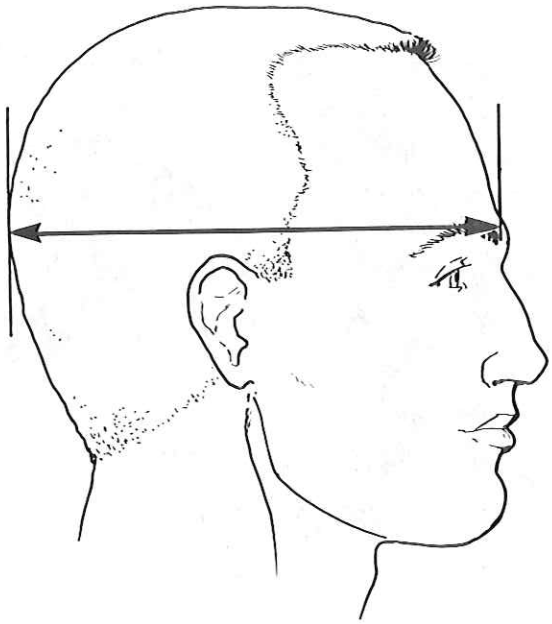


HEAD LENGTH

ORIGIN-TERMINATION: **Glabella -- opisthocranion.**

PROCEDURE: Subject sits. Stand at the right of the subject. Use a spreading caliper to measure in the midsagittal plane, the distance between a point between the browridges (**glabella**) and the posterior point on the back of the head. Place one tip of the caliper on **glabella** and move the other tip up and down on the back of the head in the midsagittal plane until the maximum measurement is obtained. Use light pressure on glabella, and enough pressure at **opisthocranion** to compress the hair.



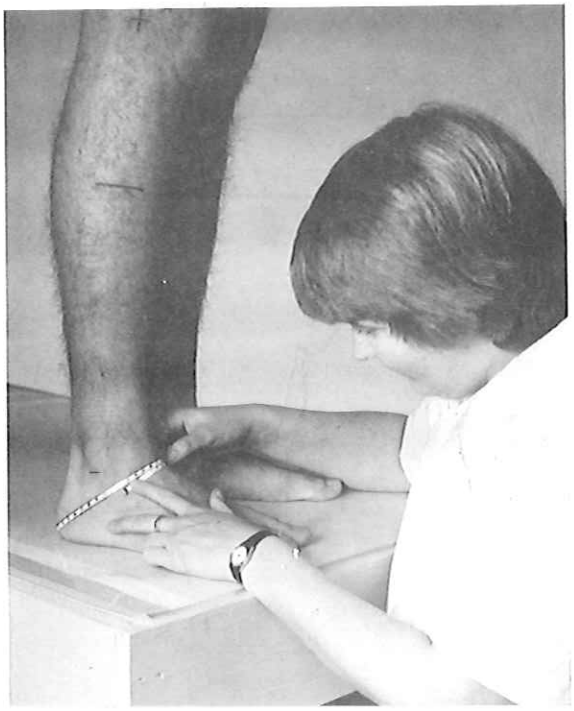


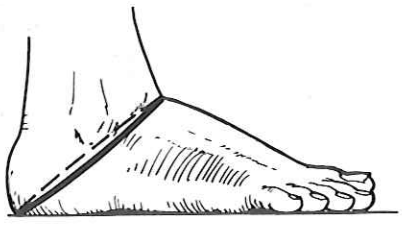
HEEL ANKLE CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Dorsal juncture of the foot and leg.**

PROCEDURE: Subject stands on a table with the feet about 10 cm apart and the weight distributed equally on both feet. Stand in front of the subject and use a tape to measure the circumference of the foot at the ankle and base of the heel. The tape passes over the point at which the heel first contacts the table and over the drawn landmark at the front of the ankle **(dorsal juncture of the foot and leg).** The tape spans hollows of the foot. Exert only enough tension to maintain contact between the tape and the skin.

CAUTION: The tape may be held at the base of the heel to prevent its slipping during the measurement.



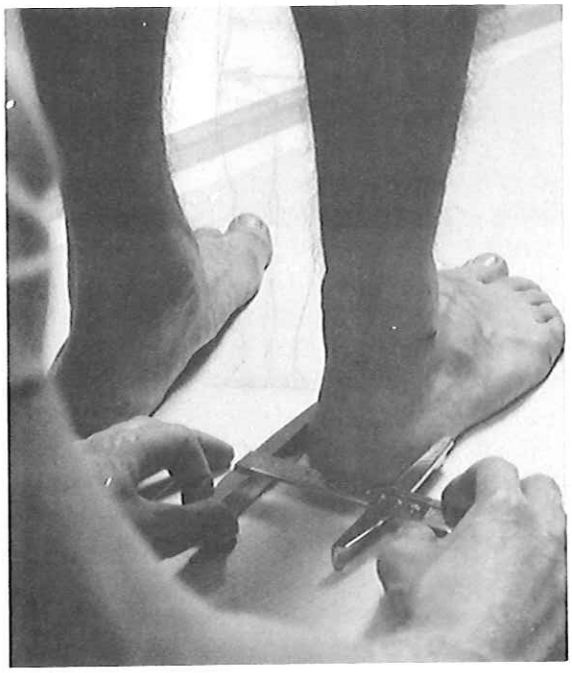


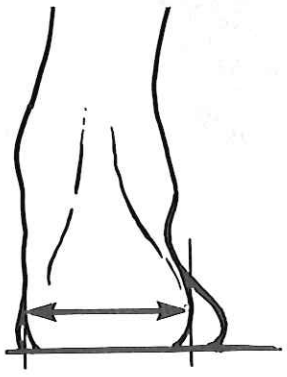
HEEL BREADTH

ORIGIN-TERMINATION: **Heel point, lateral -- heel point, medial.**

PROCEDURE: Subject stands on a table with the weight distributed equally on both feet. The feet are spread apart about 10 cm and are parallel. Stand behind the subject and use a Holtain caliper to measure the maximum horizontal distance between the medial and lateral points on the inside and outside of the heel. The measurement is taken just above the level of the table at the most protruding points of the curvature of the heel. Hold the caliper so that the fixed blade is on the **medial heel point** on the inside of the heel, and parallel to the medial side of the foot. Exert only enough pressure to ensure that the caliper blades are on the heel points.

CAUTION: Some subjects will not exhibit medial and lateral heel points. For these subjects, measure the breadth of the heel at the level of the most protruding point of the lateral malleolus.

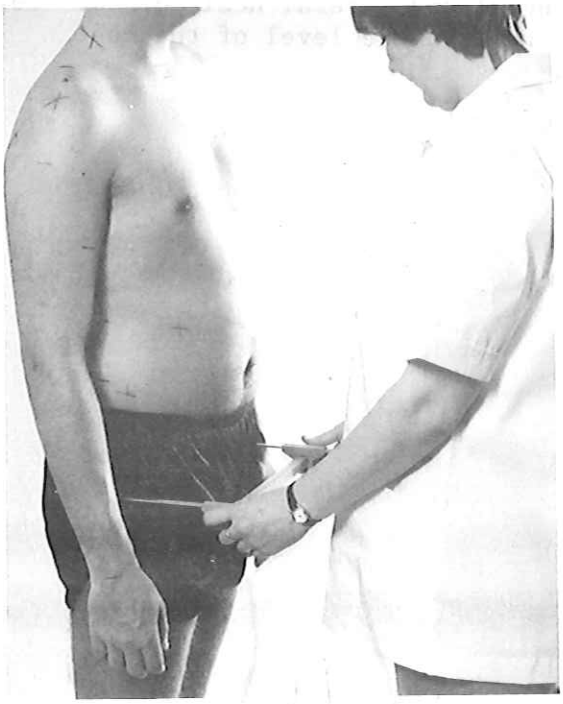


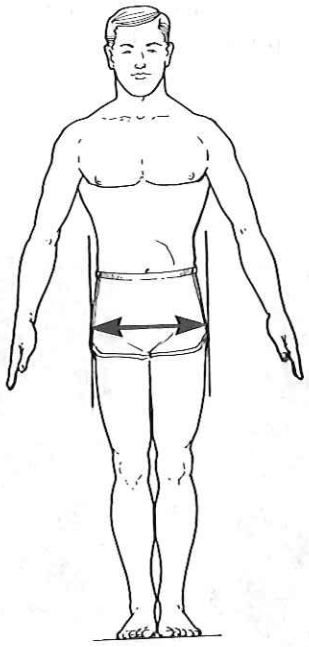


HIP BREADTH

DESCRIPTION: **Buttock point: right lateral** and **left lateral.**

PROCEDURE: Subject is in the anthropometric standing position with the arms held slightly away from the body. Stand in front of the subject and use a beam caliper to measure the horizontal distance between the drawn **lateral buttock landmarks.** Exert only enough pressure to ensure that the caliper blades are on the hips.

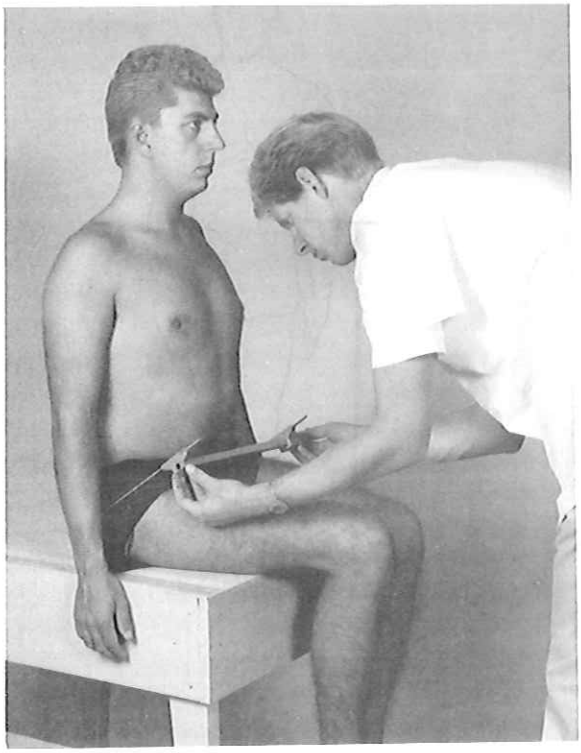


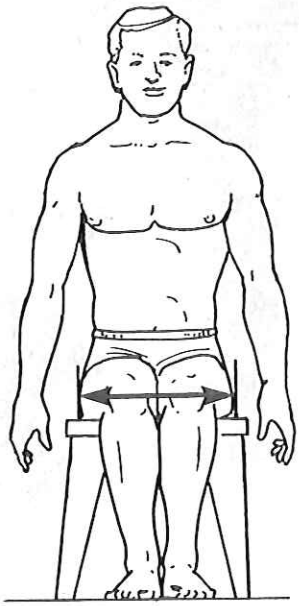


HIP BREADTH SITTING

DESCRIPTION: Maximum hip (or thigh) breadth of a seated subject.

PROCEDURE: Subject sits erect with the feet and knees together and the arms relaxed at the sides. Stand in front of the subject and use a beam caliper to measure the most lateral points on the hips or thighs (whichever are broader). The blades of the caliper are kept at approximately a 45-degree angle to the horizontal and moved up and down to locate the maximum breadth. Exert only enough pressure to ensure that the caliper blades are on the body.

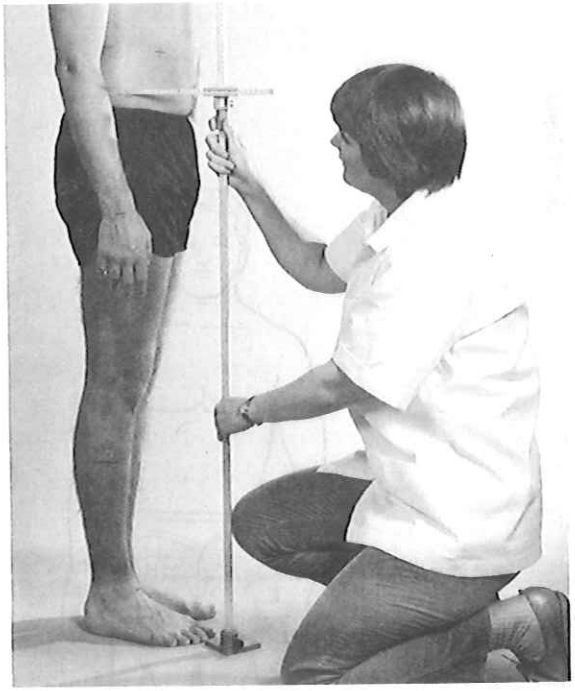


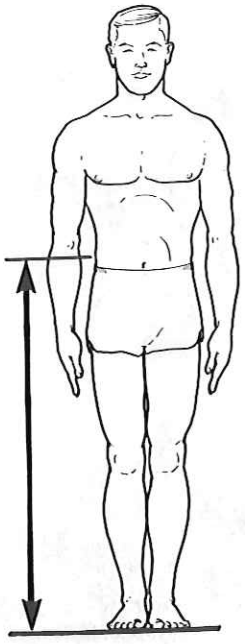


ILIOCRISTALE HEIGHT

ORIGIN-TERMINATION: Standing surface -- **iliocristale.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **iliocristale landmark** (an "I") on the right side of the pelvis.



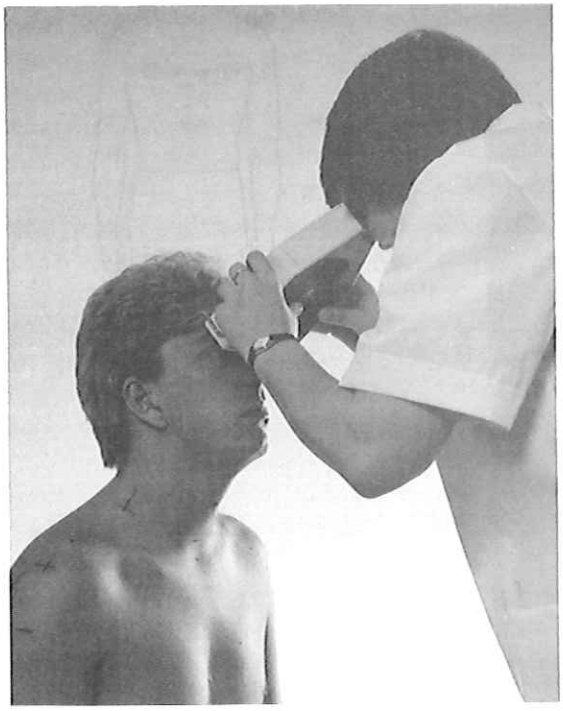


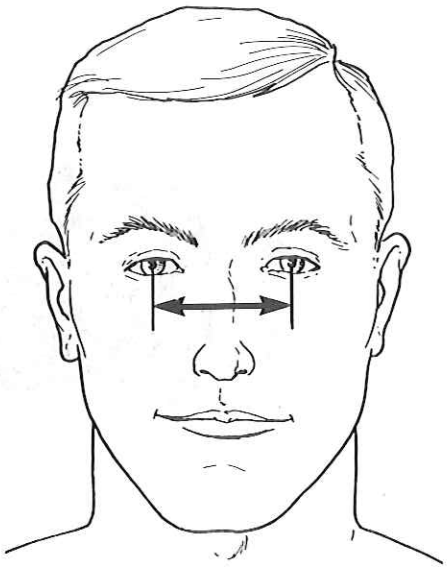
INTERPUPILLARY BREADTH

ORIGIN-TERMINATION: Center of **right pupil** -- center of **left pupil.**

PROCEDURE: Subject sits. Stand in front of the subject and use a pupillometer to measure the horizontal distance between the two pupils. Move the lever on the top of the device all the way to the right. Ask the subject to look into the pupillometer and focus on the light. Look into the other end of the device and move the right vertical hairline to the point at which it passes through the center of the pupil of the right eye. Move the lever all the way to the left and repeat the process for the other pupil. Repeat the process for the left pupil. Remove the device from the subject's face and read the measurement from the middle of the three scales on the bottom of the pupillometer.

CAUTION: Be certain that the dial is always set on infinity (∞).

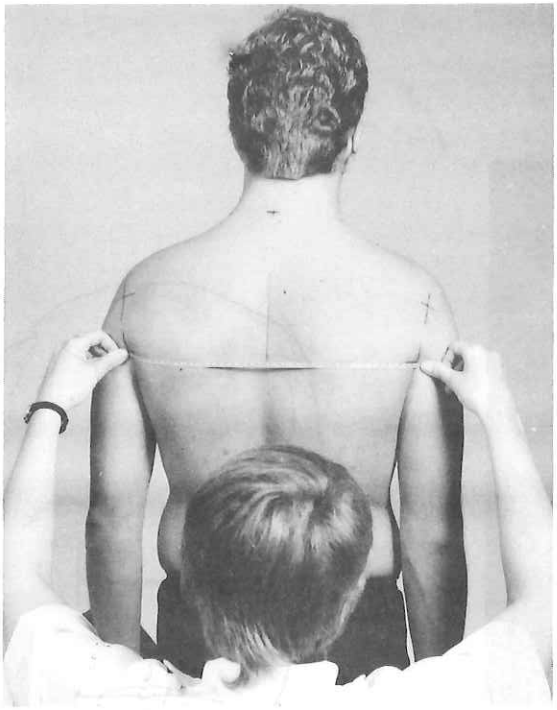


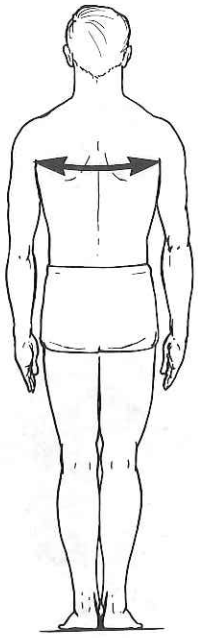


ORIGIN-TERMINATION: **Axillary fold, right posterior -- axillary fold, left posterior.**

PROCEDURE: Subject is in the anthropometric standing position. Stand behind the subject and use a tape to measure the distance between the top of the **right posterior axillary fold** and the top of the **left posterior axillary fold** (where the arms join the torso). The tape is held on the skin surface except where it spans the hollow of the back. Be sure the tape goes across the back in a straight line and does not arch up over the shoulder blades. The measurement is taken at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.



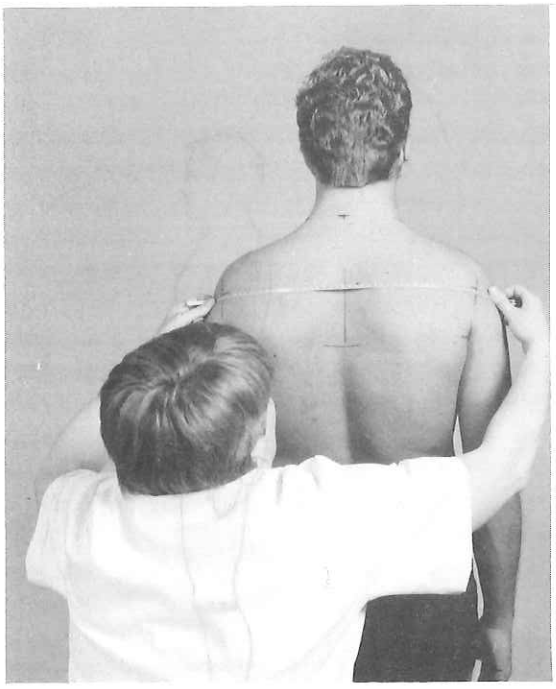


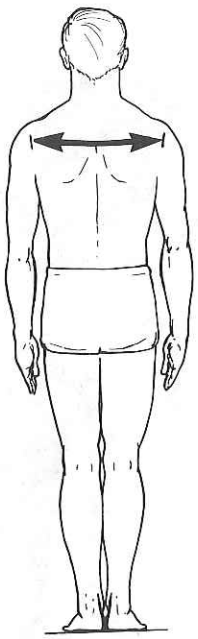
INTERSCYE II

ORIGIN-TERMINATION: **Midscye, right -- midscye, left.**

PROCEDURE: Subject is in the anthropometric standing position. Stand behind the subject and use a tape to measure the distance between the drawn **right** and **left midscye landmarks.** The tape is held on the skin except where it spans the hollows of the back. Be sure the tape goes across the back in a straight line and does not arch up over the shoulder blades. The measurement is taken at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.



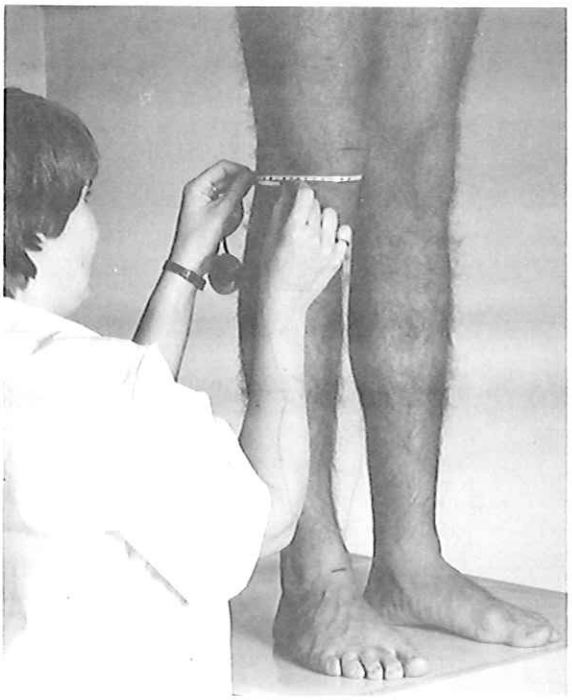


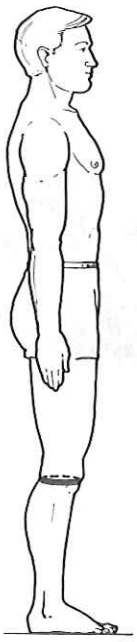
KNEE CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Midpatella**

PROCEDURE: Subject stands erect on a table with the feet about 10 cm apart and the weight distributed equally on both feet. Stand at the right of the subject and use a tape to measure the horizontal circumference of the knee at the level of the drawn **midpatella landmark** at the center of the knee. Exert only enough tension on the tape to maintain contact between the tape and the skin.

CAUTION: Subjects will tend to lock their knees. If a subject has difficulty keeping the knee loose, firmly grasp the thigh a few inches above the knee for a moment. This will induce relaxation of the patella which is necessary for this measurement.



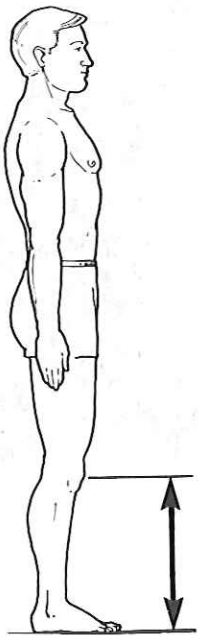


KNEE HEIGHT, MIDPATELLA

ORIGIN-TERMINATION: Standing surface -- **midpatella.**

PROCEDURE: Subject stands erect on a table with the heels together and the weight distributed equally on both feet. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **midpatella landmark** at the center of the knee.

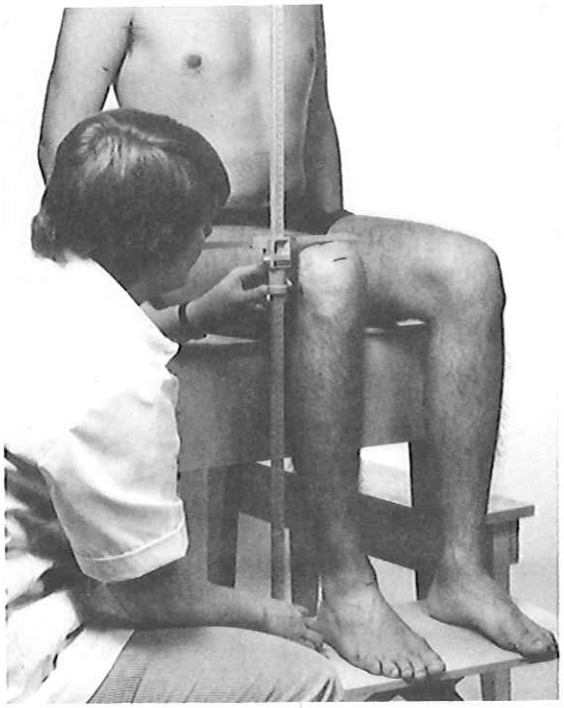
CAUTION: Subjects will tend to lock their knees. If subjects have difficulty keeping the knee loose, firmly grasp the thigh a few inches above the knee for a moment. This will induce relaxation of the patella which is necessary for this measurement.

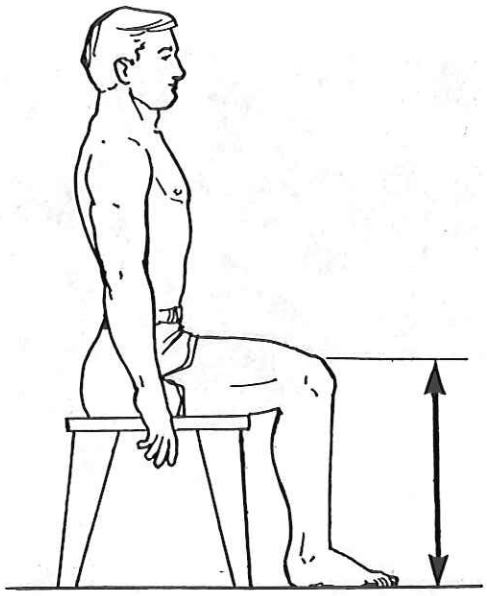


KNEE HEIGHT, SITTING

ORIGIN-TERMINATION: Footrest surface -- **suprapatella.**

PROCEDURE: Subject sits with the thighs parallel, the knees flexed 90 degrees, and the feet in line with the thighs. The arms are relaxed at the sides. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the footrest surface and the drawn **suprapatella landmark** at the top of the knee.

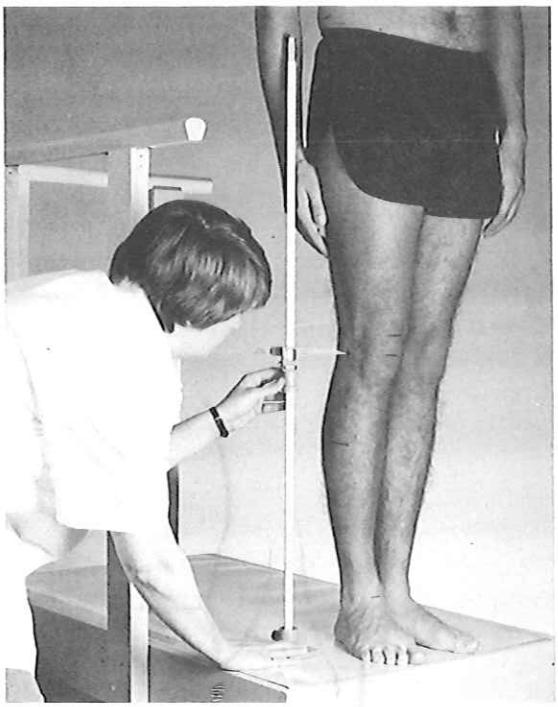


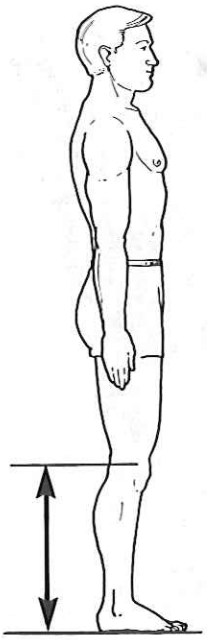


LATERAL FEMORAL EPICONDYLE HEIGHT

ORIGIN-TERMINATION: Standing surface -- **lateral femoral epicondyle, standing.**

PROCEDURE: Subject stands erect on a table with the heels together and the weight distributed equally on both feet. Stand at the right side of the subject and use an anthropometer to measure the vertical distance between the standing surface and the marked **standing lateral femoral epicondyle landmark** on the outside of the knee.



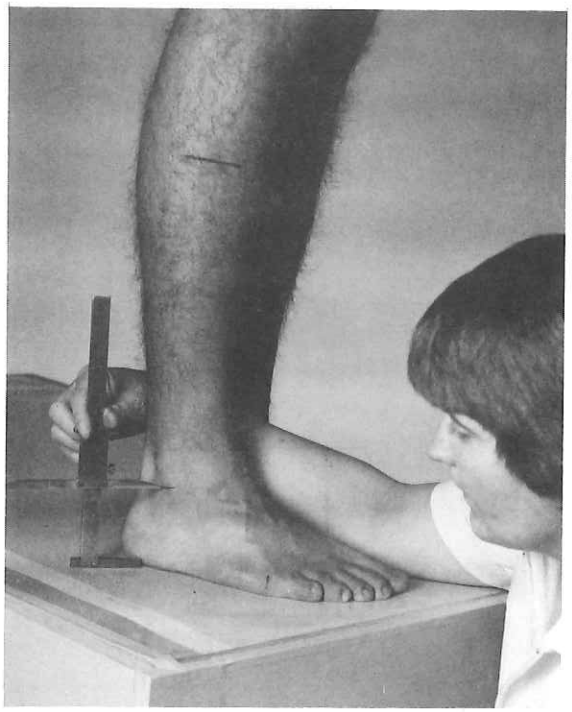


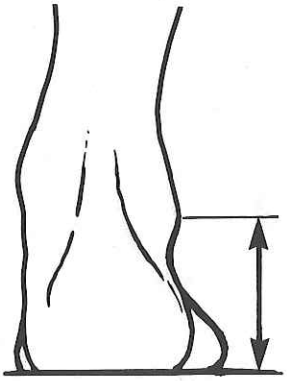
LATERAL MALLEOLUS HEIGHT

ORIGIN-TERMINATION: Standing surface -- **lateral malleolus.**

PROCEDURE: Subject stands erect on a table with the heels together and the weight distributed equally on both feet. Stand at the right of the subject and use a modified sliding caliper to measure the vertical distance between the standing surface and the drawn **lateral malleolus landmark** on the outside of the ankle.

CAUTION: The measurer's eyes must be at the level of the blade or the gauge.



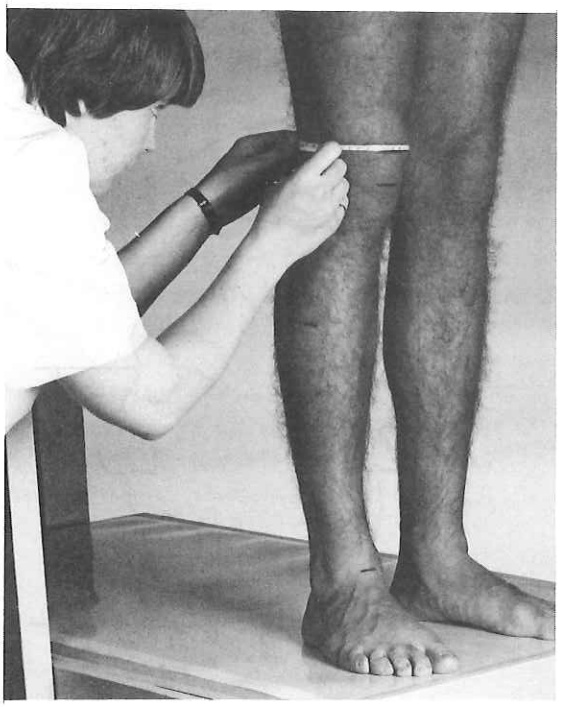


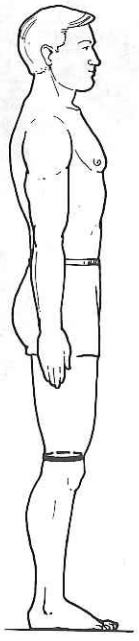
LOWER THIGH CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Suprapatella.**

PROCEDURE: Subject stands erect on a table with the feet about 10 cm apart and the weight distributed equally on both feet. Stand at the right of the subject and use a tape to measure the horizontal circumference of the thigh at the level of the **suprapatella landmark** at the top of the knee. The bottom of the tape follows the top of the landmark. Exert only enough tension on the tape to maintain contact between the tape and the skin.

CAUTION: Subjects will tend to lock their knees. If subjects have difficulty keeping the knee loose, firmly grasp the thigh a few inches above the knee for a moment. This will induce relaxation of the patella which is necessary for this measurement.



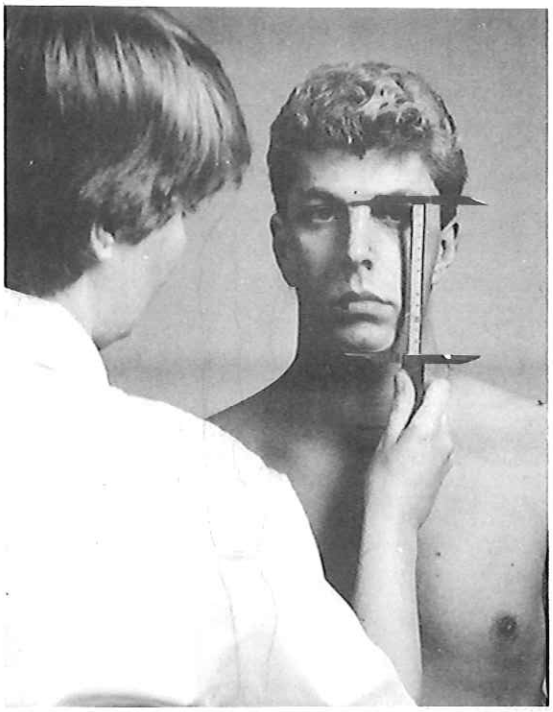


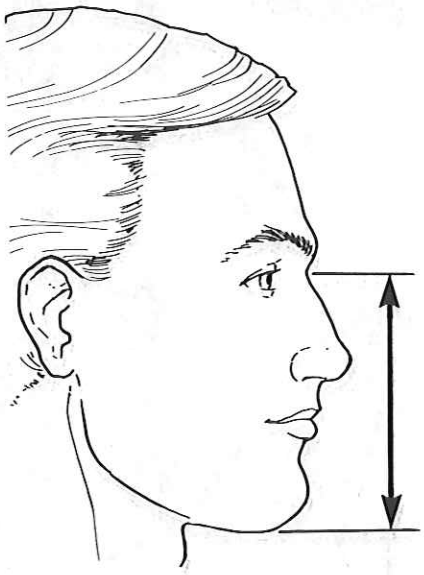
MENTON-SELLION LENGTH

ORIGIN-TERMINATION: **Menton -- sellion.**

PROCEDURE: Subject sits. The teeth are together but not clenched. Stand toward the right of the subject and use a sliding caliper to measure, in the midsagittal plane, the distance between the drawn **menton landmark** at the bottom of the chin and the drawn **sellion landmark** at the deepest point of the nasal root depression. Place the fixed blade of the caliper on **sellion.** Exert only enough pressure to attain contact between the caliper and the skin.

CAUTION: Be sure that the subject's teeth are together (lightly occluded) during the measurement.



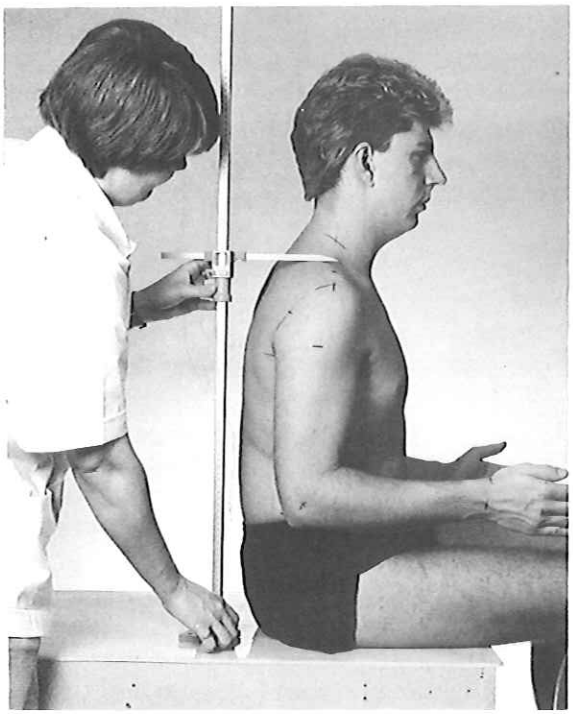


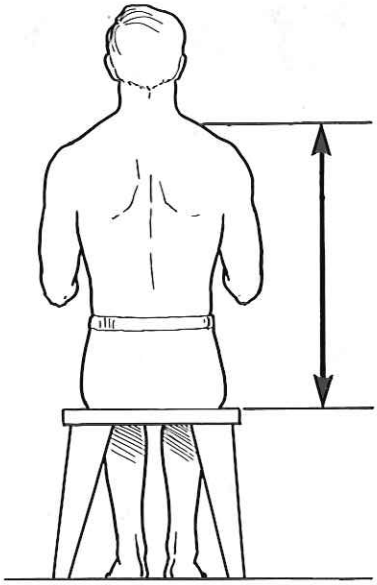
MIDSHOULDER HEIGHT, SITTING

ORIGIN-TERMINATION: Sitting surface -- **midshoulder.**

PROCEDURE: Subject is in the anthropometric sitting position. Stand behind the subject and use an anthropometer to measure the vertical distance between the sitting surface and the drawn **midshoulder landmark** at the middle of the top of the right shoulder. The measurement is taken at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.

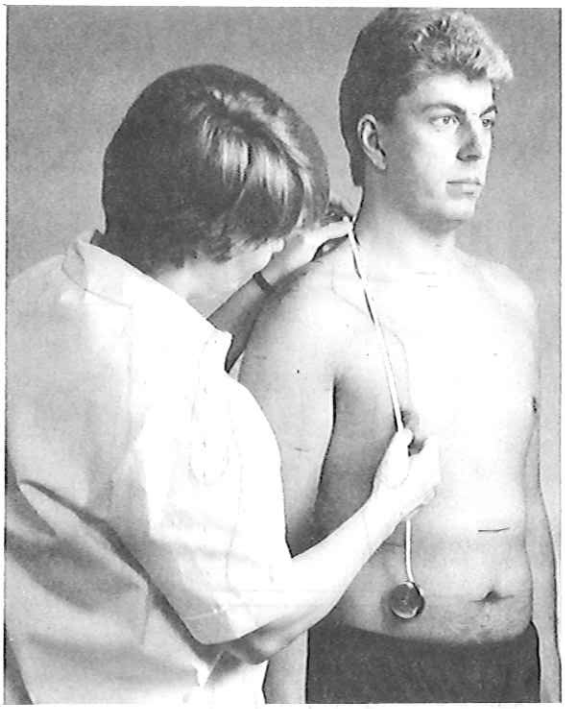


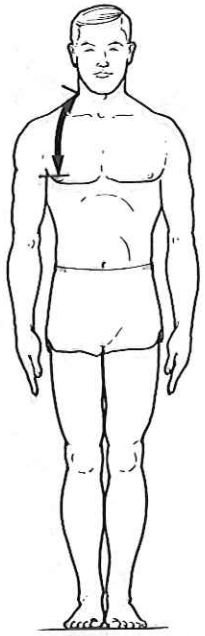


NECK-BUSTPOINT/THELION LENGTH

ORIGIN-TERMINATION: **Trapezius point, right -- bustpoint/thelion, right.**

PROCEDURE: Subject is in the anthropometric standing position. Stand at the right of the subject and use a tape to measure the distance between the drawn **trapezius point** at the right side of the neck and the right bustpoint on women and nipple on men (**bustpoint/thelion**). The **bustpoint/thelion landmark** is drawn on the bra for women; it is not drawn on male subjects. The tape may span body hollows in this measurement. Place the zero point of the tape on the **trapezius point.** Exert only enough pressure to prevent slack on the tape. The measurement is taken at the maximum point of quiet respiration.



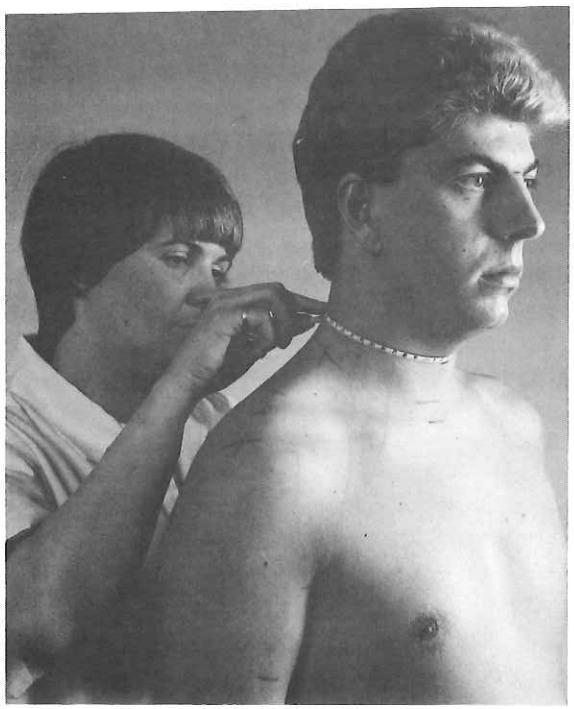


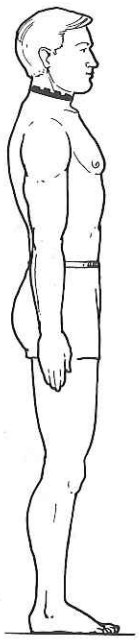
NECK CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Infrathyroid.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand at the right of the subject and use a tape to measure the circumference of the neck at the level of the drawn **infrathyroid landmark** (Adam's apple). The plane of the measurement is perpendicular to the long axis of the neck. Exert only enough tension on the tape to maintain contact between the tape and the skin.

CAUTION: Be sure that the subject's head is in the Frankfort plane.



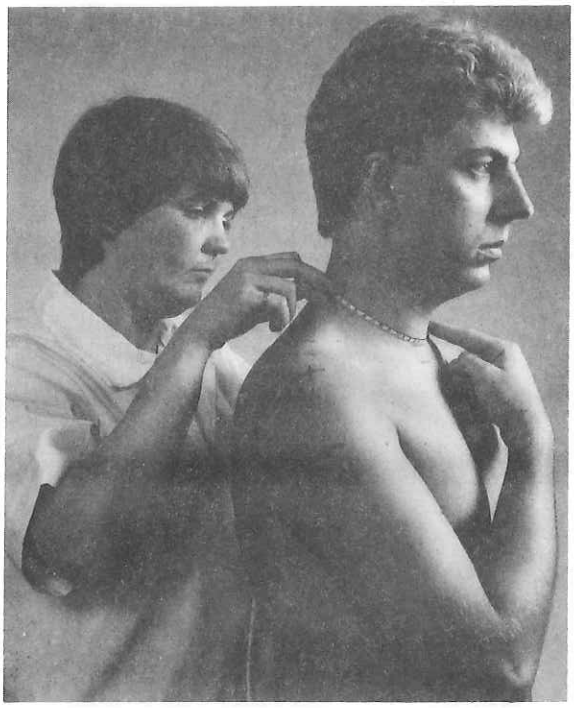


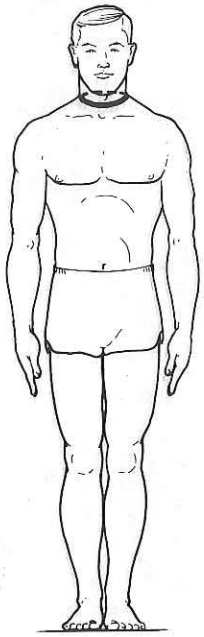
NECK CIRCUMFERENCE, BASE

LANDMARK(S) ENCOMPASSED: **Lateral neck, right; lateral neck, left; anterior neck.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand behind the subject and use a tape to measure the circumference of the base of the neck. The tape passes over the drawn **lateral** and **anterior neck landmarks.** Exert only enough tension on the tape to maintain contact between the tape and the skin. The subject will hold the tape on the **anterior neck landmark.**

CAUTION: Be sure that the subject's head is in the Frankfort plane.



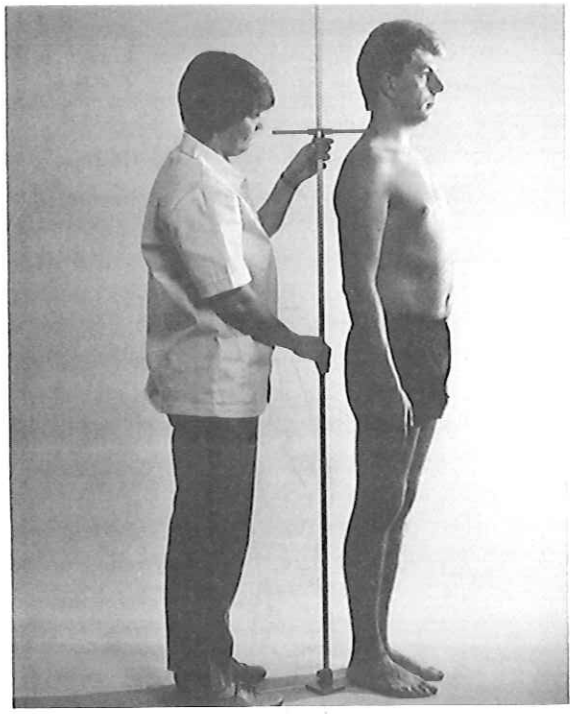


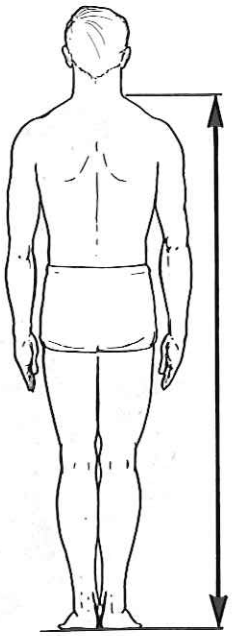
NECK HEIGHT, LATERAL

ORIGIN-TERMINATION: Standing surface -- **trapezius point, right.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand behind the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **trapezius point** on the right side of the neck. The measurement is made at the maximum point of quiet respiration.

CAUTION: Be sure the head is in the Frankfort plane.



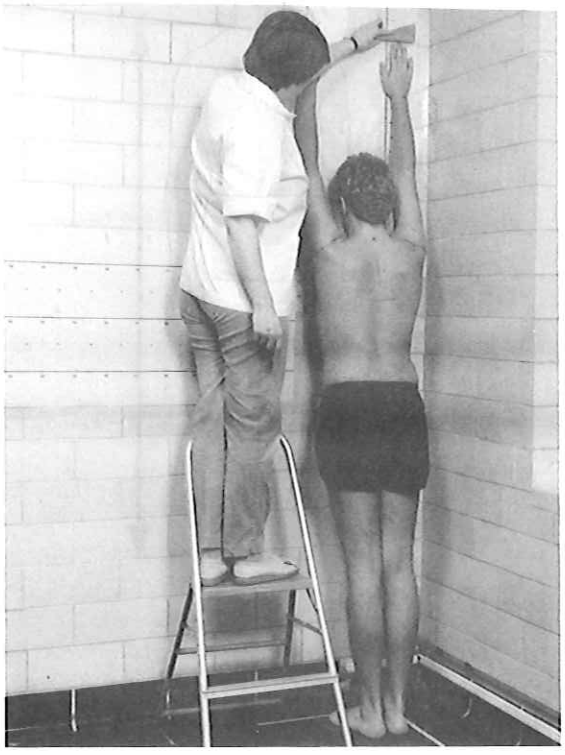


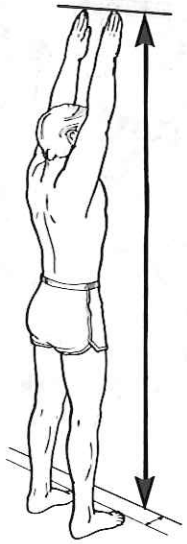
OVERHEAD FINGERTIP REACH

ORIGIN-TERMINATION: Standing surface -- **dactylion III, right.**

PROCEDURE: Subject stands facing a wall-mounted scale with both arms extended overhead parallel to each other. The palms of the hands rest on a wall-mounted scale. The toes are on an established line (20 cm from the wall), and the feet are about 10 cm apart. Stand at the side of the subject and use a block to establish, on the wall scale, the vertical distance between the standing surface and the tip of the right middle finger (**dactylion III**). The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure the subject's arms are fully extended and that the head and chest of the subject do not touch the wall.



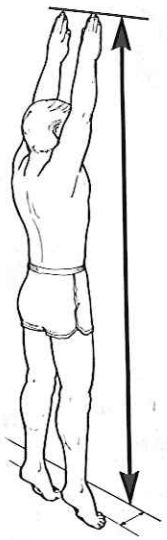


OVERHEAD FINGERTIP REACH, EXTENDED

ORIGIN-TERMINATION: Standing surface -- **dactylion III, right.**

PROCEDURE: Subject faces a wall-mounted scale while standing on the tips of the toes on an established line 20 cm from the wall. The feet are about 10 cm apart. The arms are extended overhead parallel to each other, stretched as high as possible, with the palms of the hands resting on a wall-mounted scale. Stand at the side of the subject and use a block to establish, on the wall scale, the vertical distance between the standing surface and the tip of the right middle finger (**dactylion III**). The measurement is made at the maximum point of quiet respiration.

CAUTION: Urge the subject to reach as high overhead as possible. Be sure that the head and chest of the subject do not touch the wall.

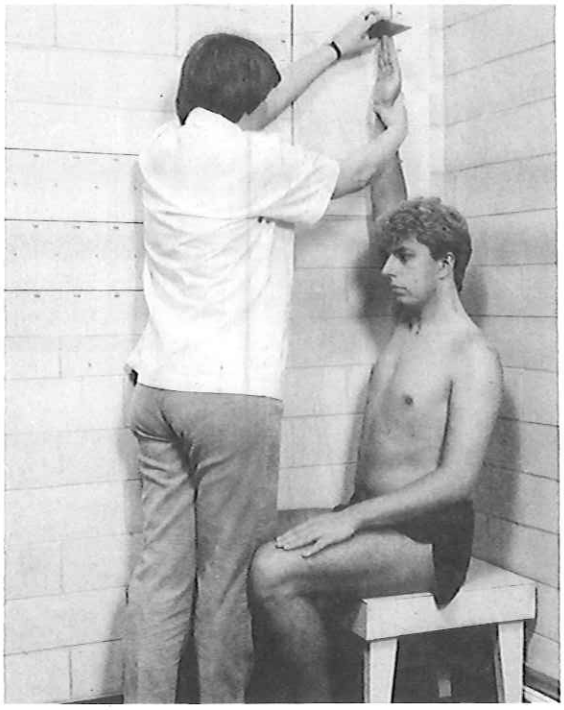


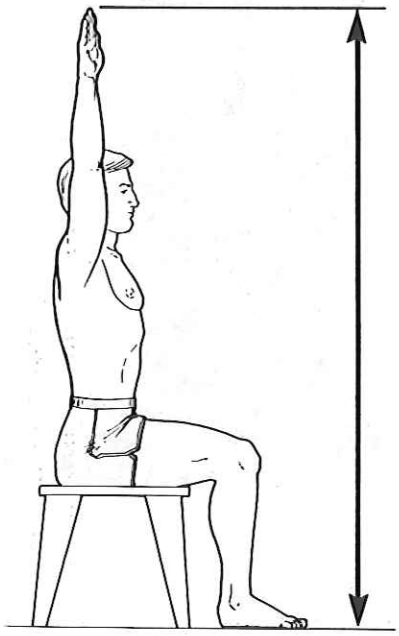
OVERHEAD FINGERTIP REACH, SITTING

ORIGIN-TERMINATION: Floor -- **dactylion III, right.**

PROCEDURE: Subject sits erect on a flat surface with the right arm and hand extended vertically overhead as far as possible, and the palm of the hand facing forward. The back does not touch the wall. Grasp the subject's wrist to guide the arm into a vertical position. Some subjects will not be able to fully extend the arm into this position without discomfort. In these cases, do not force the arm any higher than it can comfortably go without changing the position of the torso. The sitting surface and the subject are arranged so that the wall-mounted scale is at the subject's right side. Stand at the left of the subject and use a block to establish, on the wall-mounted scale, the vertical distance between the floor and the tip of the middle finger (**dactylion III**). The computer will subtract the height of the seat from this measurement. The measurement is made at the maximum point of quiet respiration.

CAUTION: Do not permit the subject to hyperextend the wrist. Women, in particular, will tend to do this.



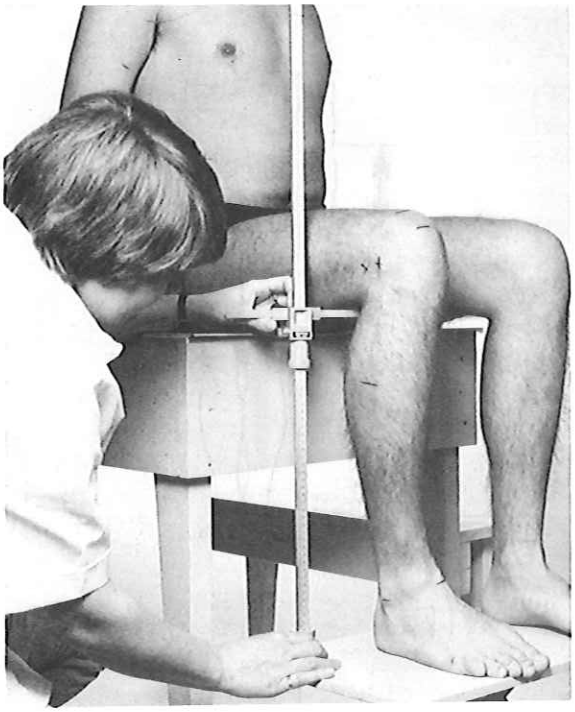


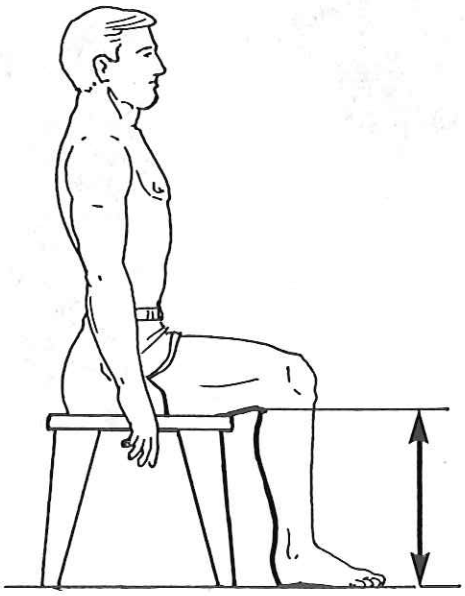
POPLITEAL HEIGHT

ORIGIN-TERMINATION: Footrest surface -- **dorsal juncture of the calf and thigh.**

PROCEDURE: Subject sits with the thighs parallel, the knees flexed 90 degrees. The feet are in line with the thighs, and the arms are relaxed at the sides. Stand to the right of the subject and use an anthropometer to measure the distance between the footrest surface and the bottom surface of the thigh just behind the knee (**dorsal juncture of the calf and thigh**).

CAUTION: Take care that the blade of the anthropometer does not compress the tissue. Be sure the knees are in the proper position. The computer will add 1 cm to this measurement to account for the width of the anthropometer blade.

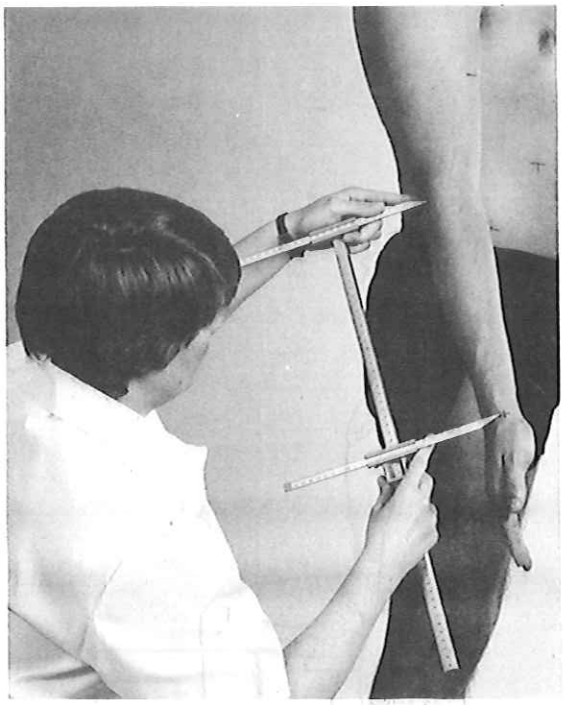


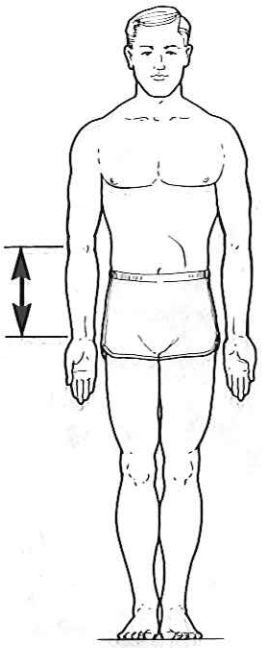


RADIALE-STYLION LENGTH

ORIGIN-TERMINATION: **Radiale -- stylion.**

PROCEDURE: Subject stands with the arms relaxed at the sides and the right palm facing forward. Stand at the right of the subject and use a beam caliper to measure the distance between the drawn **radiale landmark** on the elbow and the drawn **stylion landmark** on the wrist. Be sure that the beam of the caliper is parallel to the long axis of the arm. Place the fixed blade on **radiale.** Exert only enough pressure to attain contact between the caliper and the skin.



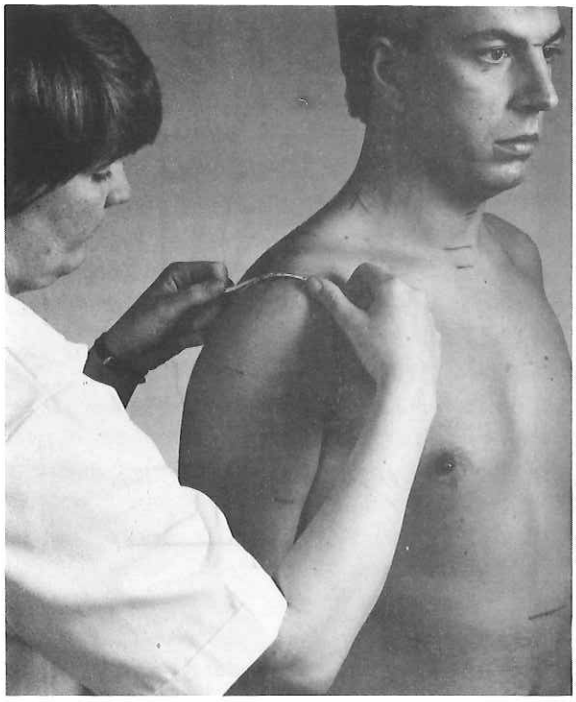


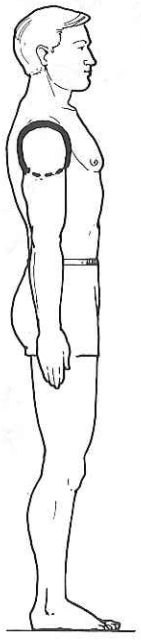
SCYE CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Acromion, right.**

PROCEDURE: Subject stands erect looking straight ahead with the right fist on the side of the hip for placement of a tape. Stand at the right of the subject. Pass the tape through the armpit (axilla) and bring both ends of the tape up vertically and parallel with each other while the subject's hand is on the hip. Exert sufficient tension on both ends of the tape to ensure that it is well into the axilla. The subject now drops the arm to hang relaxed at the side, and the measurement is taken with the tape passing over the drawn **acromion landmark.** Exert only enough tension on the tape to maintain contact between the tape and the skin.

CAUTION: Care should be taken to minimize, as far as possible, the inevitable compression of soft tissue in the axilla.



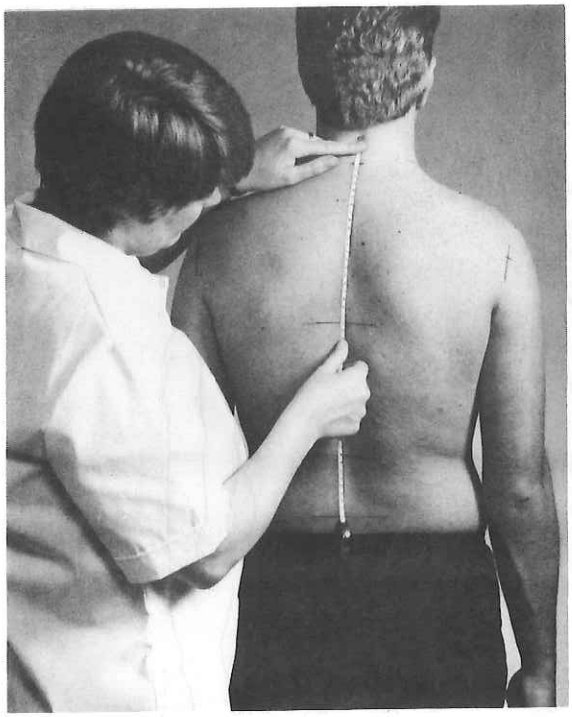


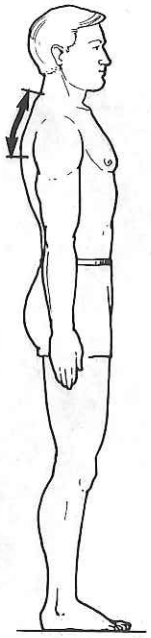
SCYE DEPTH

ORIGIN-TERMINATION: **Cervicale -- scye at midspine.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand behind the subject and use a tape to measure the vertical surface distance along the spine between the drawn **cervicale landmark** and the drawn **scye level at midspine landmark.** Place the zero point of the tape on **cervicale.**

CAUTION: Be sure that the head is in the Frankfort plane.

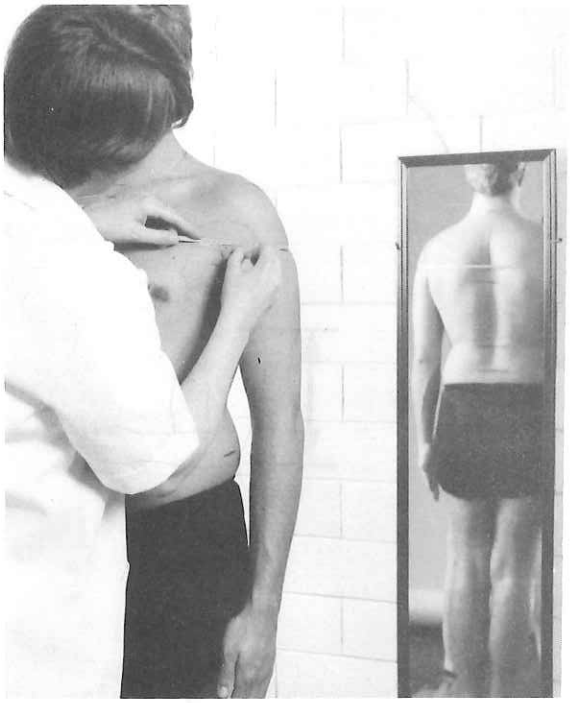


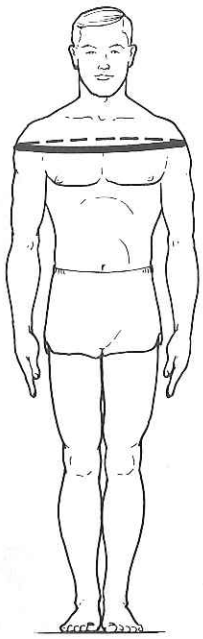


SHOULDER CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Deltoid point, right; deltoid point, left.**

PROCEDURE: Subject is in the anthropometric standing position in front of a mirror. Stand in front of the subject and use a tape to measure the horizontal circumference of the shoulders at the level of the maximum protrusion of the right deltoid muscle. Use the mirror to check the position of the tape as it crosses the subject's back. The tape will pass over the drawn **right** and **left deltoid point landmarks.** Exert only enough tension on the tape to maintain contact between the tape and the skin. The measurement is taken at the maximum point of quiet respiration.



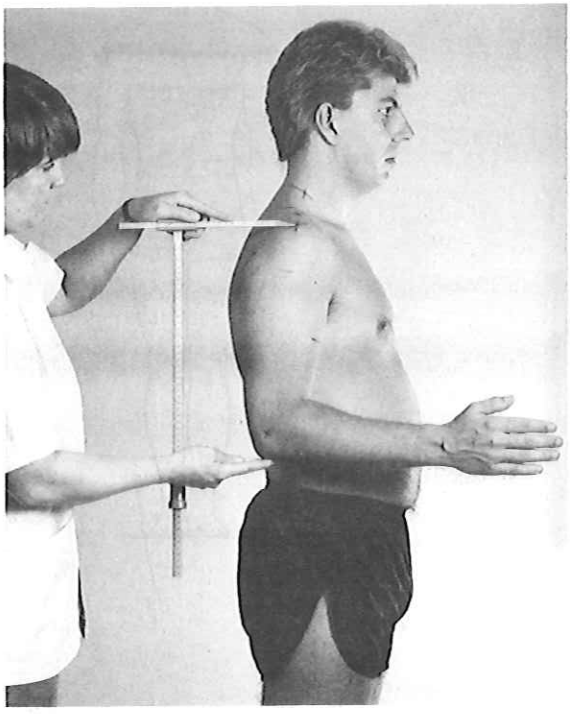


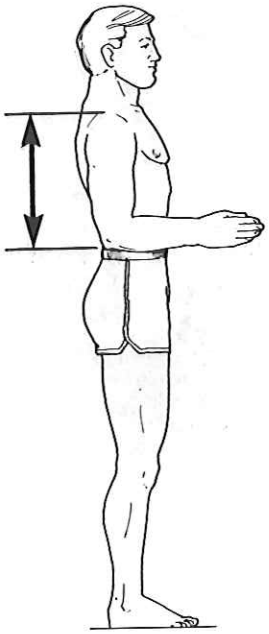
SHOULDER-ELBOW LENGTH

ORIGIN-TERMINATION: **Acromion, right -- olecranon, bottom.**

PROCEDURE: Subject stands erect with the upper arm hanging at the side and the elbow flexed 90 degrees. The hand is straight and the palm faces inward (medially). Stand at the right of the subject and use a beam caliper to measure the distance between the drawn **acromion landmark** on the tip of the shoulder and the bottom of the elbow (**olecranon, bottom**). The measurement is made parallel to the long axis of the upper arm. Place the fixed blade of the caliper on **acromion.** Exert only enough pressure to attain contact between the caliper and the skin.

CAUTION: Be sure that the zero edge of the blade of the caliper is on **acromion** when the measurement is made and that the skin is not distorted.



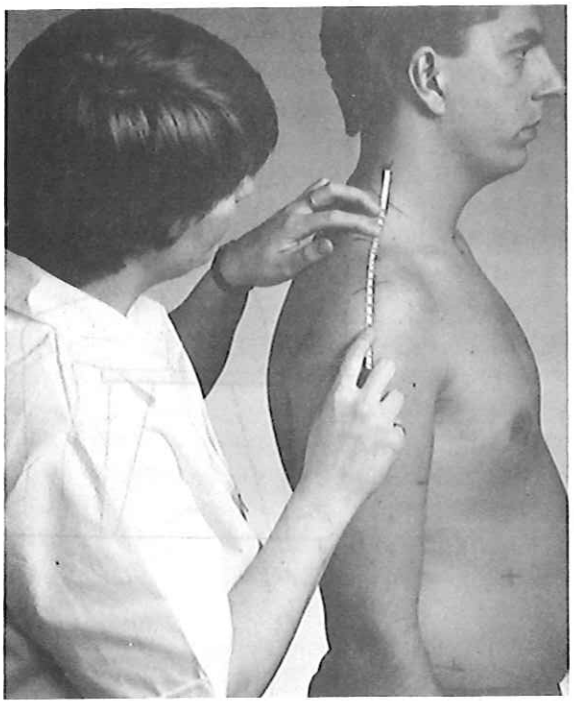


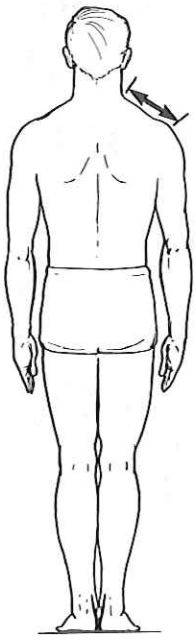
SHOULDER LENGTH

ORIGIN-TERMINATION: **Trapezius point, right -- acromion, right.**

PROCEDURE: Subject is in the anthropometric standing position. Stand at the right of the subject and use a tape to measure the surface distance between the drawn **trapezius point landmark** at the base of the neck and the drawn **acromion landmark** on the outer border of the shoulder. The zero end of the tape is on the **trapezius point**, and the front (anterior) edge of the tape passes over the drawn **clavicle point landmark.**

CAUTION: The subject must not be allowed to change the position of the shoulders.



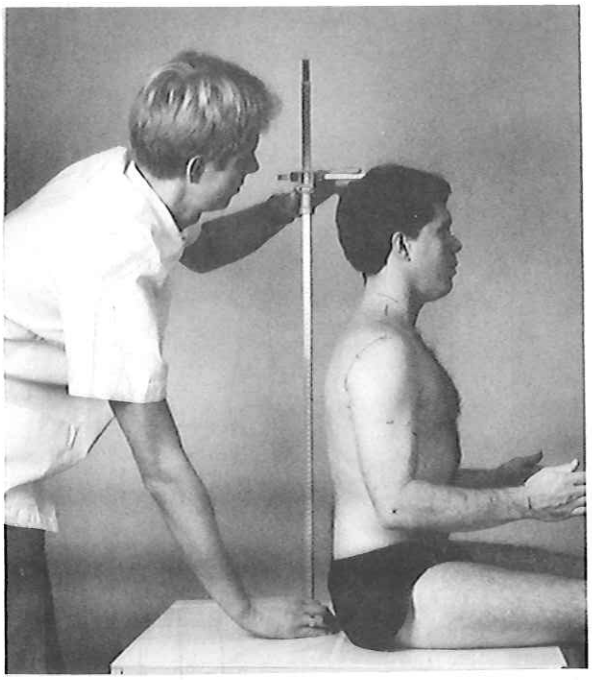


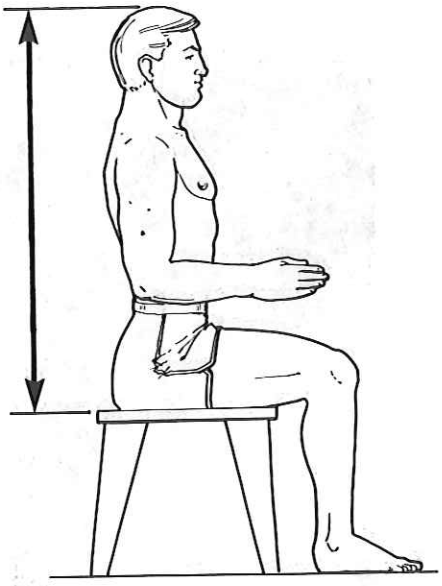
SITTING HEIGHT

ORIGIN-TERMINATION: Sitting surface -- **top of head.**

PROCEDURE: Subject is in the anthropometric sitting position with the head in the Frankfort plane. Stand at the right rear of the subject and use an anthropometer to measure the vertical distance between the sitting surface and the **top of the head.** Use sufficient pressure to compress the hair. The measurement is made at the maximum point of quiet respiration.

CAUTION: Be sure the head is in the Frankfort plane.



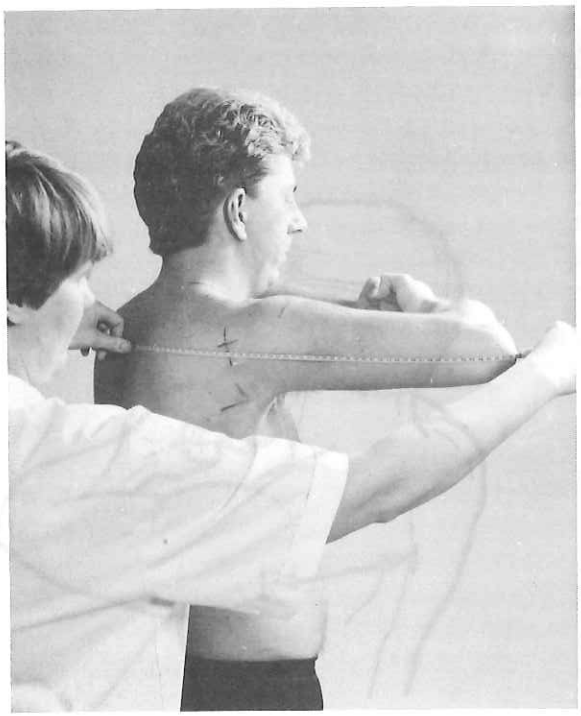


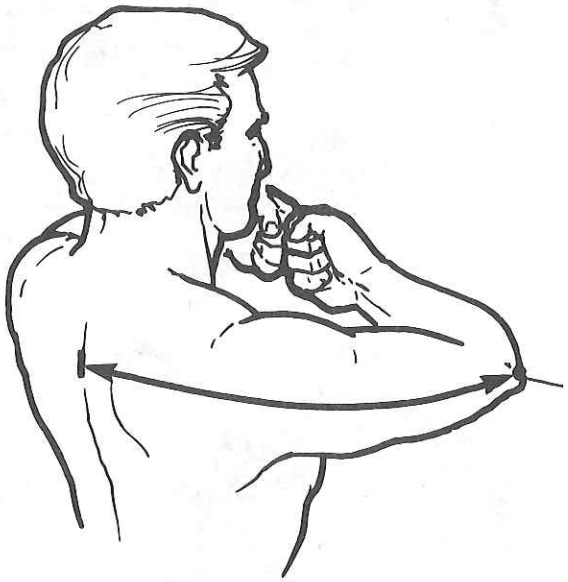
SLEEVE LENGTH: SPINE-ELBOW

ORIGIN-TERMINATION: **Midspine -- olecranon, center.**

PROCEDURE: Subject makes fists and brings them together in such a way that the metacarpophalangeal and proximal interphalangeal knuckles are touching. With the dorsal surfaces of the joined hands facing outward and the palmar sides facing inwards, the subject raises the arms until they are in a horizontal position parallel to the standing surface. The forearms and fists are in a straight line. Stand at the right of the subject and use a tape to measure the horizontal surface distance between the midpoint of the spine (drawn **midspine landmark**) and the bony tip of the elbow (drawn **olecranon, center landmark**). Place the zero point of the tape on the **midspine landmark**, and be sure the tape lies on the surface of the skin for the measurement.

CAUTION: The subject must not be allowed to change the position of the shoulders and arms. Be sure that the zero point of the tape is on the **midspine landmark** when the measurement is made.



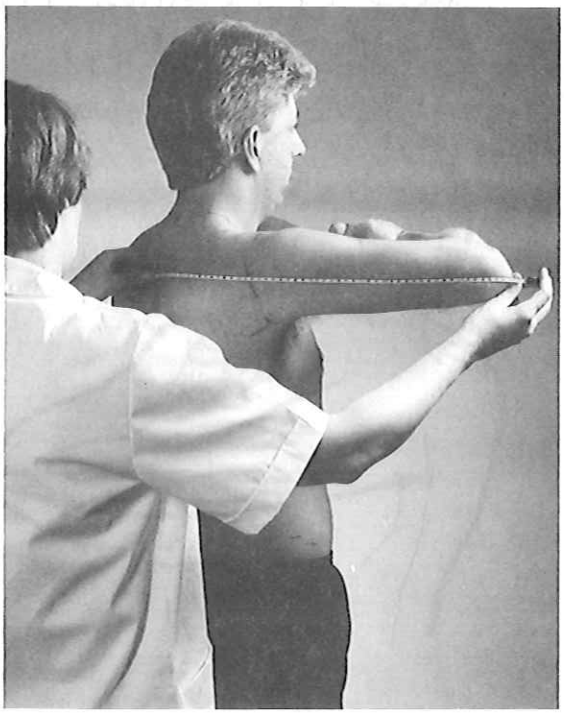


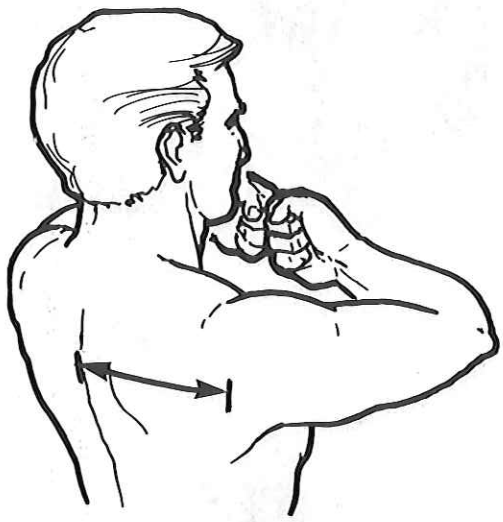
SLEEVE LENGTH: SPINE-SCYE

ORIGIN-TERMINATION: **Midspine -- posterior diagonal scye, right.**

PROCEDURE: Subject makes fists and brings them together in such a way that the metacarpophalangeal and proximal interphalangeal knuckles are touching. With the dorsal surfaces of the joined hands facing outward and the palmar sides facing inwards, the subject raises the arms until they are in a horizontal position parallel to the standing surface. The forearms and fists are in a straight line. Stand behind the subject and use a tape to measure the horizontal surface distance between the midpoint of the spine (drawn **midspine landmark**) and the drawn **right posterior diagonal scye landmark.** Place the zero point of the tape on the **midspine landmark**, and be sure the tape lies on the surface of the skin for the measurement.

CAUTION: The subject must not be allowed to change the position of the shoulders and arms. Be sure the zero point of the tape is on the **midspine landmark** when the measurement is made.



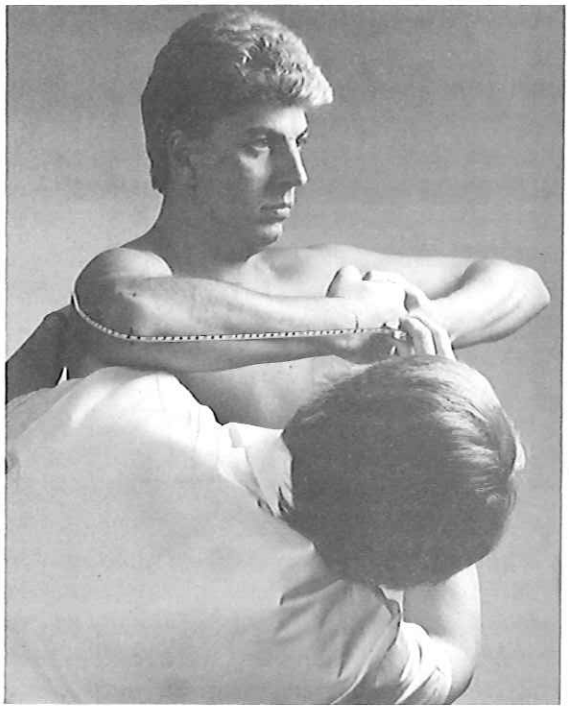


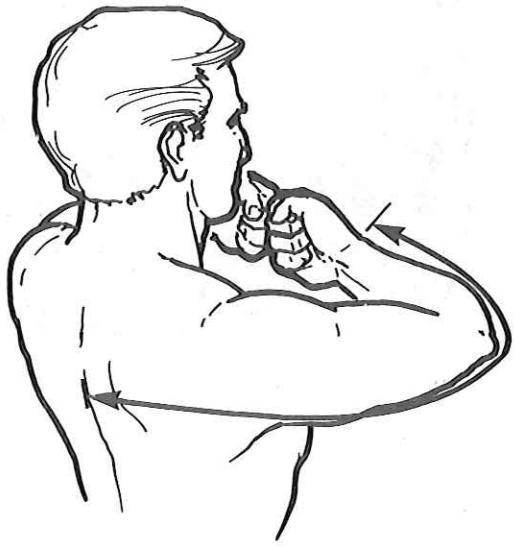
SLEEVE LENGTH: SPINE-WRIST

ORIGIN-TERMINATION: **Midspine -- wrist, dorsal.**

PROCEDURE: Subject makes fists and brings them together in such a way that the metacarpophalangeal and proximal interphalangeal knuckles are touching. With the dorsal surfaces of the joined hands facing outward and the palmar sides facing inwards, the subject raises the arms until they are in a horizontal position parallel to the standing surface. The forearms and fists are in a straight line. Stand at the right of the subject and use a tape to measure the horizontal surface distance between the midpoint of the spine (drawn **midspine landmark**) and the drawn **dorsal wrist landmark.** The tape passes over the drawn **olecranon, center landmark** at the tip of the elbow. Place the zero point of the tape on the **midspine landmark** and be sure the tape lies on the surface of the skin for the measurement.

CAUTION: The subject must not be allowed to change the position of the shoulders and arms. Be sure the zero point of the tape is on the **midspine landmark** when the measurement is made.



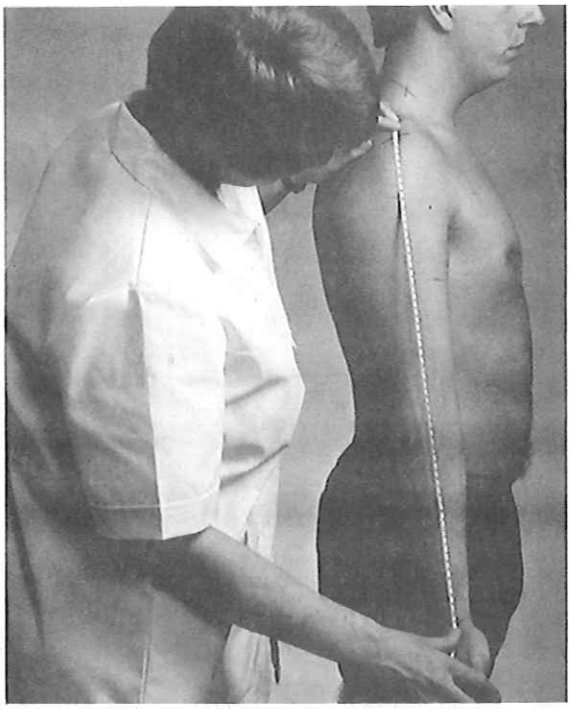


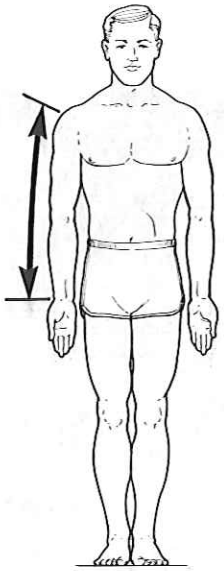
SLEEVE OUTSEAM

ORIGIN-TERMINATION: **Acromion, right -- stylion.**

PROCEDURE: Subject stands erect with both arms straight and the palms facing forward. The elbows lightly touch the sides of the body. Stand at the right of the subject and use a tape to measure the straight-line distance between the drawn **acromion landmark** and the drawn **stylion landmark.** The tape will span body hollows. Be sure the zero point of the tape is on the **acromion landmark.**

CAUTION: Take care not to distort the skin at the shoulder.



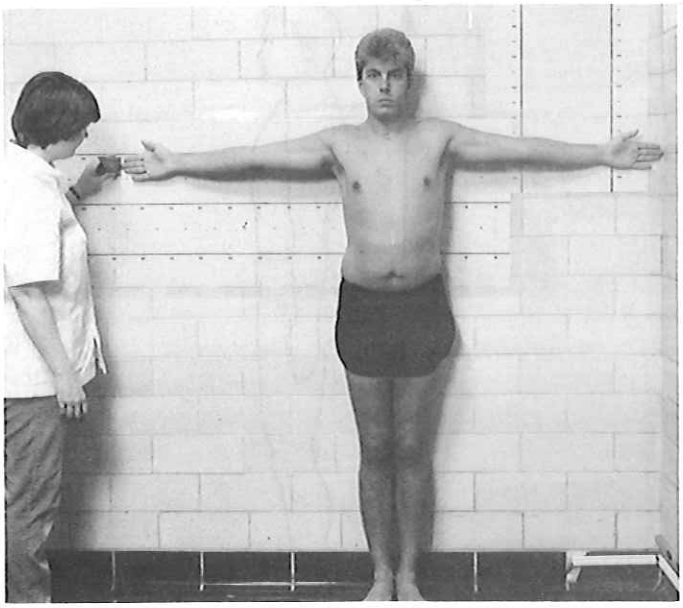


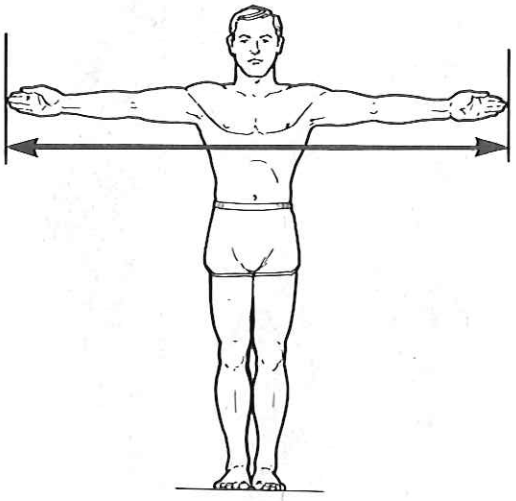
SPAN

ORIGIN-TERMINATION: **Dactylion III, right -- dactylion III, left.**

PROCEDURE: Subject stands erect with the back against a wall-mounted scale and the feet together. Both arms and hands are stretched horizontally against the back wall with the tip of the third finger of one hand just touching a side wall. Stand near the hand of the subject opposite the side wall. Use a block to establish, on the wall-mounted scale, the distance between the side wall and the tip of the middle finger (**dactylion III**). The subject's middle fingers are in light contact with the side wall on one side and the block on the other. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Urge the subject to stretch the arms laterally as much as possible. Check that the arms remain in the required position.



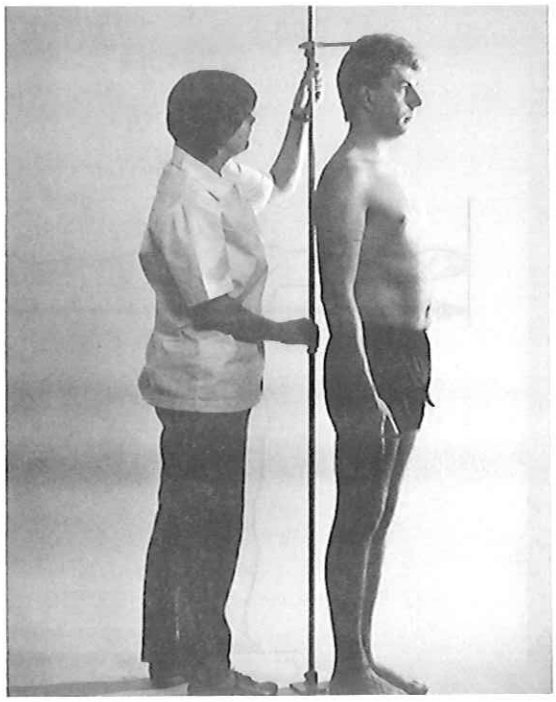


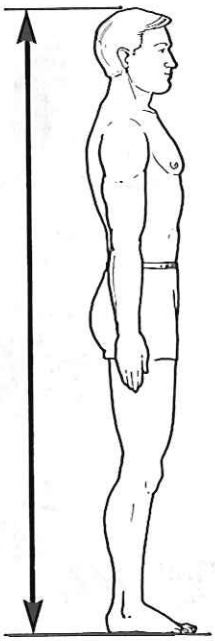
STATURE

ORIGIN-TERMINATION: Standing surface -- **top of head.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand at one side of the subject and use an anthropometer to measure the vertical distance between the standing surface and the **top of the head.** Move the blade of the anthropometer across the top of the head to ensure measurement of the maximum distance. Use firm pressure to compress the subject's hair. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure that the head is in the Frankfort plane.



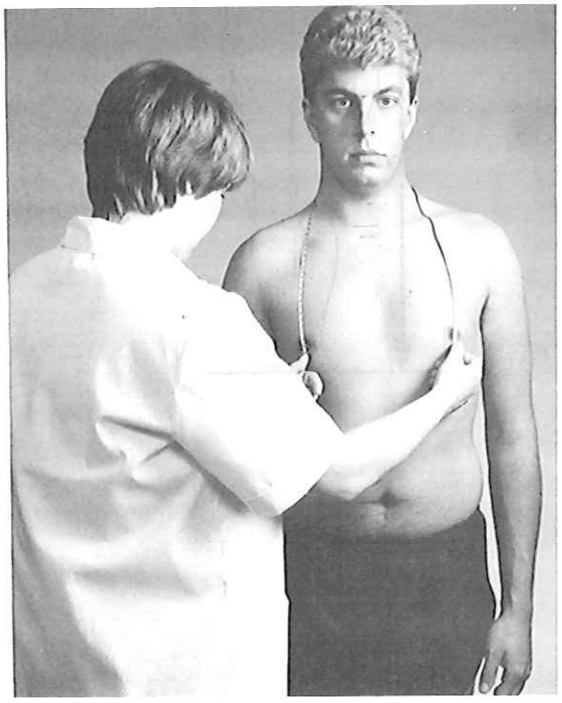


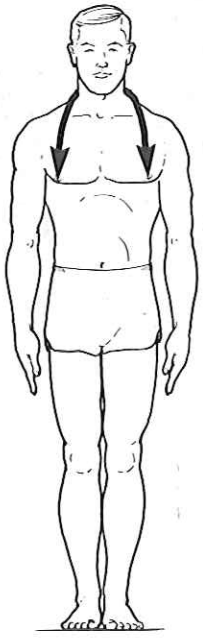
STRAP LENGTH

DESCRIPTION: The distance from **bustpoint/thelion, right**, across the back of the neck, to **bustpoint/thelion, left.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand in front of the subject and use a tape to measure the surface distance from the right bustpoint of women or nipple for men (**bustpoint/thelion**) over the back of the neck to the left bustpoint or nipple. The **bustpoint/thelion landmarks** are drawn on the bra for women; they are not drawn on male subjects. The tape should pass over the **right** and **left lateral neck landmarks.** Exert only enough tension to maintain contact between the tape and the skin (or bra). The tape will span body hollows. The measurement is made at the maximum point of quiet respiration.

CAUTION: Be sure that the zero point of the tape is on the **right bustpoint/thelion landmark** when the measurement is made. Be sure that the subject's head is in the Frankfort plane.

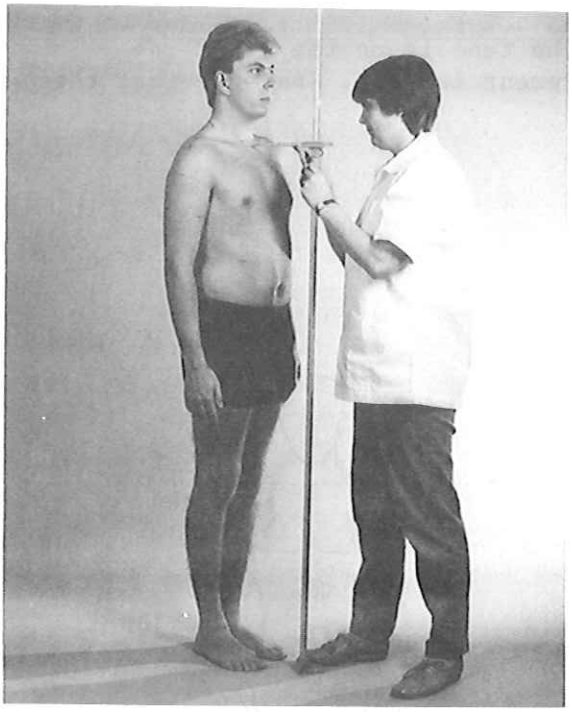


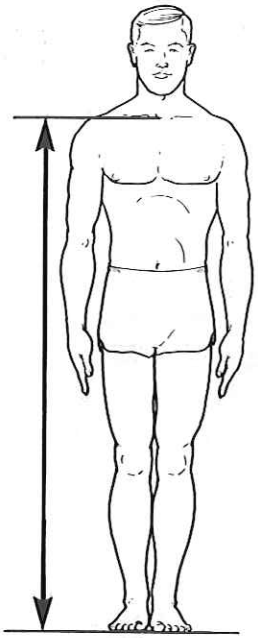


SUPRASTERNALE HEIGHT

ORIGIN-TERMINATION: Standing surface -- **suprasternale.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **suprasternale landmark** at the lowest point of the notch at the top of the breastbone. The measurement is made at the maximum point of quiet respiration.

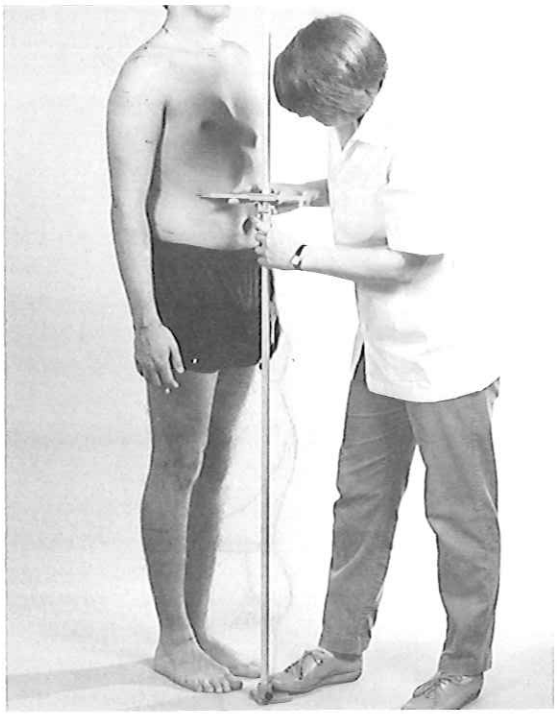


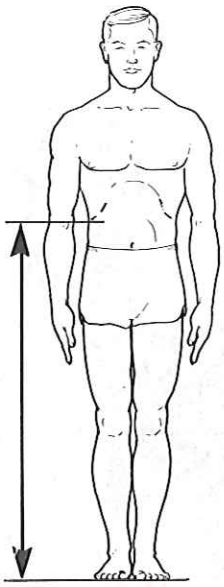


TENTH RIB HEIGHT

ORIGIN-TERMINATION: Standing surface -- **tenth rib.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **tenth rib landmark** at the bottom of the rib cage. The measurement is made at the maximum point of quiet respiration.



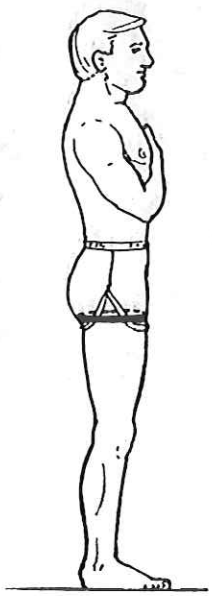


THIGH CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Gluteal furrow point.**

PROCEDURE: Subject stands erect on a table with the weight distributed equally on both feet. The legs are spread apart just enough so that the thighs do not touch, and the right hand is on the chest. Stand at the right of the subject and use a tape to measure the circumference of the thigh at its juncture with the buttock (drawn **gluteal furrow point**). The measurement is made perpendicular to the long axis of the thigh. Exert only enough tension on the tape to maintain contact between the tape and the skin.

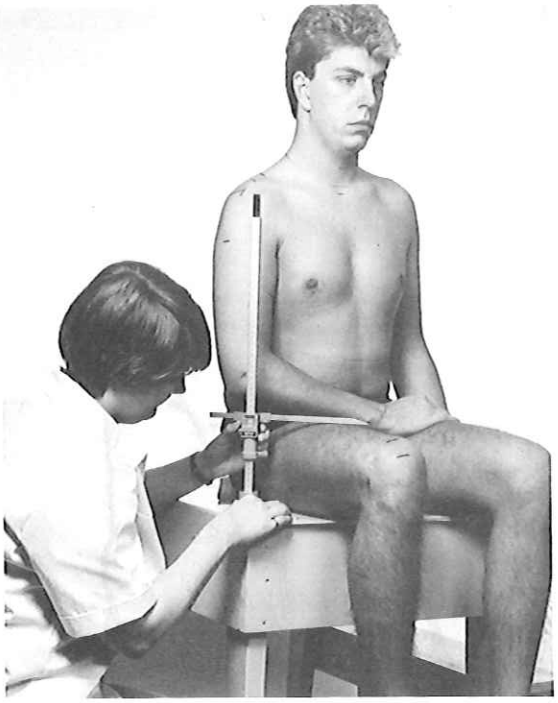
CAUTION: The subject must not tense the thigh muscles. The tape must not be placed in a furrow.

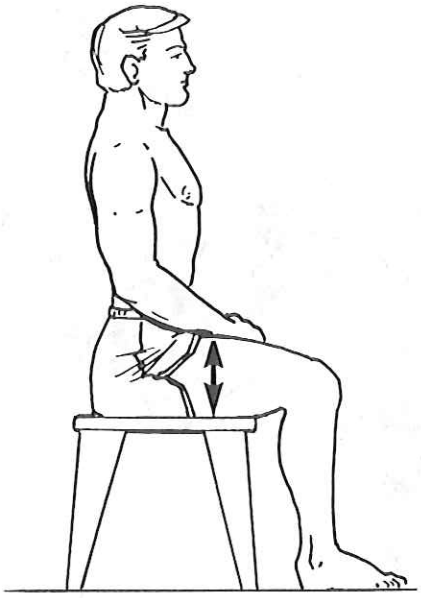


THIGH CLEARANCE

ORIGIN-TERMINATION: Sitting surface -- **thigh point, top.**

PROCEDURE: Subject sits with the thighs parallel, knees flexed 90 degrees and the feet in line with the thighs. The arms are relaxed on the lap. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the sitting surface and the highest point on the top of the thigh (**thigh point, top**). Brush the blade of the anthropometer back and forth across the top of the thigh to locate its highest point.

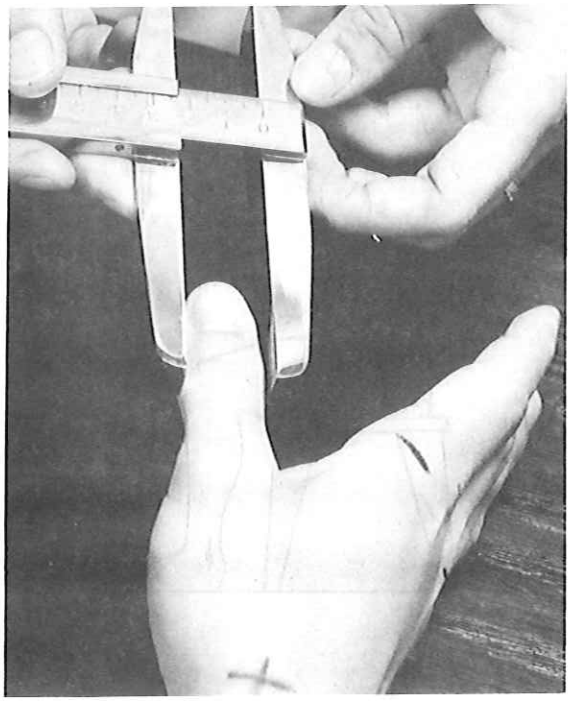


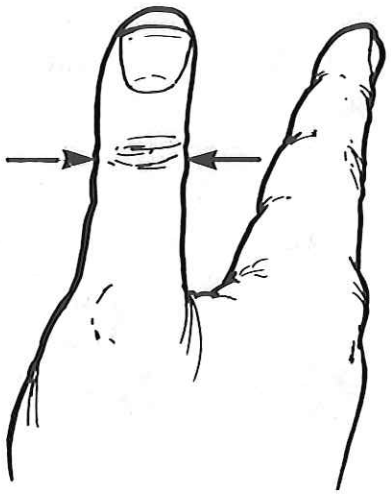


THUMB BREADTH

DESCRIPTION: The maximum breadth of the thumb.

PROCEDURE: Subject sits with the right elbow on a table, and the forearm and hand held vertically. The thumb is straight and held away from the hand at about a 45-degree angle. Stand in front of the subject and use a Holtain caliper to measure the maximum breadth of the thumb perpendicular to its long axis. Exert only enough pressure to attain contact between the caliper and the skin.



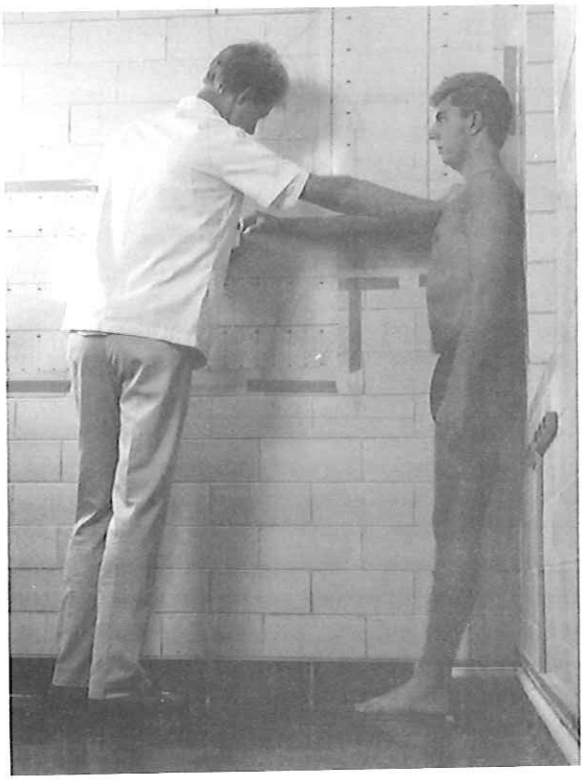


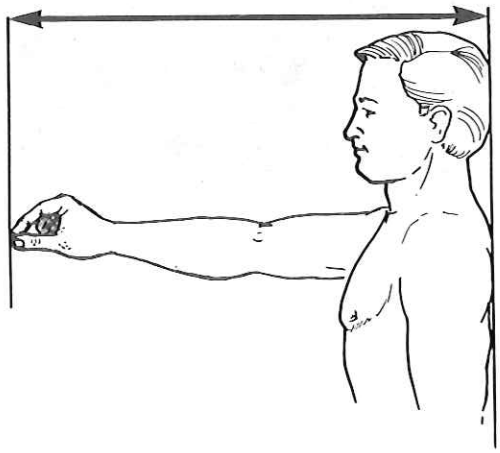
THUMBTIP REACH

ORIGIN-TERMINATION: Wall -- **thumbtip.**

PROCEDURE: Subject stands erect in a corner looking straight ahead with the feet together and the heels on a marked line 20 cm from the wall. The buttocks and shoulders are against a back wall. The right arm and hand are stretched forward horizontally against the side wall, palm down. The thumb continues the horizontal line of the arm and the index finger curves around to touch the pad at the end of the thumb. Stand in front of the subject and hold the subject's right shoulder against the rear wall. Place a block at the **thumbtip** to establish, on the wall scale, the horizontal distance between the back wall and the tip of the thumb. The measurement is taken three times, repositioning the arm each time.*

* The computer selects the final value by calculating the smallest two and the largest two values and comparing the differences to the allowable observer error (see Appendix F, Table F-1). It then exercises one of three options: (1) If both differences are smaller than or equal to the allowable error, the middle value is retained. (2) If only the smallest or only the largest value is distant from the middle value by more than the allowable error, the mean of the other two values is used. (3) If both differences are greater than the allowable error, all three measurements are made again.

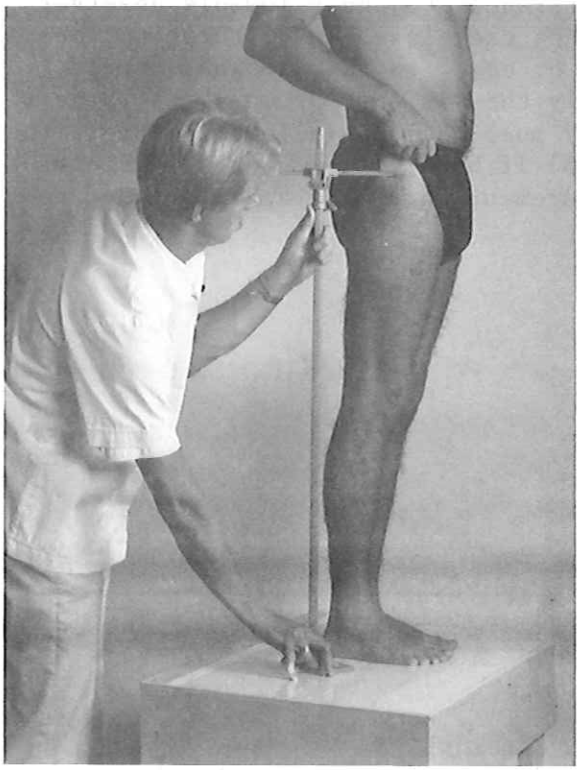


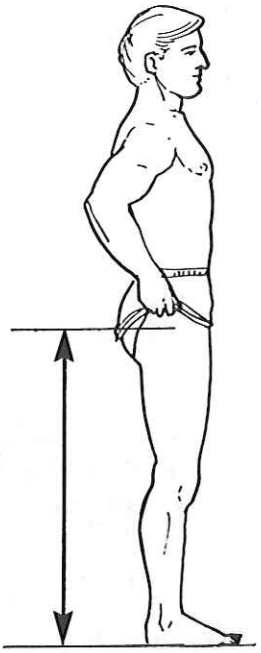


TROCHANTERIC HEIGHT

ORIGIN-TERMINATION: Standing surface -- **trochanterion.**

PROCEDURE: Subject stands on a table in the anthropometric standing position. Ask the subject to hold up the right leg of the shorts to expose the landmark. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **trochanterion landmark.**





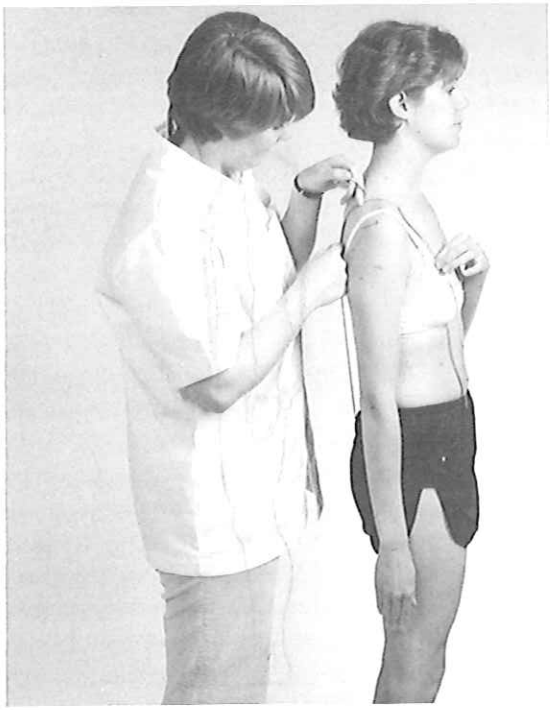
VERTICAL TRUNK CIRCUMFERENCE (ASCC)*

DESCRIPTION: The vertical circumference of the trunk on a line passing between the buttocks and through the **crotch**, and over the **bustpoint/thelion, right**, and **midshoulder landmarks.**

PROCEDURE: Subject stands in the anthropometric standing position with the feet about 10 cm apart to allow the placement of a tape in the crotch, and then brings the heels together. Stand at the right of the subject. (On men, the tape passes to the right of the scrotum.) One side of the tape is brought upward to pass across the **right bustpoint/thelion landmark** (drawn on women) and over the drawn **midshoulder landmark.** The other side of the tape passes between the buttocks up the back and to the **midshoulder landmark.** Hold the case of the tape on the upper chest to help keep the tape in place, and ask the subject to hold the tape over the **right upper breast** with the left hand. Apply sufficient tension on the tape to achieve firm pressure in the crotch without compressing the tissue at **midshoulder.** The tape will span body hollows. The measurement is taken at the "midpoint" of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders. This is the only dimension affected by respiration that is measured at the midpoint of quiet respiration.

* Aircrew Standardization Coordinating Committee



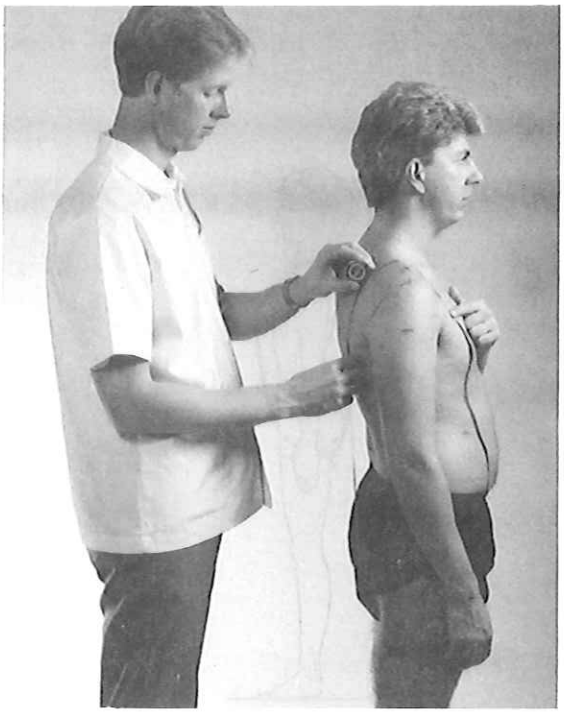
VERTICAL TRUNK CIRCUMFERENCE (USA)*

DESCRIPTION: The vertical circumference of the trunk on a line passing through the crotch and over the landmarks at **bustpoint/thelion, right, midshoulder,** and **buttock point, posterior.**

PROCEDURE: The subject stands in the anthropometric standing position with the feet about 10 cm apart to allow the placement of a tape in the crotch, and then brings the heels together. (On men, the tape passes to the right of the scrotum.) Stand at the right of the subject. The zero end of the tape is brought upward to pass across the **right bustpoint/thelion landmark** (drawn on women) and over the drawn **midshoulder landmark.** The other side of the tape is brought up the back and to the **midshoulder landmark** crossing the maximum protrusion of the right buttock. Hold the case of the tape on the upper chest to help keep the tape in place, and ask the subject to hold the tape over the **right upper breast** with the left hand. Exert only enough tension on the tape to maintain contact between the tape and the skin. The tape will span body hollows. The measurement is taken at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.

* U.S. Army

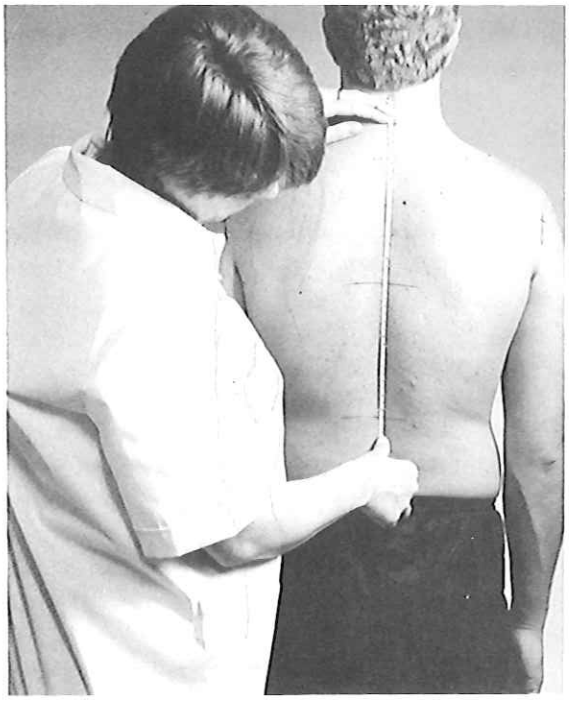


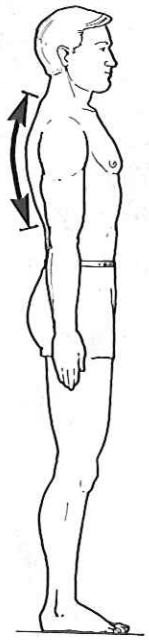
WAIST BACK LENGTH (NATURAL INDENTATION)

ORIGIN-TERMINATION: **Cervicale -- waist (natural indentation), posterior.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand behind the subject and use a tape to measure the vertical surface distance between the drawn landmarks at **cervicale** and **posterior waist (natural indentation).** The tape follows body contours. Place the zero point of the tape on **cervicale.** Exert only enough pressure to prevent slack in the tape. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure that the head is in the Frankfort plane and that the zero point of the tape is on the **cervicale landmark** when the measurement is made. The measurer may have to hold the tape against the subject's back to maintain skin contact.



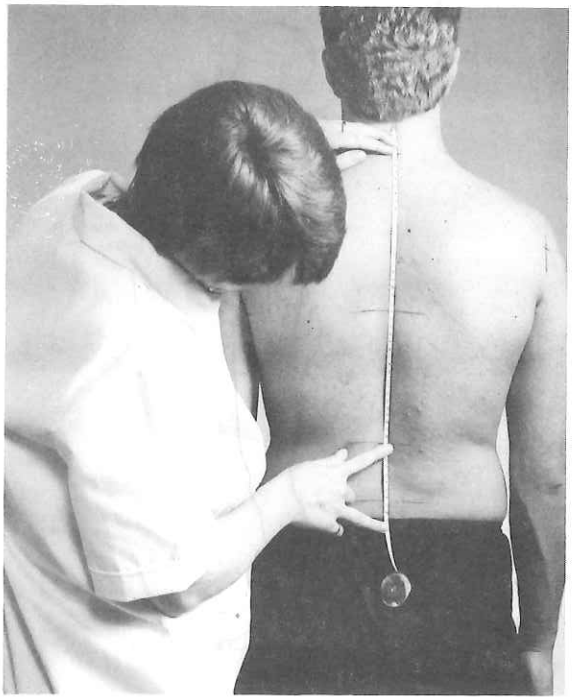


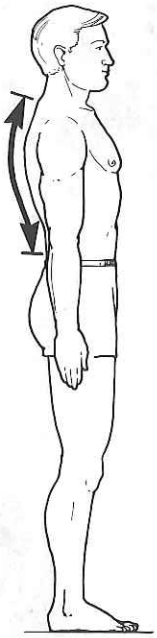
WAIST BACK LENGTH (OMPHALION)

ORIGIN-TERMINATION: **Cervicale -- waist (omphalion), posterior.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand behind the subject and use a tape to measure the vertical surface distance between the drawn landmarks at **cervicale** and **posterior waist (omphalion).** The tape follows body contours. Place the zero point of the tape on **cervicale.** Exert only enough pressure to prevent slack in the tape. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Be sure that the head is in the Frankfort plane and that the zero point of the tape is on the **cervicale landmark** when the measurement is made. The measurer will often have to hold the tape against the subject's back to maintain skin contact.



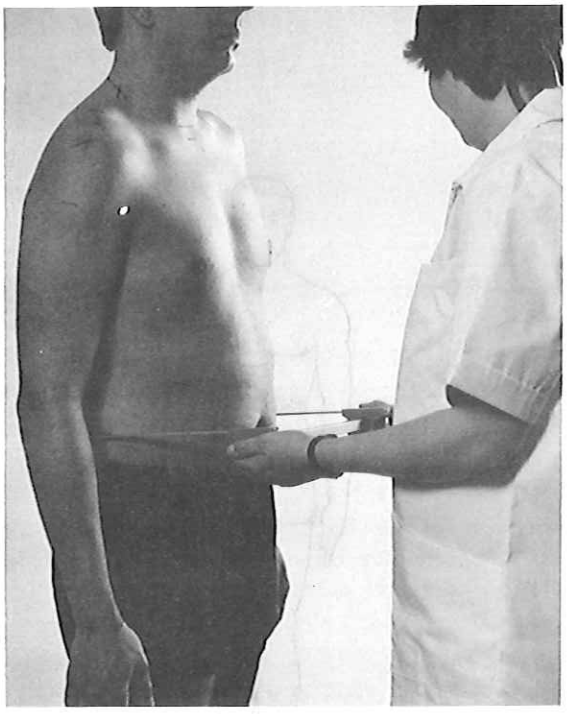


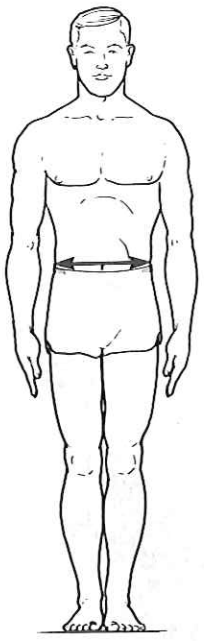
WAIST BREADTH

ORIGIN-TERMINATION: **Waist (omphalion), right -- waist (omphalion), left.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use a beam caliper to measure the horizontal breadth of the waist from the drawn landmark at **right waist (omphalion)** to the drawn landmark at **left waist (omphalion).** Exert only enough pressure to attain contact between the caliper and the skin. The measurement is taken at the maximum point of quiet respiration.

CAUTION: Care must be taken not to compress the soft tissue.



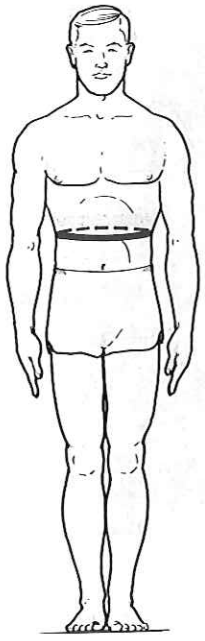


WAIST CIRCUMFERENCE (NATURAL INDENTATION)

LANDMARK(S) ENCOMPASSED: **Waist (natural indentation): right** and **left; posterior** and **anterior.**

PROCEDURE: Subject is in the anthropometric standing position in front of a mirror. Stand in front of the subject and use a tape to measure the horizontal circumference at the level of the drawn **waist (natural indentation) landmarks.** (Since all the waist landmarks are established at the level of the greatest indentation on the right side, the tape passes over both landmarks regardless of where the natural indentation on the left side may actually be.) Use the mirror to check the position of the tape as it crosses the subject's back. Exert only enough tension on the tape to maintain contact between the tape and the skin. The measurement is made at the maximum point of quiet respiration.

CAUTION: The subject must not tense the abdominal muscles.

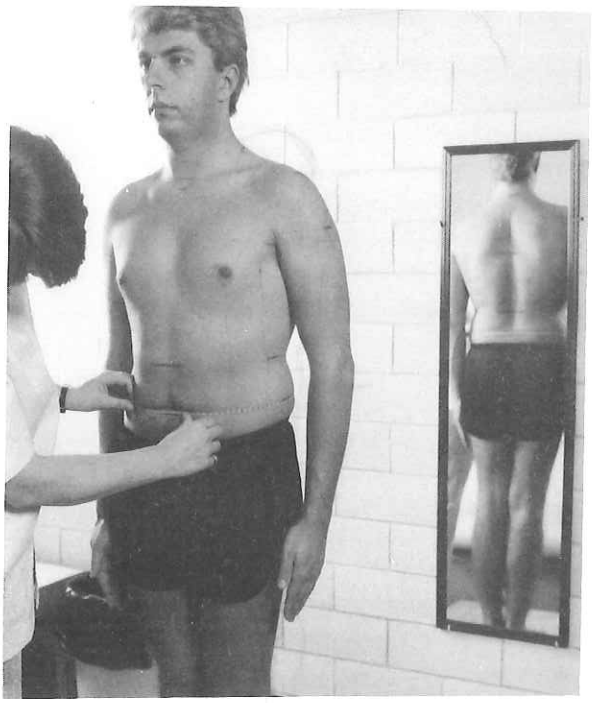


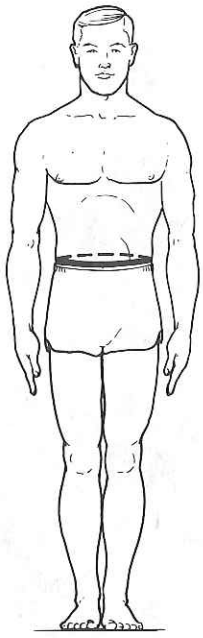
WAIST CIRCUMFERENCE (OMPHALION)

LANDMARK(S) ENCOMPASSED: **Waist (omphalion): right and left; posterior and anterior.**

PROCEDURE: Subject is in the anthropometric standing position in front of a mirror. Stand in front of the subject and use a tape to measure the horizontal distance around the torso at the level of the center of the navel. The tape will pass over the drawn **waist (omphalion) landmarks** at the front, back and sides. Use the mirror to check the position of the tape as it crosses the subject's back. Exert only enough tension on the tape to maintain contact between the tape and the body. The measurement is made at the maximum point of quiet respiration.

CAUTION: The subject must not tense the abdominal muscles.



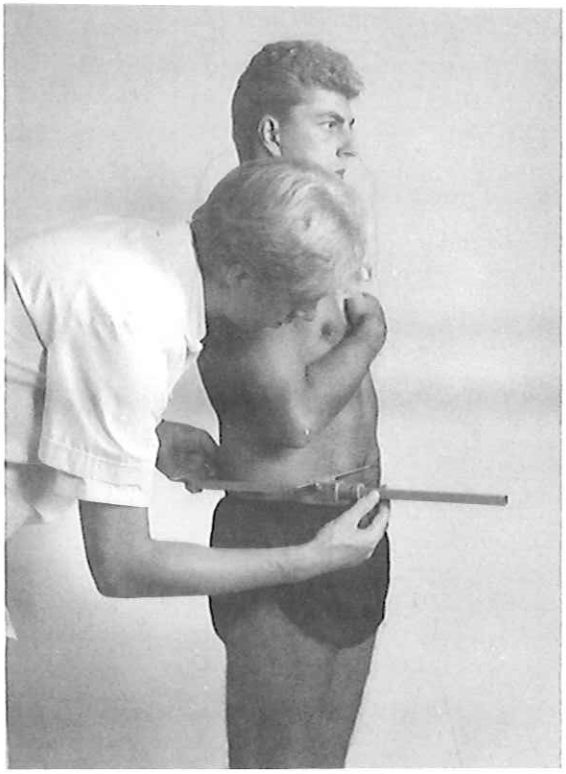


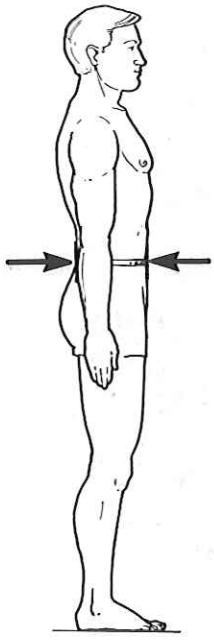
WAIST DEPTH

ORIGIN-TERMINATION: **Waist (omphalion), posterior -- waist (omphalion), anterior.**

PROCEDURE: Subject is in the anthropometric standing position but with the right hand on the chest. Stand at the right of the subject and use a beam caliper to measure the horizontal distance between the drawn landmarks at **waist (omphalion), posterior** and **waist (omphalion), anterior.** The fixed blade of the caliper is on the back. Exert only enough pressure to attain contact between the caliper and the skin. The measurement is taken at the maximum point of quiet respiration.

CAUTION: The subject must not tense the abdominal muscles.



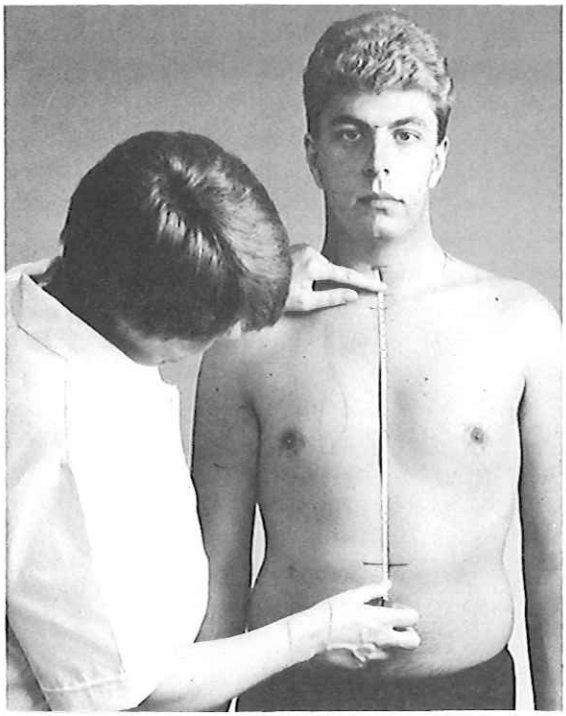


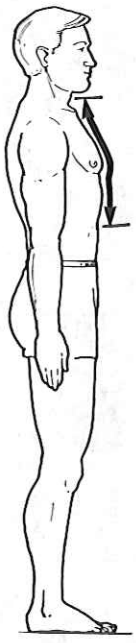
WAIST FRONT LENGTH (NATURAL INDENTATION)

ORIGIN-TERMINATION: **Anterior neck -- waist (natural indentation), anterior.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand in front of the subject and use a tape to measure the surface distance between the drawn landmark at the front of the neck (**anterior neck**) and the drawn **anterior waist (natural indentation) landmark.** The zero point of the tape is placed on the neck landmark. Exert only enough tension to prevent slack in the tape. The measurement is made at the maximum point of quiet respiration.

CAUTION: Be sure that the subject's head is in the Frankfort plane and that the zero point of the tape is on the **anterior neck landmark** when the measurement is taken. The subject must not tense the abdominal muscles.



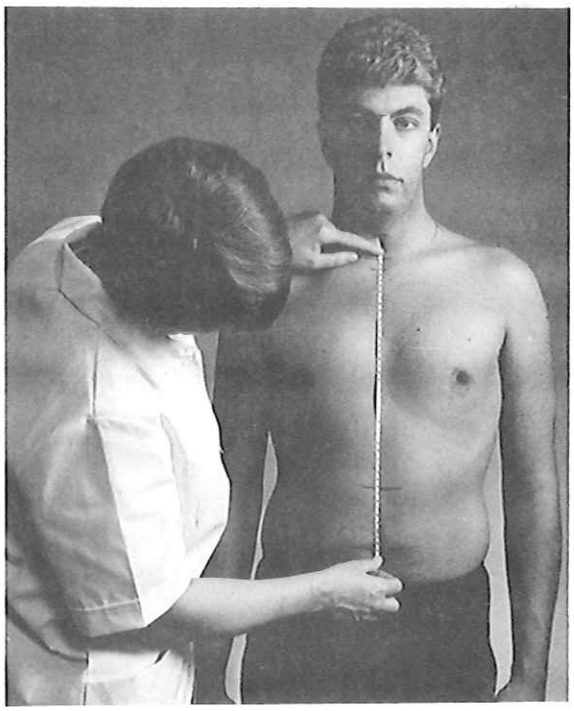


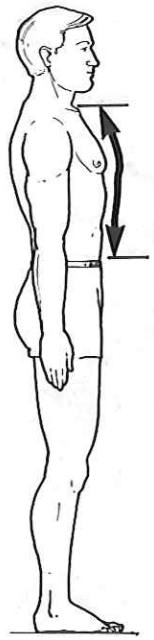
WAIST FRONT LENGTH (OMPHALION)

ORIGIN-TERMINATION: **Anterior neck — waist (omphalion), anterior.**

PROCEDURE: Subject is in the anthropometric standing position with the head in the Frankfort plane. Stand in front of the subject and use a tape to measure the surface distance between the drawn landmark at the front of the neck (**anterior neck**) and the drawn **anterior waist (omphalion) landmark.** The zero point of the tape is placed on the neck landmark. Exert only enough tension to prevent slack in the tape. The measurement is made at the maximum point of quiet respiration.

CAUTION: Be sure that the subject's head is in the Frankfort plane and that the zero point of the tape is on the **anterior neck landmark** when the measurement is taken. The subject must not tense the abdominal muscles.



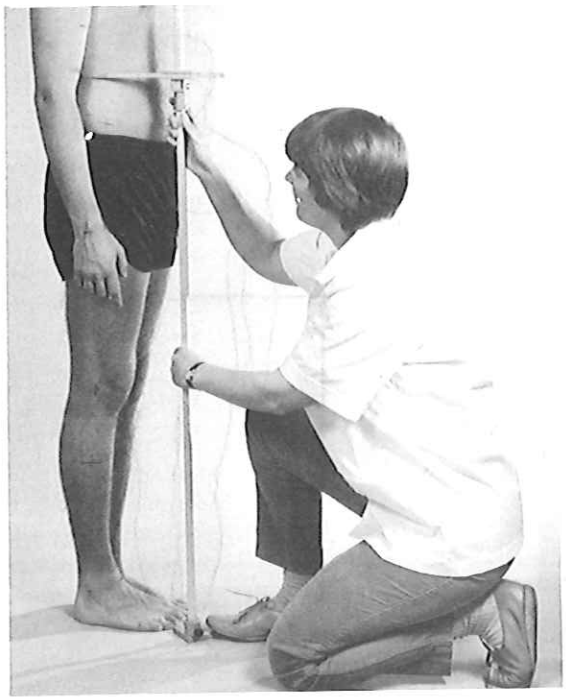


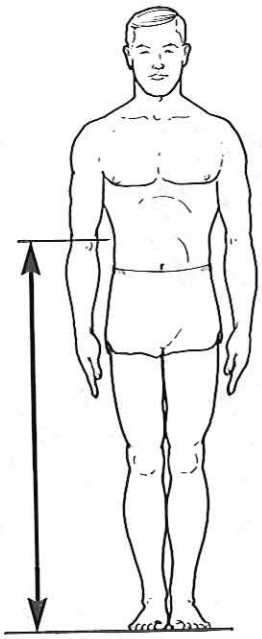
WAIST HEIGHT (NATURAL INDENTATION)

ORIGIN-TERMINATION: Standing surface -- **waist (natural indentation), right.**

PROCEDURE: Subject stands in the anthropometric standing position. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn landmark at **right waist (natural indentation).** The measurement is made at the maximum point of quiet respiration.

CAUTION: Subject must not be allowed to tense the abdominal muscles.



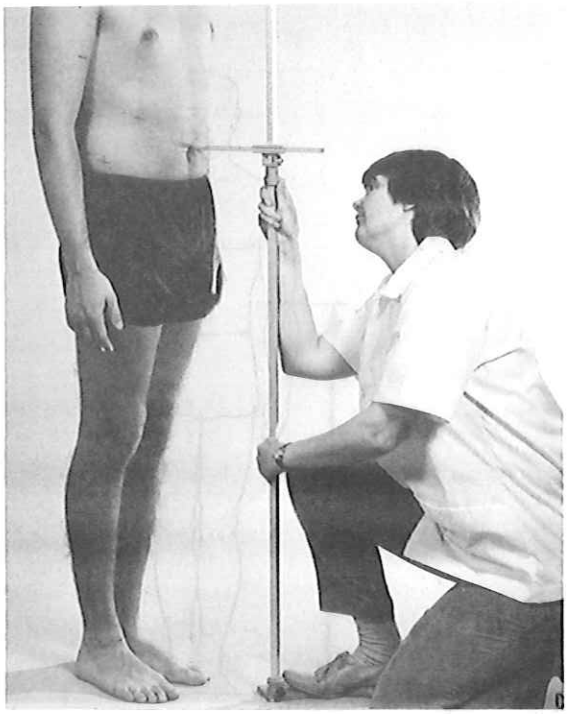


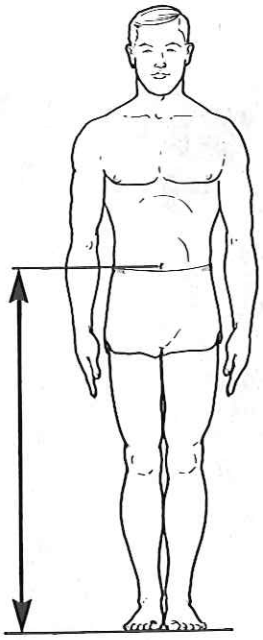
WAIST HEIGHT (OMPHALION)

ORIGIN-TERMINATION: Standing surface -- **waist (omphalion), anterior.**

PROCEDURE: Subject is in the anthropometric standing position. Stand in front of the subject and use an anthropometer to measure the vertical distance between the standing surface and the center of the navel [drawn **waist (omphalion) anterior landmark**]. The measurement is made at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to tense the abdominal muscles.



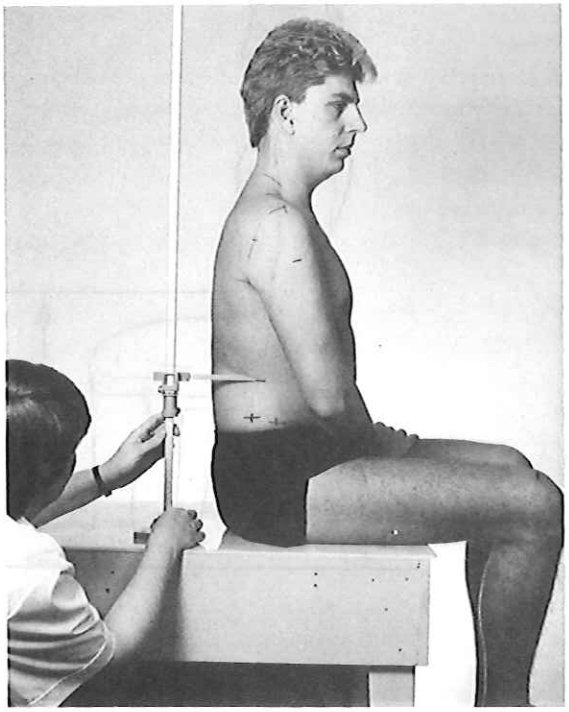


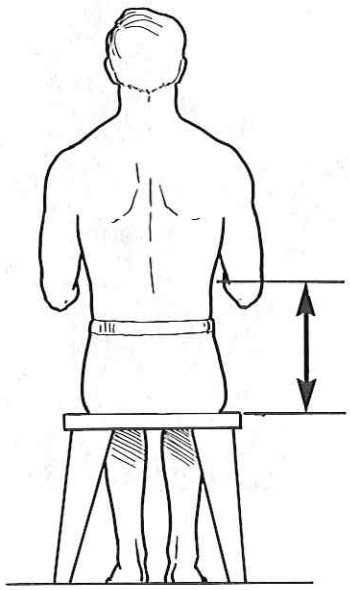
WAIST HEIGHT, SITTING (NATURAL INDENTATION)

ORIGIN-TERMINATION: Sitting surface -- **waist (natural indentation), right.**

PROCEDURE: Subject is in the anthropometric sitting position although the arms need not be flexed. Stand behind the subject and use an anthropometer to measure the vertical distance from the sitting surface to the drawn landmark at **right waist (natural indentation).** NOTE: For subjects whose **waist (natural indentation) landmark** is also marked with a "1/2" a notation will be made on the subject's disk. The measurement is made at the maximum point of quiet respiration.

CAUTION: Be sure to look for a drawn "1/2", and if present, to record it in the computer.

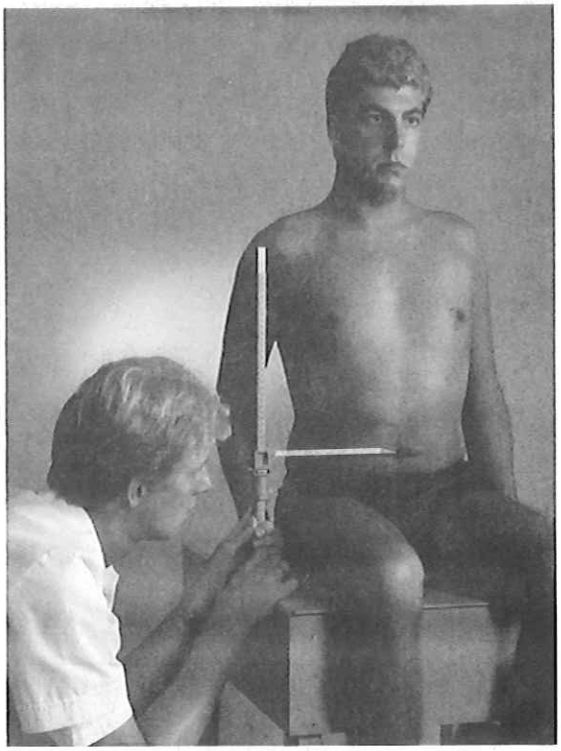


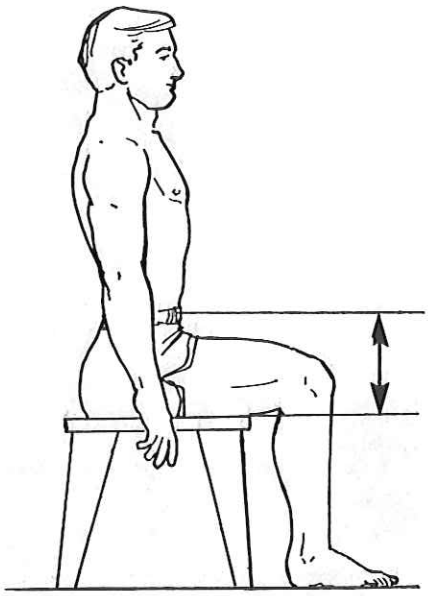


WAIST HEIGHT, SITTING (OMPHALION)

ORIGIN-TERMINATION: Sitting surface -- **waist (omphalion), anterior.**

PROCEDURE: The subject is in the anthropometric sitting position but with the arms relaxed at the sides. Stand at the side of the subject and use an anthropometer to measure the vertical distance from the sitting surface to the drawn **omphalion landmark** at the front of the waist. The measurement is made at the maximum point of quiet respiration.

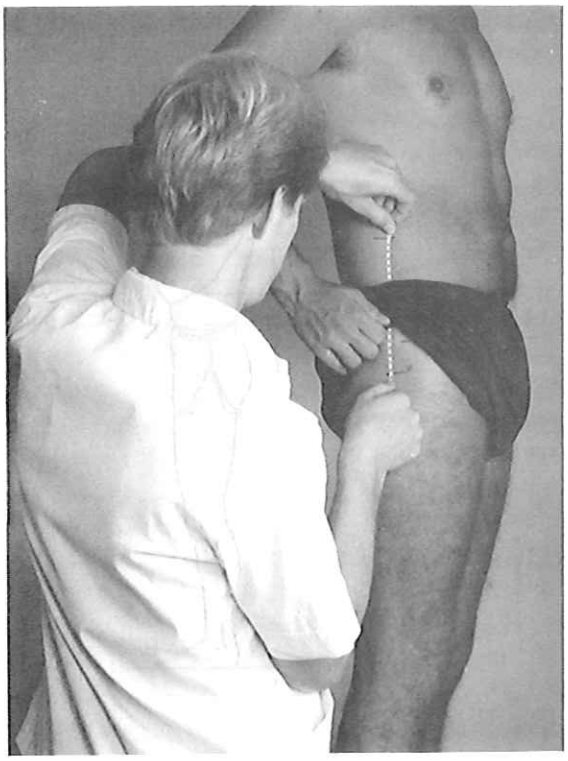


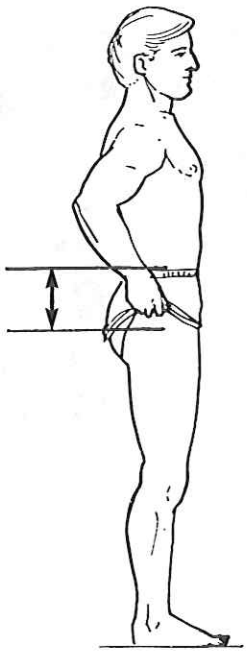


WAIST-HIP LENGTH

ORIGIN-TERMINATION: **Waist (omphalion), right -- buttock point, right lateral.**

PROCEDURE: Subject stands on a table in the anthropometric standing position. Ask the subject to hold up the right leg of the shorts to expose the landmark. Stand at the side of the subject and use a tape to measure the vertical surface distance between the drawn landmarks at the **waist (omphalion), right** and at the **right lateral buttock point.** The subject assists in placing the tape so that it passes inside the clothing. Be sure the tape lies on the surface of the skin.

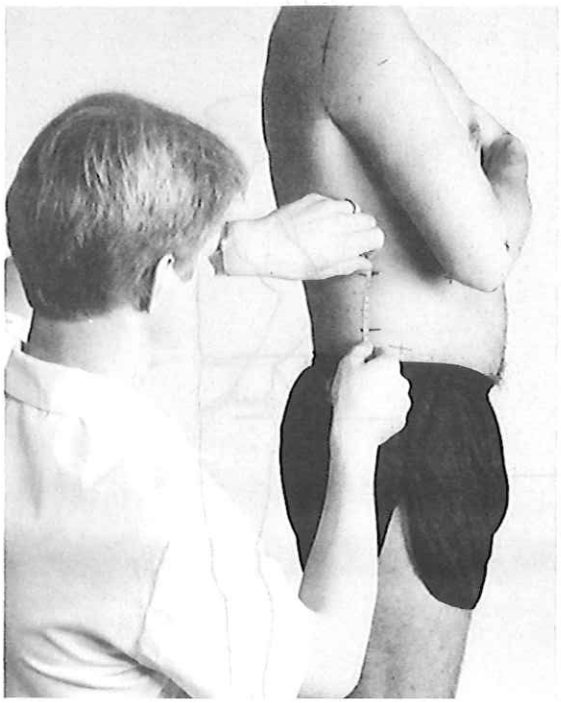


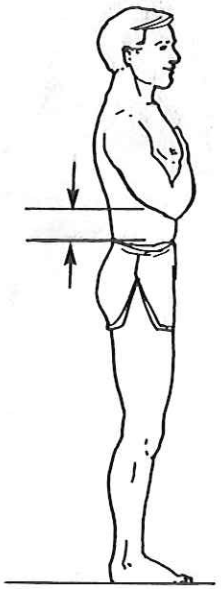


WAIST (NATURAL INDENTATION) -- WAIST (OMPHALION) LENGTH

ORIGIN-TERMINATION: **Waist (natural indentation), right -- waist (omphalion), right**

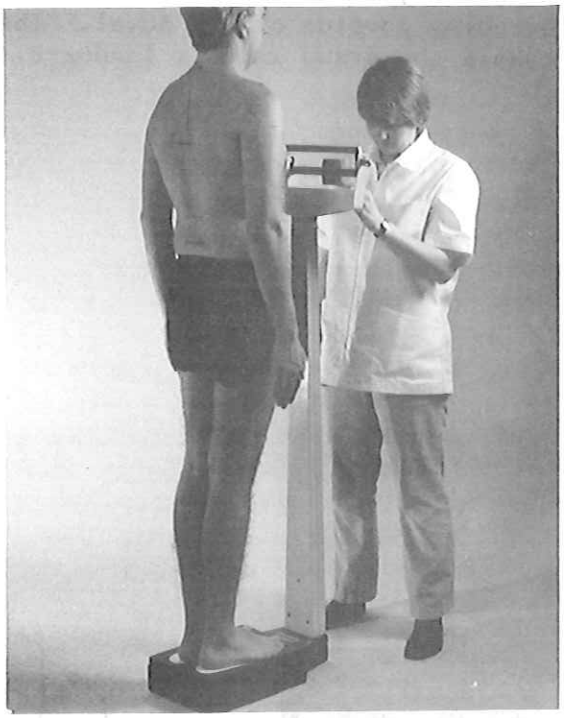
PROCEDURE: Subjects stands on the table in the anthropometric standing position but with the right hand on the chest. Ask the subject to hold up the right leg of the shorts to expose the landmark. Stand at the right of the subject and use a tape to measure the surface distance between the drawn **waist (natural indentation)** and **waist (omphalion) landmarks.** Be sure the tape lies on the surface of the skin.





WEIGHT

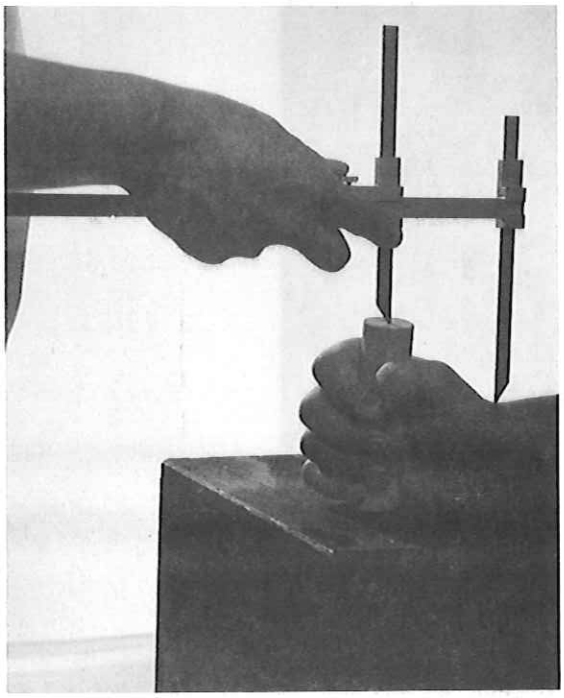
PROCEDURE: Subject stands on the footprints of the platform of the scale. Stand in front of the subject and take the weight of the subject to the nearest tenth of a kilogram.

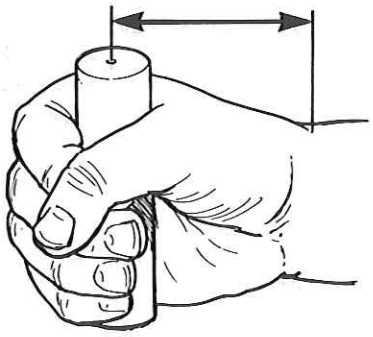


WRIST-CENTER OF GRIP LENGTH

ORIGIN-TERMINATION: **Stylion** -- center of hand grip.

PROCEDURE: Subject sits grasping a dowel (3-1/2" long and 1-1/4" in diameter) in the right hand. The base of the dowel is flush with the bottom of the fist. The subject puts the bottom of the fist on a flat surface in such a way that the base of the dowel rests on the surface. The fist is in line with the long axis of the arm. Stand at the right of the subject and use a Poech caliper to measure the horizontal distance between the drawn **stylion landmark** on the wrist and the hole in the center of the protruding portion of the dowel. The beam of the caliper is directed toward the drawn **radiale landmark.**

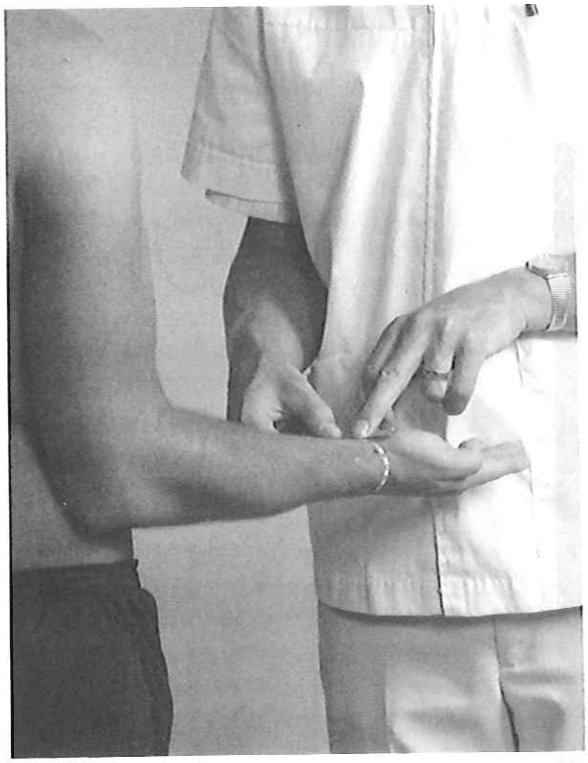


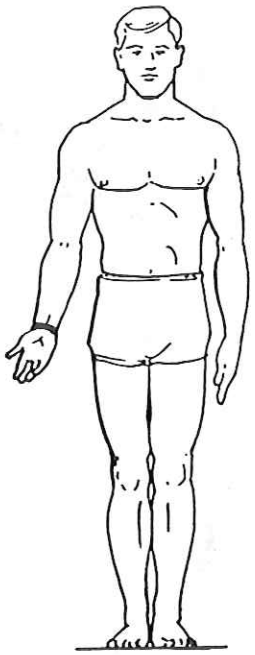


WRIST CIRCUMFERENCE

LANDMARK(S) ENCOMPASSED: **Stylion.**

PROCEDURE: Subject stands with the right arm extended forward and the palm up. Stand in front of the subject and use a tape to measure the circumference of the wrist perpendicular to the long axis of the forearm. When correctly placed, the upper edge of the tape will run just below the bony prominence at **stylion**, and the lower edge of the tape will run just above the pisiform bone at the bottom of the little finger side of the hand. Exert only enough tension on the tape to maintain contact between the tape and the skin.



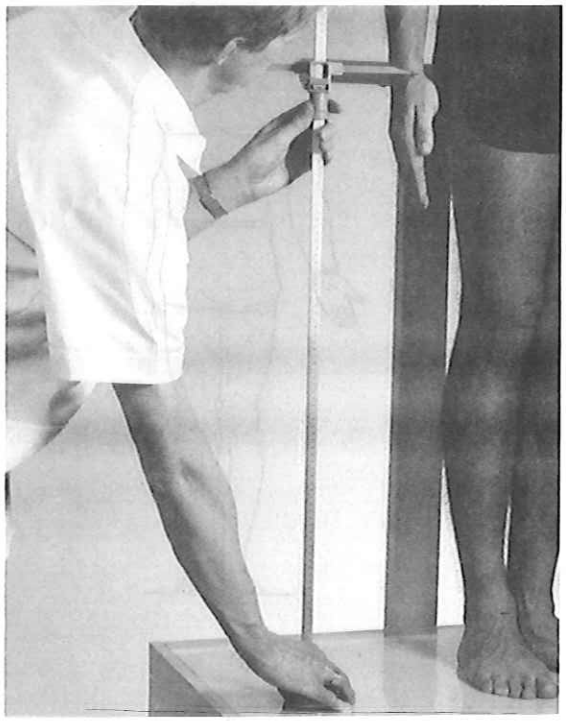


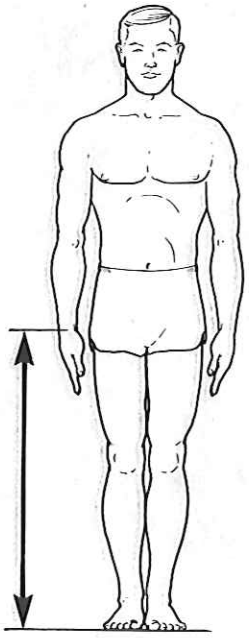
WRIST HEIGHT

ORIGIN-TERMINATION: Standing surface -- **stylion.**

PROCEDURE: Subject stands erect on a table looking straight ahead with the heels together and the weight distributed equally on both feet. The shoulders are relaxed and the arms are extended downwards with the elbow, wrist, and fingers held rigidly straight. The arms lightly touch the sides. The palms face inwards (medially). Stand in front of the subject and use an anthropometer to measure the vertical distance between the standing surface and the drawn **stylion landmark** at the wrist. The measurement is taken at the maximum point of quiet respiration.

CAUTION: The subject must not be allowed to change the position of the shoulders.



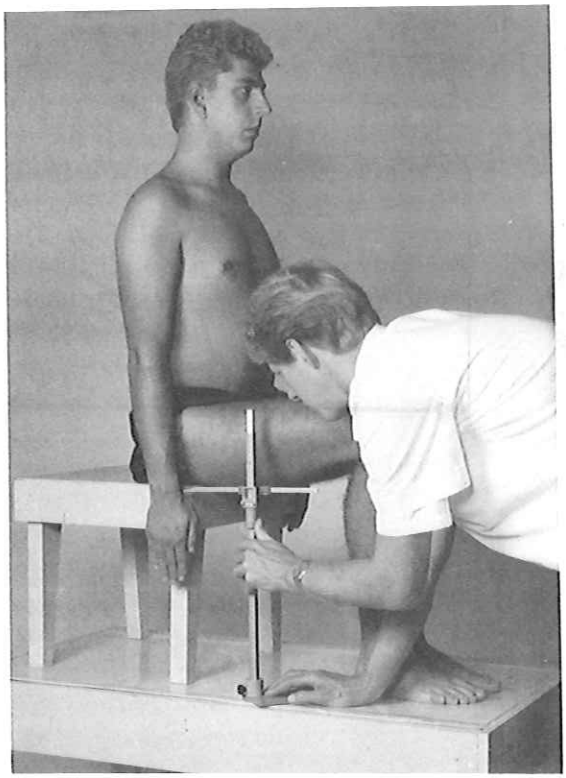


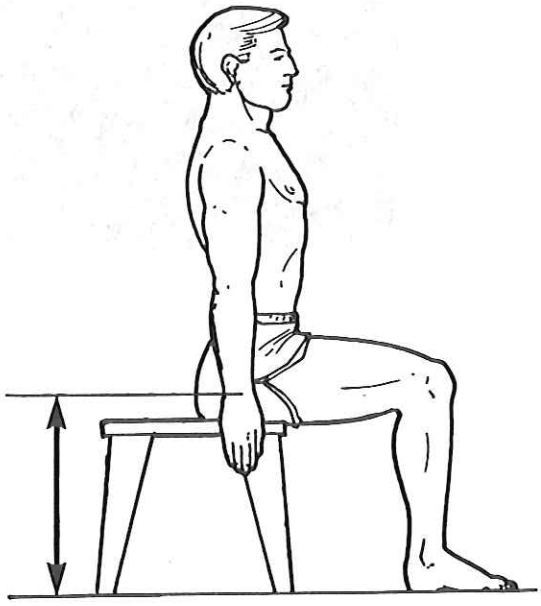
WRIST HEIGHT, SITTING

ORIGIN-TERMINATION: Table -- **stylion.**

PROCEDURE: Subject sits erect toward the edge of a seat (the drawn **trochanter landmark** is lined up with a marker placed on the seat about 7 cm from the front edge). The subject looks straight ahead. The shoulders are relaxed and the arms are extended downwards with the elbow, wrist, and fingers held rigidly straight. The arms lightly touch the sides. Stand at the right of the subject and use an anthropometer to measure the vertical distance between the table and the drawn **stylion landmark** at the wrist. The measurement is taken at the maximum point of quiet respiration. Ask the subject to hold his or her breath at this point.

CAUTION: The subject must not be allowed to change the position of the shoulders. When asking subjects to hold their breath be sure they do not take a deep breath. The computer will subtract the height of the seat from this measurement.

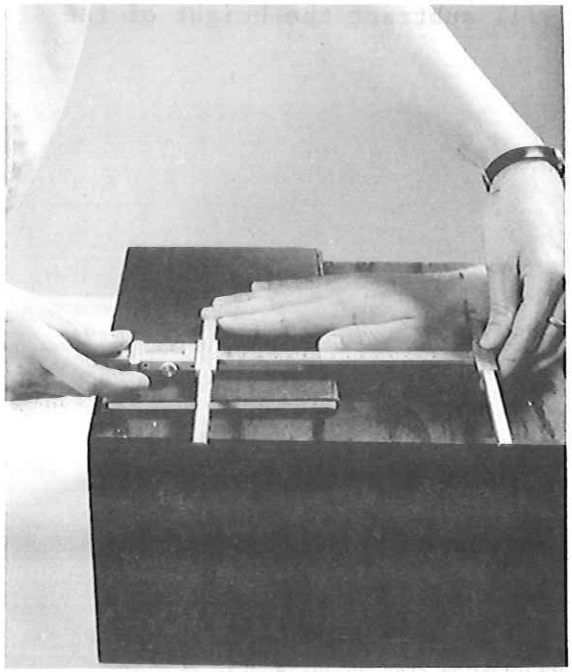


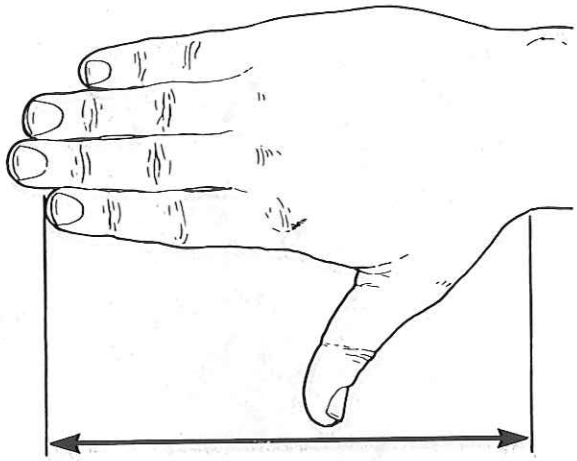


WRIST-INDEX FINGER LENGTH

ORIGIN-TERMINATION: **Stylion -- dactylion II.**

PROCEDURE: Subject sits with the palm on a table and the fingers on a flat surface 8 mm higher. The fingers are together and the thumb is held away from the hand at about a 45-degree angle. The measurer presses the hand into firm contact with the table and instructs the subject to hold this position. The middle finger is parallel to the long axis of the forearm. Stand at the left of the subject and use a Poech sliding caliper to measure the distance between the drawn **stylion landmark** on the wrist and the tip of the index finger **(dactylion II).** The beam of the caliper is held parallel to the long axis of the hand.



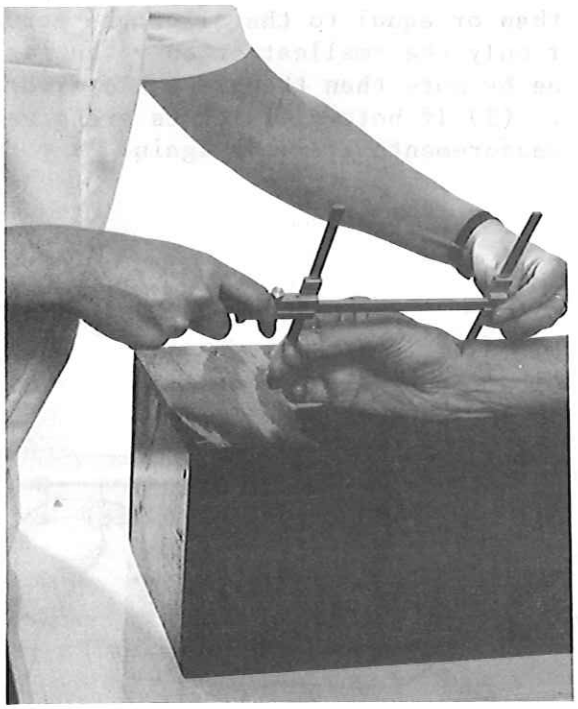


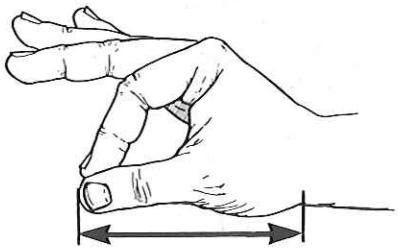
WRIST-THUMBTIP LENGTH

ORIGIN-TERMINATION: **Stylion -- thumbtip.**

PROCEDURE: Subject sits with the little-finger edge of the hand resting on a flat surface. The thumb is held straight and in line with the long axis of the forearm. The index finger curves around to touch the pad at the end of the thumb. Stand in front of the subject and use a Poech caliper to measure the horizontal distance between the drawn **stylion landmark** and the tip of the thumb. The fixed blade of the caliper is on **stylion** and the beam is held parallel to the long axis of the thumb and forearm.

CAUTION: Be sure that the thumb is straight and that the long axes of the thumb and forearm are in line.





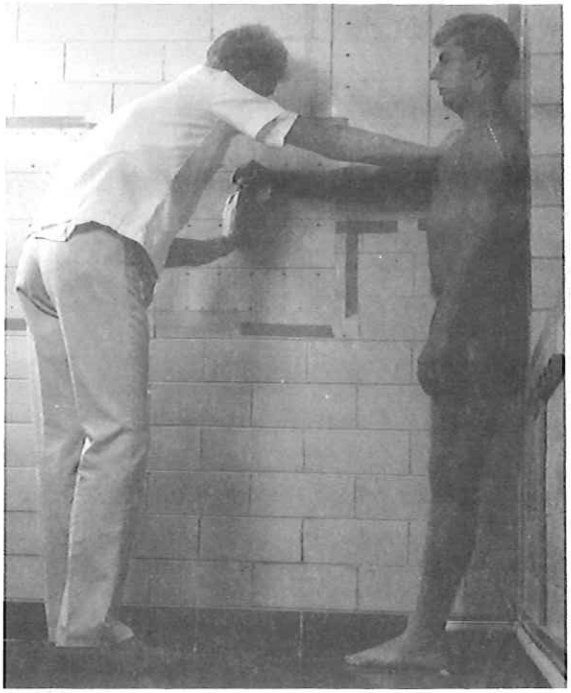
WRIST-WALL LENGTH

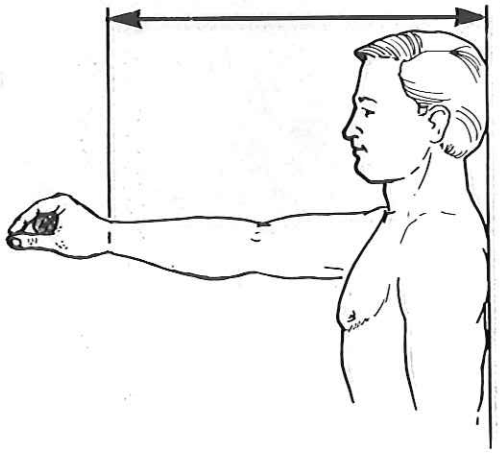
ORIGIN-TERMINATION: Wall -- **stylion.**

PROCEDURE: Subject stands erect in a corner looking straight ahead. The feet are together and the heels on a marked line 20 cm from the wall. The buttocks and shoulders are against the back wall. The right arm and hand are stretched forward horizontally against the side wall, palm down. The thumb continues the horizontal line of the arm and the index finger curves around to touch the pad at the end of the thumb. Face the wall-mounted scale and hold the subject's right shoulder against the wall. Place the wrist block on the wall at the drawn **stylion landmark** to establish, on the scale, the horizontal distance between the rear wall and the wrist. The measurement is taken three times, repositioning the arm each time.*

CAUTION: Be sure that the thumb is straight and that the arm is horizontal.

* The computer selects the final value by calculating the smallest two and the largest two values and comparing the differences to the allowable observer error (see Appendix F, Table F-1). It then exercises one of three options: (1) If both differences are smaller than or equal to the allowable error, the middle value is retained. (2) If only the smallest or only the largest value is distant from the middle value by more than the allowable error, the mean of the other two values is used. (3) If both differences are greater than the allowable error, all three measurements are made again.





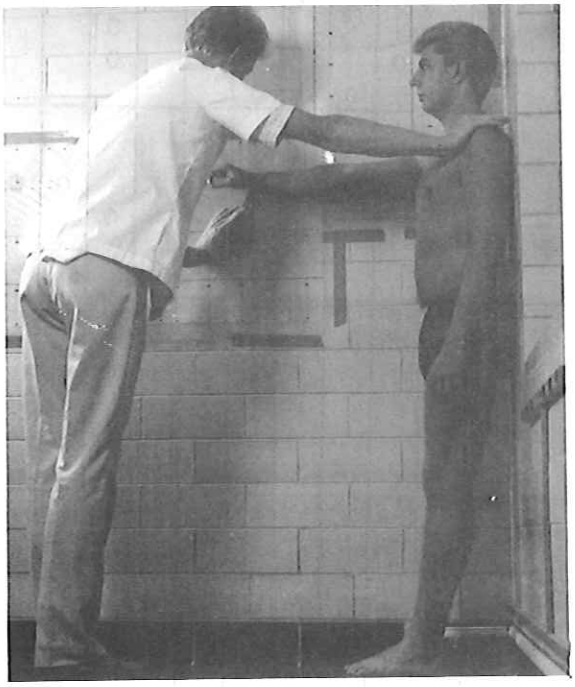
WRIST-WALL LENGTH, EXTENDED

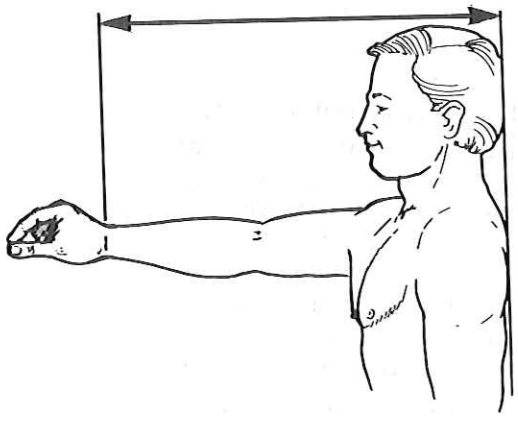
ORIGIN-TERMINATION: Wall -- **stylion.**

PROCEDURE: Subject stands erect in a corner looking straight ahead with the feet together and the heels on a marked line 20 cm from the wall. The buttocks and shoulders are against the back wall. The right arm and hand are stretched forward horizontally against the side wall, palm down, as far as possible. The thumb continues the horizontal line of the arm and the index finger curves around to touch the pad at the end of the thumb. The right shoulder is rotated forward in making this effort. Face the wall-mounted scale and hold the subject's left shoulder against the wall with your right hand. Place the wrist block on the wall at the drawn **stylion landmark** to establish, on the scale, the horizontal distance between the rear wall and the extended wrist. The measurement is taken three times, repositioning the arm each time.*

CAUTION: The left shoulder must remain in contact with the wall. Be sure that the thumb is straight and the arm is horizontal.

* The computer selects the final value by calculating the smallest two and the largest two values and comparing the differences to the allowable observer error (see Appendix F, Table F-1). It then exercises one of three options: (1) If both differences are smaller than or equal to the allowable error, the middle value is retained. (2) If only the smallest or only the largest value is distant from the middle value by more than the allowable error, the mean of the other two values is used. (3) If both differences are greater than the allowable error, all three measurements are made again.





USE OF THE DIMENSIONS

Subjects often ask why certain dimensions are being measured. You too may wonder what uses can possibly be made of some measurements you are taking. Table 1 lists all the dimensions to be measured in the Army survey and designates what use or uses they may serve. (The 12 categories into which these applications are divided are briefly described following Table 1.) Anthropometrists should become familiar with the applications made of at least the 20 or so dimensions for which they are responsible.

TABLE 1. Applications for the Dimensions to Be Measured in the Army Survey

	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES
ABDOMINAL EXTENSION DEPTH, SITTING			0						0			0
ACROMIAL HEIGHT	0		0	0							0	0
ACROMIAL HEIGHT, SITTING									0		0	0
ACROMION-RADIALE LENGTH			0								0	
ANKLE CIRCUMFERENCE			0	0				0				0
AXILLA HEIGHT			0	0	0							
AXILLARY ARM CIRCUMFERENCE			0	0								0
BALL OF FOOT CIRCUMFERENCE								0				0
BALL OF FOOT LENGTH		0						0				
BIACROMIAL BREADTH			0	0	0						0	0
BICEPS CIRCUMFERENCE, FLEXED			0									
BIDELTOID BREADTH			0						0	0		0
BIMALLEOLAR BREADTH			0					0				0
BISPINOUS BREADTH											0	
BITRAGION CHIN ARC						0						
BITRAGION CORONAL ARC						0						
BITRAGION CRINION ARC						0						
BITRAGION FRONTAL ARC						0						
BITRAGION SUBMANDIBULAR ARC						0						
BITRAGION SUBNASALE ARC						0						
BIZYGOMATIC BREADTH		0				0						0
BUSTPOINT/THELION-BUSTPOINT/THELION BREADTH			0	0	0							
BUTTOCK CIRCUMFERENCE		0	0	0					0			0
BUTTOCK DEPTH			0	0								0
BUTTOCK HEIGHT			0	0								0

TABLE 1. Continued

	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES
BUTTOCK-KNEE LENGTH			O						O	O		O
BUTTOCK-POPLITEAL LENGTH									O			O
CALF CIRCUMFERENCE			O	O								O
CALF HEIGHT			O	O				O				O
CERVICALE HEIGHT			O	O	O						O	O
CERVICALE HEIGHT, SITTING											O	O
CHEST BREADTH			O	O	O							O
CHEST CIRCUMFERENCE		O	O	O	O							O
CHEST CIRCUMFERENCE AT SCYE		O	O	O	O							
CHEST CIRCUMFERENCE BELOW BREAST			O	O	O							O
CHEST DEPTH			O	O	O				O			O
CHEST HEIGHT			O	O	O							O
CROTCH HEIGHT		O	O	O								O
CROTCH LENGTH (NATURAL INDENTATION)			O	O								
CROTCH LENGTH (OMPHALION)			O	O								
CROTCH LENGTH, POSTERIOR (NATURAL INDENTATION)			O									
CROTCH LENGTH, POSTERIOR (OMPHALION)			O			O						
EAR BREADTH						O						
EAR LENGTH						O						
EAR LENGTH ABOVE TRAGION						O						
EAR PROTRUSION						O						
ELBOW CIRCUMFERENCE				O						O		O
ELBOW REST HEIGHT										O		O
EYE HEIGHT, SITTING		O									O	O
FOOT BREADTH, HORIZONTAL		O						O				O
FOOT LENGTH		O						O			O	O
FOREARM CIRCUMFERENCE, FLEXED				O								
FOREARM-FOREARM BREADTH					②					O	O	O
FOREARM-HAND LENGTH										O		O
FUNCTIONAL LEG LENGTH										O	O	O

TABLE 1. Continued

	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES
GLUTEAL FURROW HEIGHT			0	0								0
HAND BREADTH		0					0		0			0
HAND CIRCUMFERENCE		0					0					
HAND LENGTH		0					0		0	0	0	0
HEAD BREADTH		0				0						0
HEAD CIRCUMFERENCE		0	0			0						0
HEAD LENGTH		0				0						0
HEEL-ANKLE CIRCUMFERENCE								0				
HEEL BREADTH								0				
HIP BREADTH			0	0								0
HIP BREADTH, SITTING			0						0			0
ILIOCRISTALE HEIGHT			0	0	0							0
INTERPUPILLARY BREADTH			0			0					0	0
INTERSCYE I			0	0	0							
INTERSCYE II			0									
KNEE CIRCUMFERENCE			0	0								0
KNEE HEIGHT, MIDPATELLA			0	0					0			0
KNEE HEIGHT, SITTING											0	0
LATERAL FEMORAL EPICONDYLE HEIGHT								0			0	0
LATERAL MALLEOLUS HEIGHT												
LOWER THIGH CIRCUMFERENCE			0	0								0
MENTON-SELLION LENGTH		0				0			0			0
MIDSHOULDER HEIGHT, SITTING												0
NECK CIRCUMFERENCE		0	0	0								
NECK CIRCUMFERENCE, BASE			0	0								
NECK HEIGHT, LATERAL			0	0	0					0		0
NECK-BUSTPOINT/THELION LENGTH										0		
OVERHEAD FINGERTIP REACH										0		0
OVERHEAD FINGERTIP REACH, EXTENDED												
OVERHEAD FINGERTIP REACH, SITTING												

TABLE 1. Continued

	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES
POPLITEAL HEIGHT									O			O
RADIALE-STYLION LENGTH											O	
SCYE CIRCUMFERENCE			O	O								
SCYE DEPTH			O	O	O							
SHOULDER CIRCUMFERENCE		O	O									O
SHOULDER LENGTH			O	O	O							
SHOULDER-ELBOW LENGTH			O						O			O
SITTING HEIGHT	O	O							O	O	O	O
SLEEVE LENGTH: SPINE-ELBOW			O									
SLEEVE LENGTH: SPINE-SCYE			O									
SLEEVE LENGTH: SPINE-WRIST		O	O									
SLEEVE OUTSEAM			O	O								
SPAN			O						O	O		O
STATURE	O	O	O		O				O		O	O
STRAP LENGTH			O	O	O							
SUPRASTERNALE HEIGHT			O	O							O	
TENTH RIB HEIGHT			O									O
THIGH CIRCUMFERENCE			O	O								O
THIGH CLEARANCE			O						O			O
THUMB BREADTH							O		O			
THUMBTIP REACH									O	O		O
TROCHANTERIC HEIGHT											O	
VERTICAL TRUNK CIRCUMFERENCE (ASCC)		O	O	O	O							
VERTICAL TRUNK CIRCUMFERENCE (USA)		O	O	O	O							
WAIST BACK LENGTH (NATURAL INDENTATION)			O	O	O							
WAIST BACK LENGTH (OMPHALION)			O	O	O							
WAIST BREADTH			O	O	O							O
WAIST CIRCUMFERENCE (NATURAL INDENTATION)		O	O	O	O							O
WAIST CIRCUMFERENCE (OMPHALION)		O	O	O	O							O
WAIST DEPTH			O	O	O							O

TABLE 1. Continued

	BASIC BODY DESCRIPTORS	KEY DIMEN./MICROCOSMS	GARMENTS (Clothing/PE)	CLOTHING MANIKINS	LOAD CARRYING SYSTEMS	HEAD and FACE EQUIPMENT	GLOVES	SHOE LASTS/FOOT GEAR	WORKSPACE/BODY CLEARANCE	AIRCRAFT ACCOMMODATION	BODY LINKS	ANTHROPOMORPHIC ANALOGUES
WAIST FRONT LENGTH (NATURAL INDENTATION)		0	0	0	0							
WAIST FRONT LENGTH (OMPHALION)		0	0	0	0							
WAIST HEIGHT (NATURAL INDENTATION)			0	0	0				0			0
WAIST HEIGHT (OMPHALION)			0	0	0				0			0
WAIST HEIGHT, SITTING (NATURAL INDENTATION)			0						0			0
WAIST HEIGHT, SITTING (OMPHALION)			0						0			0
WAIST-HIP LENGTH			0									
WAIST (NATURAL INDENTATION)-WAIST (OMPHALION) LENGTH			0	0								
WEIGHT	0	0	0						0	0		0
WRIST CIRCUMFERENCE							0					
WRIST HEIGHT									0			0
WRIST HEIGHT, SITTING									0	0		0
WRIST-CENTER OF GRIP LENGTH									0	0		0
WRIST-INDEX FINGER LENGTH									0			0
WRIST-THUMB TIP LENGTH									0	0		0
WRIST-WALL LENGTH									0	0		0
WRIST-WALL LENGTH, EXTENDED									0			0

The following are descriptions of each group:

Basic Body Descriptors: These are dimensions of overall body size and proportions. They are required to determine the anthropometric differences or similarities between populations. They are also used for selecting samples of subjects that are anthropometrically representative of a particular population for studies in which body size is of significance (e.g., the evaluation of the workstation layouts for a new Army tank).

Key Dimensions/Microcosm Selection: These dimensions serve as key or control dimensions for the design, sizing, procurement, and issuing of clothing and personal equipment. Key dimensions for men's dress shirt sizes,

for example, are often NECK CIRCUMFERENCE and SLEEVE LENGTH. In addition, key dimensions are useful for selecting anthropometrically representative samples of test subjects for evaluating the fit and function of new items.

Garments (Clothing/Personal Equipment): These dimensions are useful for the design and sizing of Army uniforms, utility garments, and personal protective equipment (e.g., body armor, respirators, chemical defense clothing).

Clothing Manikins: These are three-dimensional forms which represent specific body sizes and shapes. They are valuable guides for the design and sizing of clothing and personal equipment worn on the body. The better the manikins represent sizes of Army men and women, the better the fit and the less alteration required of garments designed over them.

Load-Carrying Systems: These dimensions are used for the design and sizing of systems worn by soldiers to carry full-field gear and other types of equipment. Load-carrying systems are of critical importance to the combat-effectiveness and well-being of Army troops and support personnel.

Head and Face Equipment: The dimensions in this group are used primarily in the design of personal protective equipment worn on the head and face and for the design of optical and auditory devices.

Gloves: These are hand, finger, wrist, and forearm measurements used in the design, sizing, and procurement of gloves and in the construction of hand forms used to guide the design of gloves.

Shoe Lasts/Foot Gear: These foot and ankle dimensions are needed for the design, sizing, procurement, and evaluation of shoes and boots.

Workspace and Body Clearance: Dimensions in this group are central to the design and layout of single- and multiperson workstations occupied by Army personnel. They are also of paramount importance in the design and layout of workstations of Army weapon systems, particularly those, like tanks, in which space is at a premium. Body clearance dimensions dictate, for example, the size of escape hatches and limited-size passageways that must be designed to allow quick and safe passage of an individual. In the field or in a depot, the performance of maintenance activities is also greatly enhanced if personnel have ready physical and visual access to maintenance and inspection ports, and have the reach capabilities to perform necessary service, repair, or replacement activities, often conducted under adverse conditions.

Aircraft Accommodation: The dimensions in this group are those that have been or are likely to be used to restrict individuals from operating aircraft with which they are anthropometrically incompatible. That is, certain aircraft do not safely and efficiently accommodate the complete range of body sizes found in aircrew personnel. Ideally, the more complete data that will be available from this survey can be used to avoid such problems in the future.

Body Links: These dimensions are needed for developing the link or "skeletal" system which is the foundation for all three-dimensional human models used to assess the body's reaction to hazardous environments, and for two- and three-dimensional models used in the design and evaluation of Army crew- and workstations.

Anthropomorphic Analogues: The dimensions in this group are useful for the development of four general types of models: (1) three-dimensional manikins and (2) three-dimensional computer-generated models (used to assess the body's reaction to high acceleration environments); (3) two-dimensional drawing-board manikins and (4) three-dimensional computer-generated, human-engineering analogues (used to guide the design and evaluation of workstations).

A GLOSSARY OF ANATOMICAL AND ANTHROPOMETRIC TERMS

anatomical position -- a standard position of the body to which all anatomical directions (e.g., superior, medial, anterior) are referenced (see Figure 19).

anterior -- pertaining to the front of the body; as opposed to posterior.

bi -- a prefix denoting connection with or relation to each of two symmetrically paired parts.

biceps (brachii) -- the large muscle on the anterior surface of the upper arm.

canthus -- a corner or angle formed by the meeting of the eyelids.

coronal plane -- any vertical plane at right angles to the midsagittal plane (see Figure 19).

deltoid muscle -- the muscle that forms the flesh of the lateral side of the upper third of the upper arm.

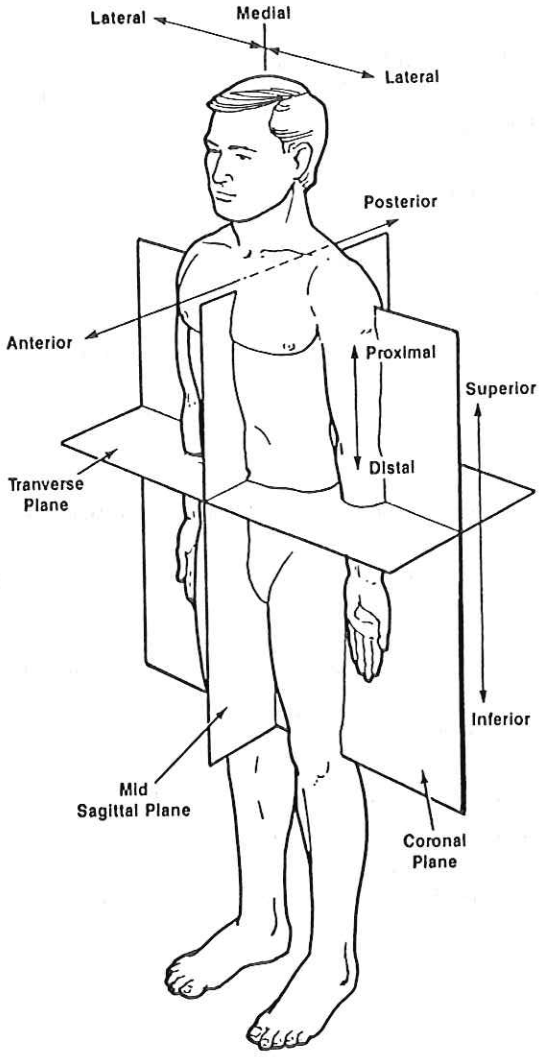


Figure 19. The body in the anatomical position.

distal -- the end of a bone or body segment farthest from the head, as opposed to proximal (see Figure 19).

dorsal -- pertaining to the back of the body or one of its parts (on the hand, its top surface as opposed to its palmar surface).

epicondyle -- the bony eminence at the distal end of the humerus, radius, and femur.

extend -- to move adjacent segments so that the angle between them is increased, as when the leg is straightened; as opposed to flex.

femoral epicondyle -- the bony projections on either side of the distal end of the femur.

femur -- the thigh bone.

flex -- to move a joint in such a direction as to bring together the two parts which it connects, as when the elbow is bent; as opposed to extend.

fossa -- a depression, usually somewhat longitudinal in shape, in the surface of a part, as in a bone.

Frankfort plane -- the standard horizontal plane or orientation of the head. The plane is established by a line passing through the right tragion (approximate earhole) and the lowest point of the right orbit (eye socket).

hyperextend -- to overextend a limb or other part of the body.

iliac -- pertaining to an ilium, which is one of the three fused bones that form one side of the pelvis.

iliac crest -- the superior rim of a pelvic bone.

ilium -- the largest and superior bone of the three fused bones that form one side of the pelvis.

inferior -- below, in relation to another structure; lower (see Figure 19).

lateral -- lying near or toward the sides of the body; as opposed to medial (see Figure 19).

latissimus dorsi -- the large muscle covering the lower half of the back above the waist and converging on the upper arm in such a way that its flesh forms the posterior border of the axilla (armpit).

malleoli -- rounded bony projection on either side of the ankle. The lateral malleolus, on the outside of the ankle, is at the distal end of the fibula (one of the two bones of the calf); the medial malleolus, on the inside of the ankle, is at the distal end of the tibia (the shin bone).

mandible -- the jaw bone.

mastoid process -- lowest bony projection behind and below the ear. It can best be felt immediately behind the earlobe.

medial -- lying near or toward the midline of the body; as opposed to lateral. (see Figure 19).

metacarpophalangeal joint -- a joint (knuckle) formed by the juncture of a finger bone (phalanx) with the palm bone (metacarpal).

metatarsophalangeal joint -- a joint formed by the juncture of a toe bone (phalanx) with the foot bone (metatarsal).

midsagittal plane -- the vertical plane which divides the body into right and left halves (see Figure 19).

olecranon -- the proximal end of the ulna (the elbow).

palmar -- pertaining to the palm side of the hand; as opposed to its dorsal surface.

patella -- the kneecap.

phalanx -- a finger or toe bone.

pisiform -- a wrist bone on the little finger side of the hand at the base of the palm. It can be felt as a bony protruberance just below the fleshy pad at the base of the palm.

plantar -- pertaining to the sole of the foot.

posterior -- pertaining to the back of the body; as opposed to anterior (see Figure 19).

proximal -- the end of a bone or body segment nearest the head; as opposed to distal (see Figure 19).

radius -- the bone of the forearm on the thumb side of the arm.

scye -- a tailoring term referring to the armhole of a garment.

superior -- above, in relation to another structure; higher (see Figure 19).

supra -- prefix designating above or on.

thoracic -- pertaining to the thorax; in this text, pertaining especially to the vertebra to which the ribs are attached.

thorax -- that part of the trunk between the neck and the abdomen enclosed by the rib cage.

trapezius -- the large muscle that originates on the neck and the upper half of the back and converges on the shoulder between midshoulder and acromion.

vertebra -- a bone of the spine. In man there are seven cervical (neck), 12 thoracic, five lumbar (lower back), five sacral (fused) and four caudal (tail) vertebrae.

zygomatic arch -- the bony arch below and to the side of the orbit of the skull extending horizontally along the side of the head from the cheekbone (the zygomatic bone) nearly to the external ear.

zygomatic bone -- a bone of the face underlying the upper part of the cheek.

REFERENCES

1. Churchill, Thomas, Bruce Bradtmiller and Claire C. Gordon. 1988. Computer Software Used in the 1987-1988 U.S. Army Anthropometric Survey. Technical Report NATICK/TR-88/045. U.S. Army Natick Research, Development and Engineering Center, Natick, Massachusetts. (In press.)

2. Zehner, Gregory, Vance Deason, Cay Ervin and Claire Gordon. 1988. A Photographic Device for the Collection of Anthropometric Data on the Hand. Technical Report NATICK/TR-87/044L. U.S. Army Natick Research, Development and Engineering Center, Natick, Massachusetts.

3. Annis, James F. and Claire C. Gordon. 1988. The Development and Validation of an Automated Headboard Device for Measurement of Three-dimensional Coordinates of the Head and Face. Technical Report NATICK/TR-88/048. U.S. Army Natick Research, Development and Engineering Center, Natick Massachusetts. (In press.)

APPENDIX A.

Instruction Manual for the Operation of the Hardware and Software Used in the 1987-1988 U.S. Army Survey

APPENDIX A.

Instruction Manual for the Operation of the Hardware and Software Used in the 1987-1988 U.S. Army Survey

This appendix contains step-by-step instructions for describing the operation, care and maintenance of the portable computers used for data collection in the field. The standard anthropometric stations #1 to #6 use Compaq Portable Computers, and the software is similar for each of those stations. The first section below describes the operation of the software and hardware for the six standard data stations. A separate section describing the procedures required at the automated headboard station and the in- and out-processing station follows.

MEASUREMENT STATIONS #1 THROUGH #6

Hardware

1. The hardware used at stations #1 to #6 consists of the Compaq Portable Computer and the Brother M-1109 printer (see Figure A-1).

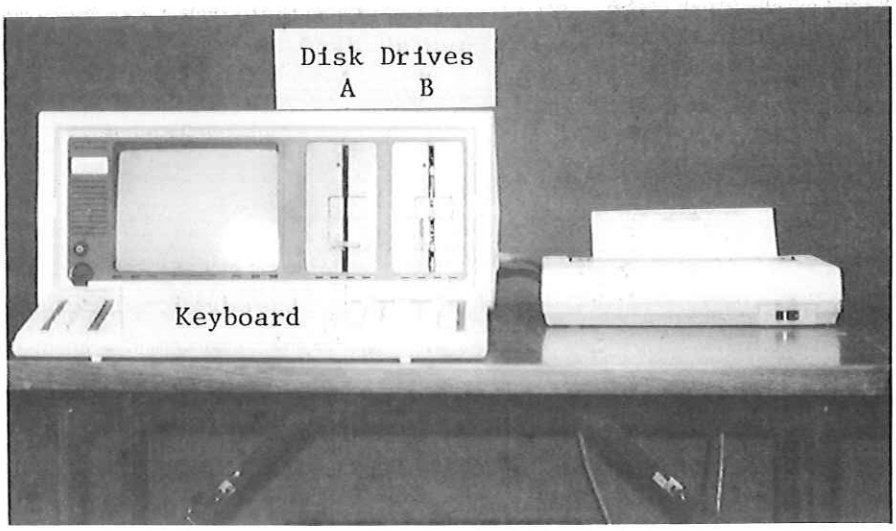


Figure A-1. Compaq Portable Computer in the open operating position with the Brother M-1109 printer.

2. Lift the computer onto the table or desk surface with the handle on the top. Locate the side of the computer with two fold-out tabs near the bottom. Flip these tabs out. Keeping the computer upright (with the handle on top), rotate it, if necessary, so that the side containing the tabs is away from you. On each end (to your right and left) near the top, is a door. Open each door by pushing in slightly on the bottom of the door and then sliding the door down. The door on the left contains the power cord for the unit. Remove the cord and affix the female end onto the prongs located inside the door. The door on the right contains the slots for attaching accessories, such as the grey printer cable. The printer cable has two ends -- one slightly smaller than the other. Attach the smaller end to the printer port inside the right-hand door. When the correct end is selected, it will fit into only one plug in the side of the computer. It will also fit only one way, so that if it does not go in smoothly on the first attempt, flip it over and try it again. After the cable is snugly attached, secure it by screwing in the screws with a small screwdriver. Now lay the computer so that the side with the tabs is down, and the handle is in back, and place it on the table resting on the tabs. The front of the computer, now facing you, contains small tabs on the right and left sides, near the bottom. Flip these tabs out. Above each tab is a keyboard lock. When you move these locks to the open position, the keyboard will fall out toward you. Position your hands in such a way as to catch the keyboard when you move the locks to the "open" position.

3. The Brother printer should be placed in a convenient location relative to the computer and to you. The printer end of the printer cable should be attached to the port on the rear of the printer with the wire clips. It, too, will fit only one of the plugs, and will fit only one way. When it is snugly attached, flip the wire clips toward each other until they lock the cable into place.

4. Both the printer and the computer power cords should be plugged into the multiple outlet power strip. The power strip is then plugged into a three-pronged wall outlet, or into a three-pronged adapter for a two-pronged wall outlet.

5. The computer has two disk drives (vertical slots above the keyboard on the right side of the machine) which accommodate standard 5 1/4-inch floppy diskettes. The drive on the left is known as Drive A; the drive on the right is Drive B. Flip up the levers on each drive and remove the cardboard disk drive protector from each drive. (These cardboard protectors should be retained and reinserted to protect the disk drives whenever the computer is moved.)

The station diskette (see Figure A-2) which is labeled, for example, "Station 1 Disk" should be inserted with the double-notched edge leading and the single notch on the bottom. Insert the station diskette into Drive A (on the left) until it doesn't go any farther. Move the drive handle clockwise until it closes the drive and retains the disk in place.

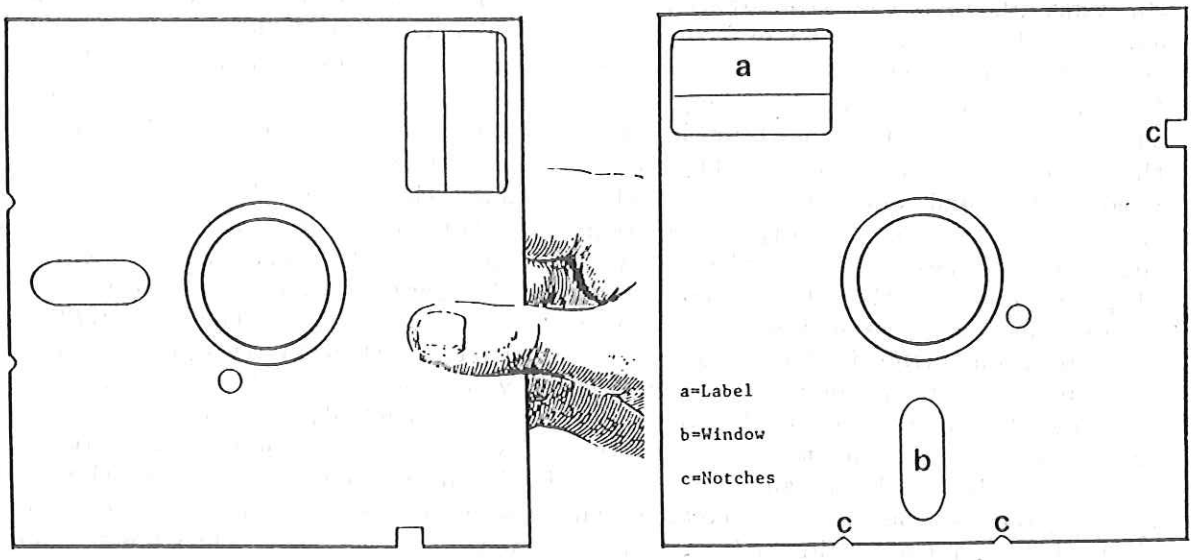


Figure A-2. A typical diskette (right), positioned for insertion into disk drive (left).

6. Turn on the switch on the power strip. Turn on the computer with the switch located inside the door where the power cord is attached. Turn on the printer with the switch located on the front panel, near the bottom right-hand corner.

Software

1. The computer will "boot" automatically. This means that the operating system software required for the operation of the machine will be read from the station diskette. In addition, it will make a number of automatic checks, including a check on the connection with the printer and confirmation that all memory locations are functional. The computer will also read, from the diskette, the program that will accept the anthropometric data. When all the automatic booting, loading, and reading is finished, the computer system is ready to accept input from the operator. During this process, the red light on each drive will come on periodically. Never insert or remove a diskette while the red light is on.

2. The screen will prompt for the current date with **ENTER NEW DATE (MM-DD-YY):** You respond with the correct date, in numbers, with the month, day, and year, using two characters for each entry. Separate the numbers with hyphens, for example, 08-15-87. Follow this entry with a carriage return (see Figure A-3 for location of RETURN key). The return key must be pressed after

each entry from now on. Next, the prompt will be for the time, **ENTER NEW TIME:** You respond with the time of day, for example, 09:30. Use 24-hour military time; for example, 2:30 in the afternoon would be entered as 14:30. (See Figure A-3 for location of the shift key to type a colon.)

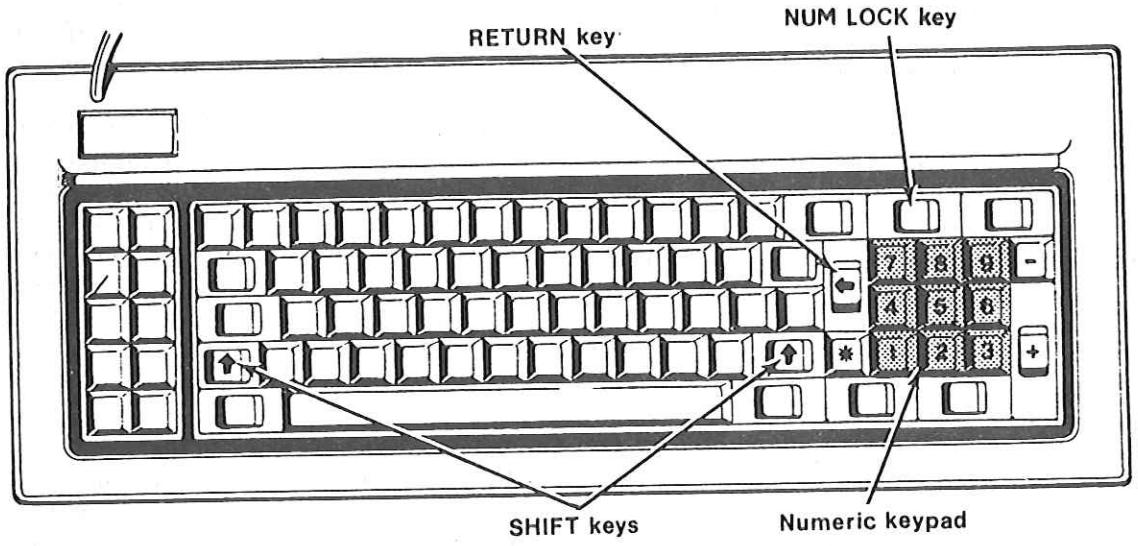


Figure A-3. Compaq computer keyboard.

3. After the recorder enters the date and time, the program will respond with **GOOD MORNING. NOW IT IS TIME TO MEASURE SOME SOLDIERS.** It then requests the sex of the current group of subjects, with **WHAT SEX IS TO BE MEASURED? (M/F).** You respond with M when males are to be measured and F when females are to be measured. The program verifies the input by responding **WE NOW MEASURE WOMEN** or **WE NOW MEASURE MEN**, as appropriate.

4. The program next informs you of the status of the session so far. It first tells you what sex is being measured: **WE ARE MEASURING MEN** or **WE ARE MEASURING WOMEN**, as appropriate. It then says **MEASURER'S NAME IS XXX**, where **XXX** is the measurer's name. A third line says **CHANGE MEASURER'S NAME? (Y/N)** and the appropriate responses are Y for yes and N for no, or -1 to return to the previous step. This is used to set the measurer's name when the program is first begun, and it is used subsequently when the measurer and recorder switch roles between subjects. When using the program for the first time each day, either the Y or N response will elicit the next prompt, **ENTER THE MEASURER'S NAME.** Later, only the Y response will elicit the prompt for the measurer's name. Your first name is sufficient as a response to the prompt. After these initial questions, the program is ready to accept data from each subject. At this point, insert the subject's diskette into disk drive B if you have not already done so.

5. The subject's diskette should be inserted into Drive B (on the right) in the same manner as the station's diskette was inserted into Drive A. Then insert the subject's data recording form into the printer. It should be centered between the marks drawn on the top panel of the printer. Insert the form as you would a paper into a typewriter and move the paper by moving the thumb roller away from you. The thumb roller is located on the left side of the top panel. Roll the paper in until the top edge is just at the edge of the clear plastic shield. Press the orange on-line button on top of the printer. The yellow light should be lit.

6. The next prompt is **TYPE IN THE SUBJECT NUMBER**, and the appropriate response is the subject number on the subject's diskette and his/her data form. Numeric data may be entered from the numbers on the top row of the keyboard (as on a typewriter) or from the numeric keypad on the side of the keyboard (see Figure A-3) which is more efficient to use when only numbers are being punched in. Note that the *, +, and - keys used in this software can all easily be reached from the numeric keypad. If the keypad is to be used, it is necessary to press the NUM LOCK key at the top of the keypad (see Figure A-3).

7. After typing in the subject number, the program is ready for the anthropometric data. The next prompt will depend on which station is being used. Assuming station #1, for example, the prompt is **PLEASE MEASURE #1 STATURE.** The correct response is the subject's stature, in millimeters (mm). No decimal points will be used. Thus if the person's stature is 185.7 cm or 1857 mm, you should enter 1857. At the same time the entry is handwritten on a data form provided at each station as insurance against a power failure. After each measurement is entered, the prompt for the next measurement will be displayed.

If, after entering a value, you realize you have entered it incorrectly, enter a -1 for the next value. This will cause the program to prompt **RESTART MEASURING SEQUENCE AT VARIABLE NUMBER.** You can then enter the number of the dimension whose correct value you wish to enter, and the program will ask for that dimension again, as in **PLEASE MEASURE #2 CERVICALE HT.** If you enter a -1 for the variable number, you will be returned to the prompt **CHANGE MEASURER'S NAME.**

Occasionally it will not be possible to make a measurement. This might occur if the subject has had surgery or some disfigurement which would make the measurement meaningless. In such a case, the correct value to enter is zero (0). Since this is not a usual response, however, when a zero is entered the program will respond, for example, **BITRAGION-CRINION ARC IS ZERO!! IS THIS CORRECT? (Y/N).** If the value is actually missing, simply respond Y or +, and the program will move to the next dimension. If the zero was entered in error, an N or - response will cause the program to ask for that dimension again, as **PLEASE MEASURE #3 BITRAGION-CRINION ARC.**

8. The data entry software contains a number of checks to verify that the data are entered accurately. The first of these is a range check to see if the entered value is within the range (minimum and maximum) of previously measured subjects for that dimension. If the entered value is outside that range, an auditory signal will be given and the screen will display a number of choices. Using CERVICALE HEIGHT as an example, let us say that the

correctly measured value is 1585. Let us further suppose that the recorder has entered the value 1855, in error. The screen will display the following:

MIN = 1424.6 MAX = 1671.6

THIS VALUE IS NOT IN RANGE!

PLEASE CHECK THE INPUTED VALUE FOR CERVICALE HT

IF YOU WANT TO CHANGE THE VALUE TYPE IN C OR *

IF THE SUBJECT IS SMALL TYPE IN S OR -

IF THE SUBJECT IS LARGE TYPE IN L OR +

This alerts you to the possibility of an error. If the recorder realizes his/her error, he/she can enter a C or *. When one of those is entered, the response is **CERVICALE HT =** , the corrected value can be entered and the program goes on to the next dimension.

To continue with the CERVICALE HEIGHT example, if the correct value were 1685 and that were entered, the same display would appear on the screen. Since in this case the subject is simply large, and the value is therefore out of range, the correct response is L or + (the subject is large). Similarly, if the correct value were below the bottom of the range, you would respond S or -.

After all the dimensions have been measured and entered, the program will display a table showing the names of all dimensions and the recorded values of all dimensions. At the bottom of the table, the following prompt is displayed: **DO YOU WANT TO CHANGE ANY VALUES? (Y/N).** If all the values are appropriate you respond, simply, N. However, if upon checking values against the handwritten entries on the backup data forms, discrepancies are apparent, you respond Y. The screen displays: **TYPE IN THE VARIABLE NUMBER AND THE NEW VALUE WITH A SPACE IN BETWEEN.** One could respond, for example, 2 1588, which would refer to variable number 2, CERVICALE HEIGHT, and the new measurement for that dimension. If you change a value, the table is displayed again, and the question is again posed, **DO YOU WISH TO CHANGE ANY VALUES?**

In addition to the measured dimensions, the display will also show nonmeasured variables. These are sex (number 31), measurer's name (number 32), system (number 33) and erase (number 34). If at this time you discover that the sex or measurer's name is wrong, it can be changed. Note that at this point the sex is numerically coded so that 1 = male and 2 = female. If you change variable 33 (system) to 1, you will have access to DOS and can enter any DOS command. (The software is currently operating in a DOS 3.2 environment.) After entering the command, enter a blank line (the RETURN key) to return to the program. If you set variable 34 (erase) to 1, all data for that subject are eliminated, and the program is ready for a new subject. This should be used when, from reviewing the table, it is clear that there has been a serious confusion and most of the values are incorrect. It is also used in the unlikely event that a subject is not able to complete the measuring sequence.

If, on reviewing the table, it is clear that there has been a serious confusion and most of the values are incorrect, the best approach is to start with that subject again. In such a case, respond Y or + to the question about changing values. When the program asks for a variable number and the new value, type 34 1. This will produce the prompt, **DO YOU WANT TO ERASE ALL THE DATA ENTERED FOR THIS SUBJECT AND ENTER A NEW SUBJECT? (Y/N).** If you respond yes here, the program will return to **CHANGE MEASURER'S NAME?.** A response of no will, of course, cause a return to the table of displayed values.

If there are no more values to be changed, enter N. This causes the program to enter the second phase of data editing. In this phase, the value for each dimension is checked against the values of other dimensions for that subject, to verify that they all "make sense."

9. If there are one or more values which do not correspond with other values for that individual, an audible signal is given, followed by the prompt **PLEASE REMEASURE WAIST HT**, or whatever dimension might appear to be in error. The proper response here is to actually remeasure the dimension indicated. Do not attempt to remember if the original value was entered in error. Simply ask the measurer to retake the measurement and enter the new value. After the new value is entered, each value is again checked. Sometimes several values will need to be remeasured. Occasionally some values may be remeasured a second time. It may occur that several remeasures are caused by a misentered value early in the remeasuring sequence. When this occurs, a -1 entered as a value for any dimension will cause the program to return to the table of measured values. From there, the errant value can be corrected. After the correction is made, and you respond N (or -) to a request for more changes, the new values are edited again.

Sometimes, even after a second remeasure, the program still finds the value out of the ordinary. In such a case the screen will prompt with **WRITE AN EXPLANATION PLEASE.** Respond to this by typing in a few words of explanation about why the measurement(s) appear(s) exceptional. Do not use a comma in the text of your explanation. This may result in other survey software having difficulty reading data from the subject's diskette.

Although it is unlikely to be needed, it is even possible at the explanation stage to return to the table of measured values. In such a case, the first two characters of the explanation must be -1. This response will return you to the table of measured values, which will allow the change of any value, or exit via variable 34. It should be noted, however, that if you return to the table of measured values from the explanation (using the -1) and change a value, the new set of values is edited only one final time. If you attempt to return to the table from the explanation line a second time, you can change values but these values will not be edited. Such an approach is not recommended because it circumvents the editing procedures and could result in bad data points creeping into the data set. The preferred action is to notify your supervisor of the problem so that the necessary corrections can be made when the data are compiled.

10. After all the data have been entered, corrected, and/or explained, the data are written onto both the station diskette and the subject diskette. This occurs automatically and requires no action on your part.

11. The printer then prints the values on the subject's hard copy data sheet. Occasionally the program will appear to "lock up" at this point. Usually this means that it is trying to send data to the printer and is unsuccessful for some reason. If printing does not start right away, first check to see if the ONLINE light is lit. If it is not, press the orange ONLINE button to light it, and printing will proceed. If no lights on the printer control panel are on, this means that there is no power to the printer. Check the ON/OFF switch or power cord, as appropriate. After restoring power to the printer, printing will proceed. When the printing is finished, remove the paper from the printer, remove the subject's diskette from Drive B (on the right), and give both to the subject for transporting to the next station.

12. The program will prompt you with **CHANGE THE MEASURER'S NAME? (Y/N)**, and you can repeat from Step 4. If, at this point, you need to measure subjects of a different gender, do so by replacing the measurer's name with the word "Sex". This will return you to the question **WHAT SEX IS TO BE MEASURED.** If you have measured the last subject for the day, you can exit the program in the following way: respond Y to the question about changing the measurer's name, and when you are prompted for the new name, respond with END. This tells the program you are finished measuring for the day, and stops execution of the program.

13. Turn off the machine, turn off the printer, and turn off the power strip. If you are leaving the measuring location and need to prepare the computer equipment for travel, perform steps 1 through 5 of the Hardware section in reverse order.

MEASUREMENT STATION #7

As at stations #1 through #6, the software to be used at station #7 is specifically designed to accommodate the dimensions at that station. The measurement system at station #7 is the automated headboard device (AHD). The software associated with the AHD is described in detail in a technical report describing the development of the headboard,[1] and Appendix D of the measurer's handbook,[3] and will not be repeated here. The hand photographic system is also located at this station but does not require computer software.

IN/OUT-PROCESSING STATION AND STATION #8 (FOOT MEASURING)

The software at this station serves a variety of functions. First, it establishes the initial data record for the subject, collects his or her biographical information from the data sheet, accepts three foot measurements, and finally, verifies that the subject has visited every station, and that the other station computers have correctly written data onto the diskette. To activate this software, insert the program disk into drive A and type in INOUT8.

The screen at this station initially displays 8 choices:

1 IN PROCESS

2 MEASURE FEET

3 OUT PROCESS

4 ENTER QUESTIONNAIRES

5 COPY QUESTIONNAIRES

6 USE DOS SYSTEM

7 END PROGRAM

8 WRITE SUBJECT'S FILE TO SCREEN

WHAT DO YOU NEED TO DO?

In-process

This choice is used to create a subject disk for each subject. The screen will display **PUT A FORMATTED DISK IN DRIVE B PLEASE** and then ask you to do the following four things (one at a time):

TYPE IN THE SUBJECT'S NUMBER

TYPE IN THE SUBJECT'S SEX (M/F)

TYPE IN THE SUBJECT'S ACTUAL WEIGHT

TYPE IN THE SUBJECT'S ACTUAL HEIGHT

The subject's actual height and actual weight are found on the back of the Biographical Data form. After you have entered the subject's actual weight, the screen will display all the values you have entered and give you an opportunity to change what you have entered. For example, the display might show:

NSUB = 1234

SEX = M

ACTUAL HEIGHT = 1567.0

ACTUAL WEIGHT = 876.0

TYPE E OR * TO EXIT TO MENU

IS ALL THE ABOVE INFORMATION CORRECT? (Y/N)

If the information is not correct, respond N to the question, and you will be given the opportunity to correct the entries. If you wish to continue in-processing, respond Y to the final question and you will be prompted for another subject number. If you respond N, you will be returned to the menu and can make another selection. If you enter -1 for a subject number, you will also be returned to the menu.

Measure Feet

The software for this menu item is nearly identical to that of the anthropometric data collection software at stations #1 through #6. It is for the collection of the three dimensions taken in the footboxes. After the data from a subject have been entered and edited, the program will ask **DO YOU HAVE MORE FEET TO MEASURE (Y/N)?** As before, if you respond Y, you will go to the beginning of the anthropometric data entry section, and enter a new subject number and the foot measurements. If you respond N, you will be returned to the menu, and can select other operations.

Out-process

The function of the software controlled under this menu item is to verify that the software at the other stations has functioned correctly and to compile a cumulative data record of all subjects measured.

When this item is selected, the screen displays:

PLEASE PUT THE NEXT SUBJECT'S DISK IN DRIVE B.

PLEASE TYPE IN THE SUBJECT NUMBER.

As with all other features in this software, the program will check the entered subject number with that on the disk and alert you if they do not match. If the subject numbers do not match, you will be asked to retype the number, or insert another disk, whichever is appropriate. You are then asked to type in the subject number again.

When the subject number you have typed in agrees with the subject number on the disk, the program functions essentially automatically. In the case where all the stations have been recorded on the disk correctly, the screen will display the subject number and inform you of the progress of the program:

SUBJECT 1234

STATION.1 HAS BEEN READ IN.

STATION.2 HAS BEEN READ IN.

STATION.3 HAS BEEN READ IN.

STATION.4 HAS BEEN READ IN.

STATION.5 HAS BEEN READ IN.

STATION.6 HAS BEEN READ IN.

STATION.8 HAS BEEN READ IN.

THE HEAD X-Y-Z COORDINATES HAVE BEEN READ IN.

If the subject has been remeasured, the screen will display the number of the station at which remeasurement occurred. If the subject was not remeasured, the screen will also display that information.

The screen will then ask you whether or not you have more disks to enter. If you answer yes, the screen will indicate that you should put the next subject disk in and ask you to type the next subject number. If you answer no, you will be returned to the menu.

Occasionally, there will be subjects whose disks are, for one reason or another, incomplete. If data from station #1, for example, are missing from the disk, the following message will be displayed:

THE FILE FOR STATION.1 IS MISSING OR DAMAGED.

THERE IS A PROBLEM; PLEASE CHECK THE SUBJECT'S PRINTOUT.

M- THIS STATION IS MISSING FROM THE SUBJECT PRINTOUT.

H- THIS SUBJECT WAS MEASURED ONLY AT THE HEADBOARD.

E- THIS STATION WAS PRINTED ON THE SUBJECT PRINTOUT. ENTER DATA VALUES.

P- PAUSE TO USE DOS SYSTEM COMMANDS.

C- CANCEL THIS SUBJECT.

PLEASE TYPE IN THE APPROPRIATE LETTER.

As the screen indicates, you should check the subject's printout which accompanies the diskette and verify whether the subject was measured at the station in question. If he or she was measured, then type in E, which will prompt you for the values of dimensions measured at that station. If he or she was not measured at that station, then type in M, and the program will go on to check the next station. If the printout shows that the subject was measured only at the headboard, or at the headboard and station #4 (traditional head and hand measurements), type in H, and the program will look only for data from the headboard and Station 4. Occasionally it will be useful to use the DIR command from DOS to view the directory on a subject disk. When this is the case, type in P, which will allow you to enter any DOS command. After entering the DOS command, you will be returned to the program. If, for any reason, you wish to stop entering data from the subject's disk, type in C, for cancel.

If the headboard data are missing from the disk, there are several things that happen. First, you will be instructed to check the subject's printout

to see if the individual was measured at the headboard. If the subject was measured at the headboard, enter +. If the subject was not measured at the headboard, enter -. If the subject was not measured at the headboard, and you enter the minus sign, the program goes on to check for remeasured stations. If the subject was measured at the headboard, enter the plus, and the following is displayed:

ENTER THE FOLLOWING COMMAND: DIR B:*.YS

When you enter the DIR command as indicated, all the headboard files on the subject's disk will be displayed on the screen, such as:

```
VOLUME IN DRIVE B: HAS NO LABEL
DIRECTORY OF B:/
SN03456          YS       234          1-17-88       2:24P
1 FILE(S)              307869 BYTES FREE
```

The program will then ask:

PLEASE TYPE IN THE NUMBER OF FILES DISPLAYED ON THE SCREEN.

In general, there will be either one headboard file, or none at all. If there is one, enter 1, and the screen will then ask you to type in the name of the file as it appears on the directory that has just been listed on the screen. In the example above, you would type in: SN03456. You may include .YS following the name, but it is not necessary. The program will then read in the file, and proceed to check for remeasured stations.

In the case that the directory shows no files, the display will be:

```
VOLUME IN DRIVE B:  HAS NO LABEL
DIRECTORY OF B:/
FILE NOT FOUND
```

Then you would type in 0 when the program asks you to type in the number of files displayed on the screen. The program will then say:

```
PLEASE TYPE IN THE X-Y-Z COORDINATES.
TYPE IN THE THREE COORDINATES WITH A SPACE IN BETWEEN.
R.  TRAGION      =
```

You then type in the X-Y-Z coordinates which are found on the back of the subject's printout. After you type in those for R. Tragion, the next point will be provided as a prompt. After you have entered the last point, the screen will show: **THE HEAD X-Y-Z COORDINATES HAVE BEEN READ IN** and will indicate whether or not the subject has been remeasured at one or more stations. After that display, you are asked, as always, whether you have more data to enter. If you answer yes, you are directed to the next subject. If you answer no, you are returned to the menu.

The data for each subject are compiled into large files on the disk in Drive A. This disk should be replaced with a new formatted disk at the beginning of each week of measuring. Failure to do this will result in loss of data.

Enter Questionnaires

This menu item is used to enter data from the Biographical Data forms. The screen will first display a list of the measuring locations and ask for your selection. Specifically, it will show:

1. **FORT MCCLELLAN**

2. **FORT CAMPBELL**

3. **FORT BRAGG**

4. **FORT STEWART**

5. **FORT DIX** . . . . . etc.

PLEASE ENTER YOUR SELECTION FOR TODAY'S POST.

After you have entered the appropriate number, the name of that post will be displayed at the top of the screen, beside the day's date. It will then ask, **DO YOU WISH TO CHANGE TODAY'S DATE? (Y/N).** If the date is correct, you respond N. If you are entering questionnaire data on a day other than when the form was filled out, respond Y and you will be asked for a new date. Enter the date that is written on the form. As in In-process, the program will next ask you to put a diskette into Drive B, and then display **TYPE IN THE SUBJECT NUMBER PLEASE.** When you enter the number, the program will check to see if the subject file has been previously created with In-process. If the file has previously not been created on the diskette, it will be created. The program then follows exactly the order of questions on the biographical data questionnaire (see Appendix D), except that the subject's name (Question #1) is not entered.

2. **UNIT TO WHICH YOU ARE ASSIGNED AT THIS POST:**

   COMPANY OR BATTERY

   BATTALION

   REGIMENT OR GROUP

   BRIGADE

   DIVISION

Each of the parts in Question 2 is responded to exactly as the subject has filled out his/her questionnaire. Because subjects often appear in groups from a single unit, the program was designed to minimize entry errors. After the first subject, the unit data for that subject are displayed automatically, followed by the question, **DO YOU WISH TO CHANGE UNIT FOR THIS SUBJECT? (Y/N).** If the unit is correct (i.e., the same as for the previous subject), respond N and proceed to Question 3. If the unit is different from the previous subject, respond Y, and the program will ask for each item in turn.

3. **MILITARY COMPONENT:**

1-REGULAR ARMY 2-ARMY RESERVE 3-NATIONAL GUARD 4-MISSING

ENTER THE APPROPRIATE NUMBER:

4. **MILITARY PERSONNEL CLASS:**

E-ENLISTED W-WARRANT OFFICER C-COMMISSIONED OFFICER M-MISSING

ENTER THE APPROPRIATE LETTER:

If either W or C is entered, a follow-on question is displayed: **SPECIFY BRANCH**, and you enter exactly what the subject has written on his or her form.

5. **RANK/GRADE RANK: GRADE:**

You enter the rank from the form using three characters (e.g., PVT for Private, 1LT for First Lieutenant, and so on), and then the grade consisting of two characters (e.g., E3, O5, etc.).

6. **TIME IN SERVICE YEARS: MONTHS:**

7. **MOS PRIMARY: SECONDARY:**

After you enter the primary MOS, as the subject has written it, the program will ask for a secondary MOS. If this is recorded, enter it as written. If there is none, just hit the carriage return for the next question.

R-RIGHT L-LEFT E-EITHER

8. **WITH WHICH HAND DO YOU USUALLY FIRE A WEAPON?**
ENTER THE APPROPRIATE LETTER:

9. **WITH WHICH EYE DO YOU USUALLY SIGHT YOUR WEAPON?**
ENTER THE APPROPRIATE LETTER:

At the bottom of the screen, the program asks **DO YOU WISH TO CHANGE ANY OF THE ABOVE INFORMATION? (Y/N).** If you respond Y, you will be asked which question to go back to and given the opportunity to change your response. If you answer N, the program will go to the next series of questions, found on the second page of the biographical data questionnaire.

The title at the top of the next display corresponds to page 2 of the biographical data questionnaire, Biographical Data: Personal History. As before, the questions on the screen follow almost exactly the questions on the form.

1. **TYPE IN THE SUBJECT'S BIRTHDATE PLEASE.**
(MONTH, DAY, YEAR)

The appropriate response is the birthdate of the subject, using numbers for the months. Each part of the date consists of two characters and is separated by a comma and/or a space.

2. **TYPE IN THE SUBJECT'S AGE PLEASE.**

Respond with the subject's age as he or she has written it on the form.

3. **TYPE IN M FOR MALE OR F FOR FEMALE PLEASE.**

4. **TYPE IN A LETTER FOR THE SUBJECT'S RACE PLEASE.**

   W-White, not of Hispanic origin

   B-Black, not of Hispanic origin

   H-Hispanic

   A-Asian/Pacific Islander

   I-American Indian/Alaskan Native

   M-Mixed

   O-Other

If M or O are entered, the program will respond **PLEASE SPECIFY:**, and you should enter what the subject has written on his or her form. In the case of Mixed, the format is generally one of the above races, followed by a slash, and then another of the races. For example, "White/Hispanic" would be a valid response.

5. **HOW TALL IS THE SUBJECT IN BARE FEET?**

   FEET:

   INCHES:

6. **HOW MUCH DOES THE SUBJECT WEIGH, WITHOUT CLOTHES, IN POUNDS?**

Both 5. and 6. are entered directly as the subject has written them on the form.

7. **DOES THE SUBJECT WEAR:**

   G FOR PRESCRIPTION GLASSES C FOR PRESCRIPTION CONTACT LENSES

   B FOR BOTH N FOR NEITHER M FOR MISSING

   TYPE IN A LETTER.

R-RIGHT L-LEFT E-EITHER M-MISSING

8. **WITH WHICH HAND DOES THE SUBJECT USUALLY WRITE.**

ENTER THE APPROPRIATE LETTER.

After answering questions 1 through 8, the program displays the entered answers in an easily readable format at the bottom of the screen and asks the question, **DO YOU WANT TO CHANGE ANY OF THE ABOVE INFORMATION (Y/N)?**, to which you answer N if all the information is correct and you want to go on to the next page, or Y if one or more items need to be changed. If you respond Y, the program will prompt for the number of the item to which you wish to return, and the correct entry may be made.

On the third page of the form, the first question is **9. DOES THE SUBJECT CURRENTLY PARTICIPATE IN RESISTANCE OR FREE WEIGHT TRAINING AT LEAST ONCE A WEEK (Y/N)?** If the subject has responded N, enter that and the program will proceed to question 10. If you enter Y, the program will display:

A. **HOW LONG HAS THE SUBJECT BEEN INVOLVED IN THIS TRAINING?**

YEARS: **MONTHS:**

B. **HOW MANY DAYS PER WEEK DOES THE SUBJECT NOW TRAIN?**

UPPER BODY: DAYS PER WEEK:

LOWER BODY: DAYS PER WEEK:

C. **ON THE DAYS THAT THE SUBJECT DOES TRAIN, HOW MANY HOURS PER DAY DOES THE SUBJECT TRAIN?**

UPPER BODY: HOURS PER DAY:

LOWER BODY: HOURS PER DAY:

In each case, you enter the numbers shown on the subject's form.

10. **DOES THE SUBJECT RUN ON A REGULAR BASIS (Y/N)?**

As in question 9 if the subject does not run, enter N, and the program will proceed to the next item. If the subject does run, enter Y, which will invoke the following prompts:

A. **HOW LONG HAS THE SUBJECT BEEN RUNNING?**

YEARS: **MONTHS:**

B. **HOW MANY DAYS PER WEEK DOES THE SUBJECT RUN?**

DAYS PER WEEK:

C. **HOW MANY MILES PER DAY DOES THE SUBJECT USUALLY RUN?**

MILES:

After questions 9 and 10 have been answered, the screen displays the information from those two questions in an easily readable format and prompts: **DO YOU WANT TO CHANGE ANY OF THE ABOVE INFORMATION (Y/N)?** As before, a Y response allows a change, and the N response moves to questions on the last page of the form.

The first three questions on the last page of the form are:

11. **SUBJECT'S BIRTHPLACE:**

12. **MOTHER'S BIRTHPLACE:**

13. **FATHER'S BIRTHPLACE:**

and the correct response is the two-letter postal abbreviation for the state in which the subject, the mother, and the father were born. The subject will often include the name of the city or the county, and will often write out the name of the state. The only thing that should be entered is the abbreviation for the state. For example, if the subject has written that his birthplace is "Little Rock, Arkansas", you would enter "AR". Where the response is a foreign country, enter the complete name of the country, but not the city or state within that country. For example, if the subject's mother were born in Ontario, Canada, you would enter "Canada" for question 12.

The screen next prompts with:

14. **TYPE IN A LETTER FOR THE SUBJECT'S MOTHER'S RACE PLEASE.**

W-White, not of Hispanic origin

B-Black, not of Hispanic origin

H-Hispanic

A-Asian/Pacific Islander

I-American Indian/Alaskan Native

M-Mixed

O-Other

As before, if you enter M or O, you will be prompted to specify the other race or the racial mix.

Similarly, question 15 is:

15. TYPE IN A LETTER FOR THE SUBJECT'S FATHER'S RACE PLEASE.

W-White, not of Hispanic origin

B-Black, not of Hispanic origin

H-Hispanic

A-Asian/Pacific Islander

I-American Indian/Alaskan Native

M-Mixed

O-Other

and you respond in like fashion.

The responses to the three parts of Question 16 on ethnicity/national extraction have been obtained by interview and are quite consistent in format. For these questions, you type in exactly the same information that is written on the form. The format of the question on the screen is:

16. ETHNICITY/NATIONAL EXTRACTION

SUBJECT:

MOTHER:

FATHER:

Next, the following appears:

17. BODY DIMENSIONS

ACTUAL HEIGHT: **ACTUAL WEIGHT:**

And you respond with the same information that is written on the form. Again, these have been obtained by team members, not specified by the subjects themselves, and they are to be entered exactly as written, which is in the form of three or four digits, as appropriate, without a decimal point.

Finally, the program will ask, one last time, if you want to change any of the information entered from the last page. If you do not, respond N and the next question will be **DO YOU HAVE MORE DATA TO ENTER (Y/N)?** If there is another subject biographical form you wish to enter, respond Y, and the screen will show **PUT THE SUBJECT'S DISK IN DRIVE AND THEN PRESS ENTER.** This will allow you to go on to the next subject's form. If you do not intend to enter another form, respond N to the question, and you will be returned to the menu.

Copy Questionnaires

This program is used when questionnaire data have been entered while the subject is being measured at Stations #1 through #7. In such a case, the subject will have his/her diskette at the stations, away from the In- and Out-Processing station. Thus the questionnaire data would not have been entered on the subject's disk but on a temporary storage disk kept at the In- and Out-Processing station. When such a subject returns for out-processing, the questionnaire data will need to be copied from the temporary storage disk onto his subject disk. That is the purpose of this menu item. When this is selected, the screen will display:

PLEASE PLACE THE TEMPORARY STORAGE DISK IN DRIVE A.

PLEASE PLACE THE SUBJECT'S DISK IN DRIVE B.

TYPE IN THE SUBJECT NUMBER PLEASE.

After you type in the subject number, the rest of the program's function is automatic and does not require operator input. When the copying is complete, the screen will display:

REMOVE THE SUBJECT'S DISK FROM DRIVE B.

DO YOU HAVE MORE QUESTIONNAIRE DATA TO COPY (Y/N)?

If you respond Y, you can copy data onto the next subject's disk. If you respond N, you will be returned to the menu.

Use DOS System

This item on the menu makes it possible to temporarily "jump out" of the program and execute a DOS command. Although any DOS command could be used, probably the most useful one in the context of this software would be DIR, the command which lists a directory of files on the disk.

To use this item, simply enter 6 from the menu. The screen will display:

PAUSE - PLEASE ENTER A BLANK LINE (TO CONTINUE) OR A DOS COMMAND.

You can then enter whichever DOS command you need. After the DOS command has been executed, the program will prompt:

PRESS THE ENTER KEY TO RETURN TO THE MENU.

and you can easily return to the program by pressing the ENTER key.

End Program

This item is self-explanatory. It will return the **A>** prompt.

Write the Subject's File to Screen

The last item on the menu is used when you wish to check that the out-processing is correctly writing information to the data disk in Drive A. This reads data from that disk and displays it on the screen. When you select this menu item, the screen prompts with **TYPE IN THE SUBJECT NUMBER YOU WANT TO SEE.** After you enter the subject number, the display is **STATION 1 PRESS THE ENTER KEY TO VIEW THE NEXT STATION** followed by all the data collected at Station #1 in an abbreviated tabular format. This includes the subject number, the measurer's name, the sex of the subject (1=male, 2=female), any comments or explanations, all the anthropometric data, remeasure values for all dimensions which were remeasured due to the regression equations, and the standard errors of estimates calculated by the regression equations. That display remains on the screen until you press ENTER, which will display Station #2, and so on proceeding through Station #6, then #8 (feet), and ending with Station #7 (the headboard data). At the bottom of the display of headboard data, the prompt is **READ ANOTHER SUBJECT'S FILE? (Y/N).** If you respond Y, you get the prompt for a new subject number; if you respond N, you are returned to the menu.

CARE AND MAINTENANCE OF THE COMPUTER EQUIPMENT

The computer, while designed to be portable, is not indestructable. It should not be dropped, thrown, or have heavy equipment stacked on it. Treat it as you would any fine piece of electronic equipment. When handled with reasonable care, the computer requires very little maintenance. Periodically, when required, clean the screen with a spray window cleaner and a soft cloth.

The diskettes require no maintenance, but must be handled very carefully. The window, a cutout place in the diskette sleeve, is where the disk drive writes and reads information to and from the diskette (see Figure A-2). **IT IS VERY IMPORTANT NOT TO TOUCH THE SURFACE OF THE DISKETTE WHERE IT IS EXPOSED AT THE WINDOW.** To do so could damage the diskette and result in loss of data. When the diskette is not in the drive, it should be inserted into its protective jacket. Insert the diskette so that the window goes into the jacket first, and is completely protected. The diskettes should be stored upright, and kept away from magnetic fields and extreme temperatures.

APPENDIX B.

Instruction Manual for the Operation and Maintenance of the Hand Photometric System

APPENDIX B.

Instruction Manual for the Operation and Maintenance
of the Hand Photometric System

Step-by-step instructions for the operation and care of the hand photometric system follow. Several steps need to be performed only after shipping and are so indicated; others are followed routinely.

OPERATION

1. The hand photometric system requires a grounded (three-pronged) electric outlet. Plug in the 19-foot long electrical cord attached to the back panel (Figure B-1, A) into a normal 1100 AC outlet.

2. Flip the power switch up to turn on the device (Figure B-1, B). The light to the left of the switch will indicate that the power is on.

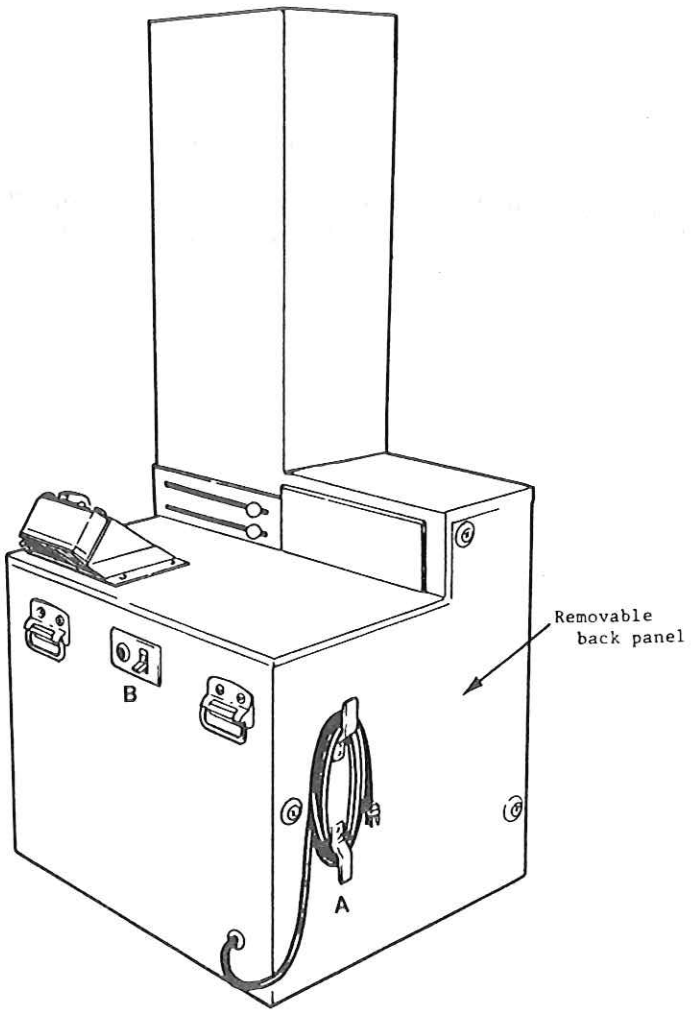


Figure B-1. Hand Photometric System: rear left view.

3. The photobox in which the subjects place their hands is accessed by a swing-down door that becomes the arm rest in its open position (see Figure B-2). The door is held in a closed position by a tension catch. To open the area, release the catch by pulling the knob out and up, simultaneously (see Figure B-3). Some sticking may occur, so pull the arm rest down slowly.

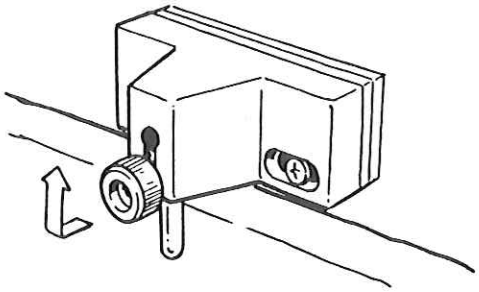


Figure B-3. Arm rest shelf catch.

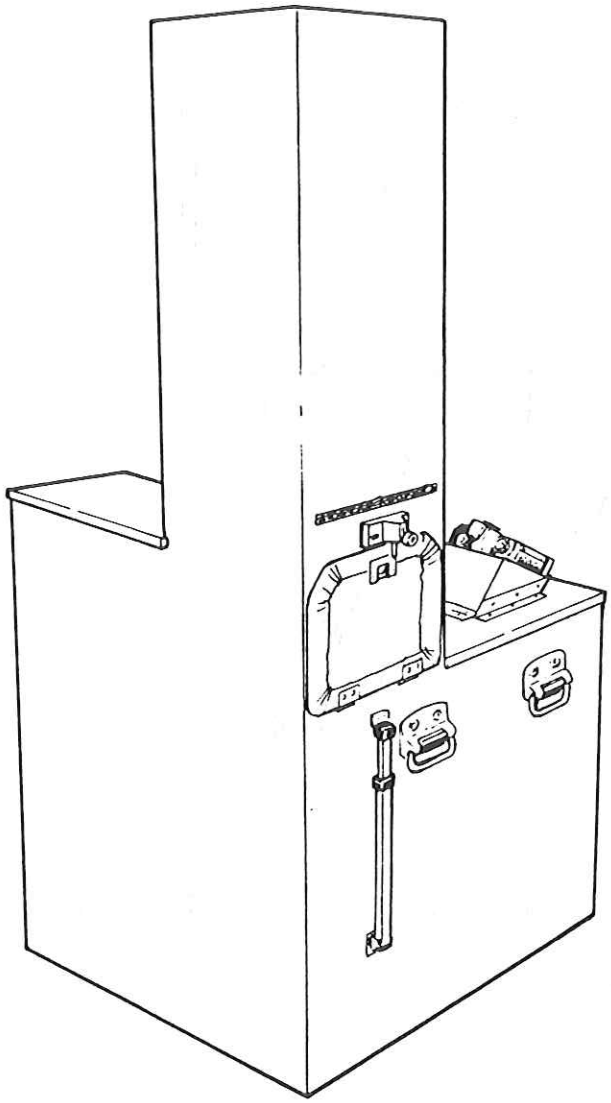


Figure B-2. Hand Photometric System: right front view.

4. Adjust the arm rest so that it is parallel to the floor by raising or lowering the extension bar (Figure B-4). The end of the extension bar should be secured firmly in a notch underneath the arm rest.

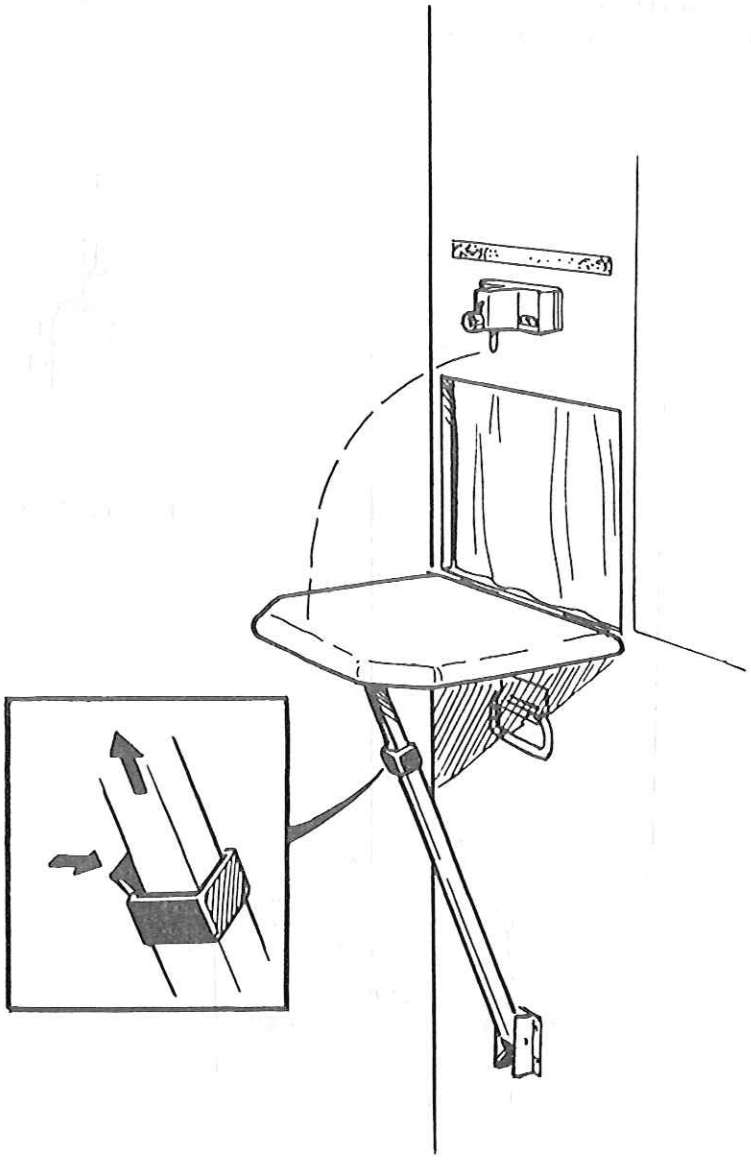


Figure B-4. Arm rest shelf and extension bar.

5. Raise the black curtain and secure it to the velcro strip (Figure B-5, A).

6. The subject is seated to the left side of the device so that the right elbow rests comfortably on the arm rest (Figure B-5). The subject should remove all jewelry from the right hand and arm.

7. On the right side of the tall section of the box are two round knobs. The upper knob (Figure B-5, B) slides the alignment grid forward and back, and the lower knob (Figure B-5, C) slides the diffuser plate forward and back. After the subject is seated, pull the alignment grid forward so that the grid is projected onto the subject's hand.

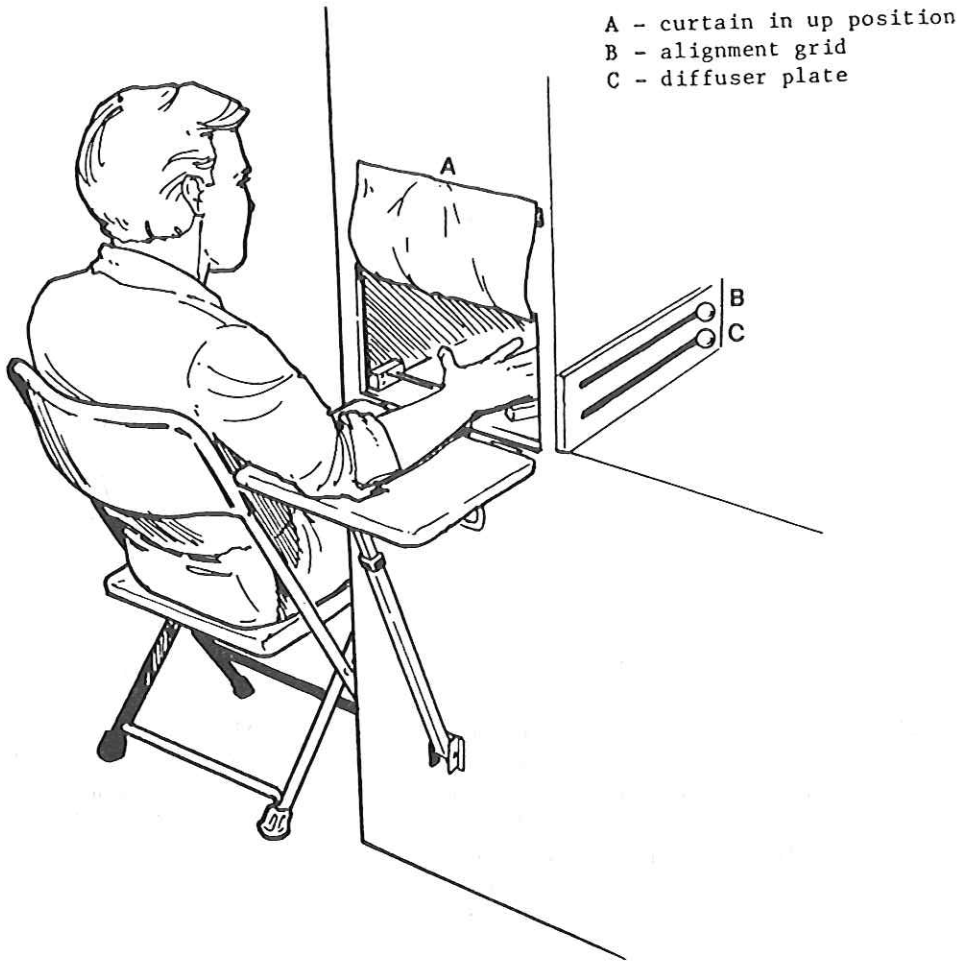


Figure B-5. Subject seated at photobox.

8. Carefully align the subject's hand (Figure B-6) using the grid and the stylion indicator rod (Figure B-7). This is a six-part process:

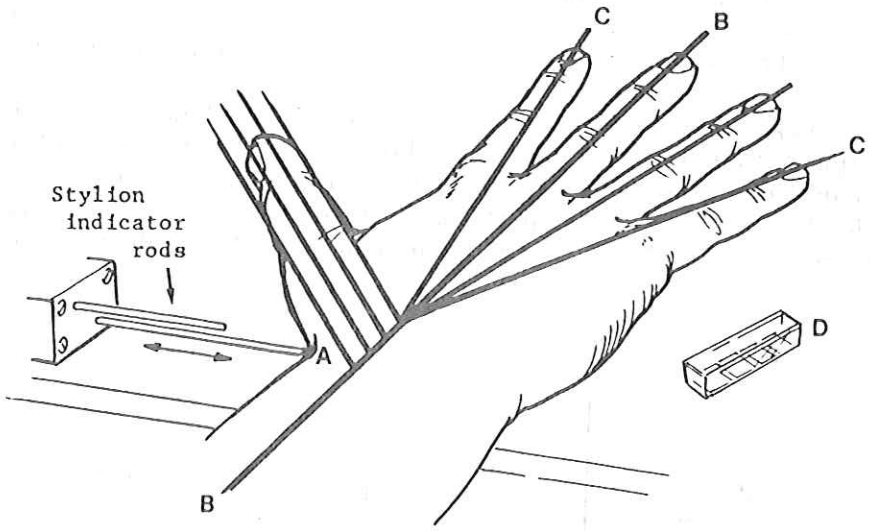


Figure B-6. Hand alignment grid.

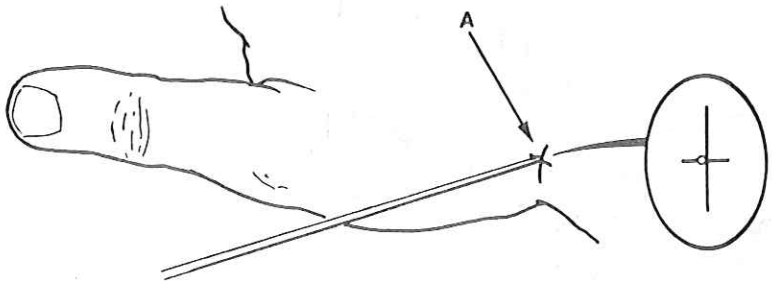


Figure B-7. Stylion indicator rod alignment.

(a) Place the subject's hand in the center of the glass plate, moving the subject's hand forward and backward until the front side of the indicator rod is in contact with the stylion mark as illustrated in Figure B-7. There are two stylion indicator rods, one closer to the inside of the box for smaller hands and one closer to the outside for larger hands.

(b) Keeping the stylion landmark aligned with the rod, rotate the hand side to side until the second-from-left long grid line (line B in Figure B-6) is projected directly over the third metacarpophalangeal joint and runs down the long axis of the forearm through the center of the wrist. That grid line B does not appear to be aligned with the center of the wrist in Figure B-6 is a function of the perspective from which the hand is drawn.

This illustrates the importance of looking straight down on the wrist while orienting it on the grid. If the hand is viewed from an angle, it will be incorrectly placed.

(c) Instruct the subject to place the hand firmly enough on the plate so that all the fleshy pads are touching. No extra pressure should be exerted. Adjust the alignment grid by using the upper knob to slide the plate back and forth on the track until the two long outside lines (Figure B-5, C) are projected over the second and fifth metacarpophalangeal joints. With three fingers lined up, the fourth metacarpophalangeal joint should automatically be aligned. Not all subjects have perfectly straight hands and fingers. In such cases line them up through the third finger and average out the discrepancies between the second and fifth fingers.

(d) Adjust the fingers so that the grid lines pass over the center of each fingertip.

(e) The thumb is aligned so that its long axis is parallel to the grid lines. Because the thumb joint allows for a great deal of freedom of movement, the thumb can be parallel in several positions. Place the thumb so it is parallel with the first set of lines closest to the hand. That is, begin with the thumb placed next to the hand, slowly abduct it (move it away from the hand), and stop when it is parallel with the grid.

(f) When the hand is aligned, check to be sure that the stylion indicator rod is still in contact with the stylion landmark. Instruct the subject to hold the hand still. Now, push back the upper knob (Figure B-5, B), removing the grid.

9. Place the subject number tray next to, but not touching, the right side of the hand (Figure B-6, D)

10. Lower the black curtain to shield out light.

11. Look through the camera lens to ensure that

- the grid is completely out of the way,
- the subject numbers are legible,
- the diffuser plate is properly placed (see step 12),
- the stylion indicator is in direct contact with the skin.

12. Two pictures will be taken of each subject: (a) a silhouette in which the diffuser plate is moved forward toward the subject, using the lower round knob (Figure B-5, C); and, (b) a palm picture which requires that the diffuser plate be removed by pushing the lower round knob toward the back of the device. A flash required for this picture is wired by way of a relay switch to the diffuser plate track. That is, it will flash automatically if the diffuser plate is properly removed.

13. After both pictures are taken, lift the curtain, pull the stylion indicator rod away from the hand, and ask the subject to remove the hand.

14. If there will be more than a 10-minute interval between subjects, turn the device off.

15. As needed (usually after use by eight or ten subjects), clean the glass plate on which subjects rest their hands by spraying glass cleaner on a lint-free cloth and then wiping the plate. DO NOT SPRAY ANYTHING INSIDE THE DEVICE. If necessary, the diffuser plate and alignment grid may be cleaned the same way.

CAMERA SETTING AND OPERATIONS

The hand photometric system uses a Nikon N2000 35-mm camera (Figure B-8), and 24- or 36-exposure 400 ASA black and white film. The camera is rigidly mounted in the photobox by means of a wing-nut screw inserted through the box frame into the camera. It should be removed only if the front settings are disturbed or if it gets out of focus. The lens is protected by a black velvet sleeve to shield out light and dust.

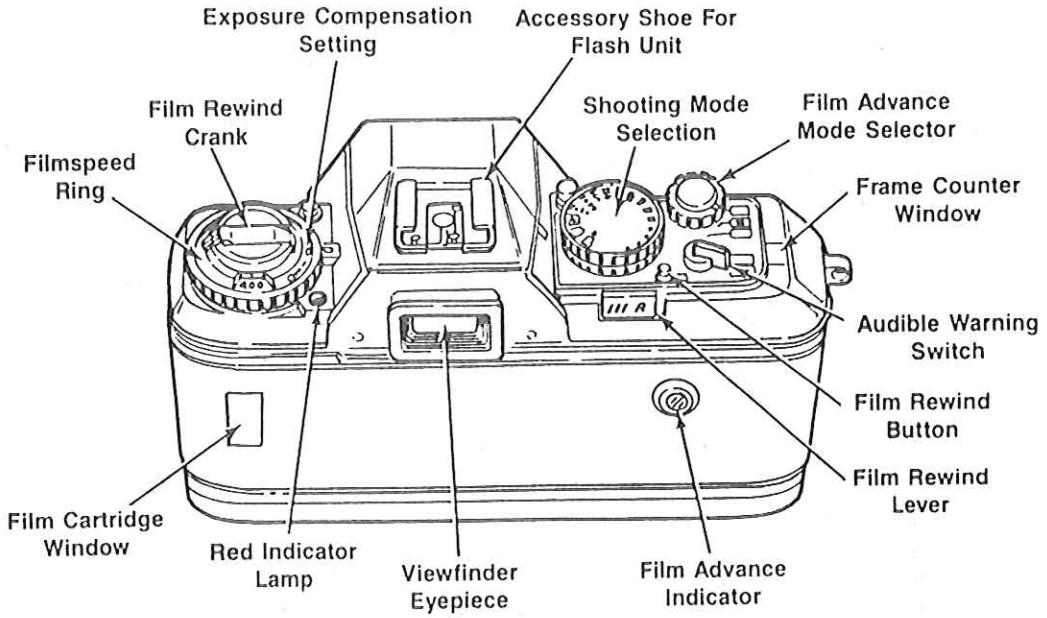


Figure B-8. Nikon N2000 35-mm camera.

After shipping, or in the event of its being jarred, the following settings should be checked:

1. Check focus by placing the subject number tray on the viewing plate to see if the numbers are clearly visible. Because the camera is firmly mounted and the focusing apparatus has been sealed by tape into the correct position, it should not require adjustment. If, however, it does become unfocused, reset to proper lens setting as shown in Figure B-9. If the camera is still out of focus after correcting the settings, the lens may need to be repaired or replaced. Notifiy the supervisor if this occurs.

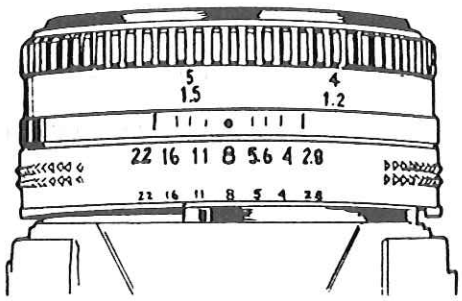


Figure B-9. Lens setting.

2. The film advance mode should be set on S (Figure B-10). If it requires adjusting, pull the knob up and turn (Figure B-11).

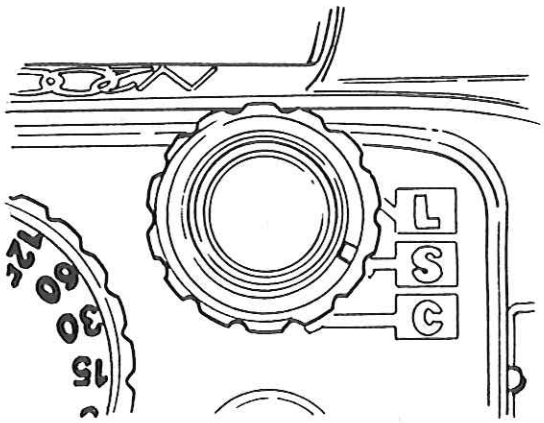


Figure B-10. Film advance mode.

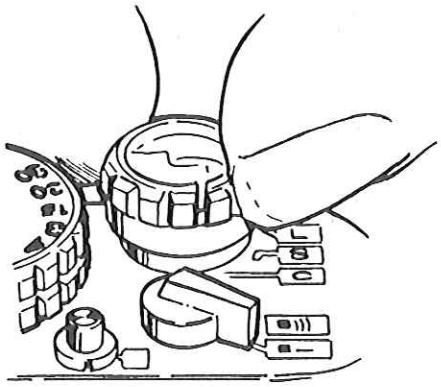


Figure B-11. Adjusting film advance mode.

3. The audible warning switch should be turned off, as shown in Figure B-12.

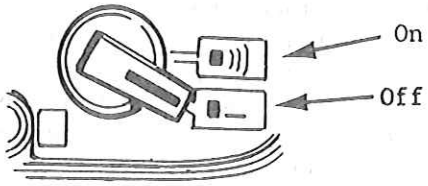


Figure B-12. Audible warning switch.

4. The shooting mode selector dial should be set on A (Figure B-13).

5. The film speed ring should be set at 400 (Figure B-14).

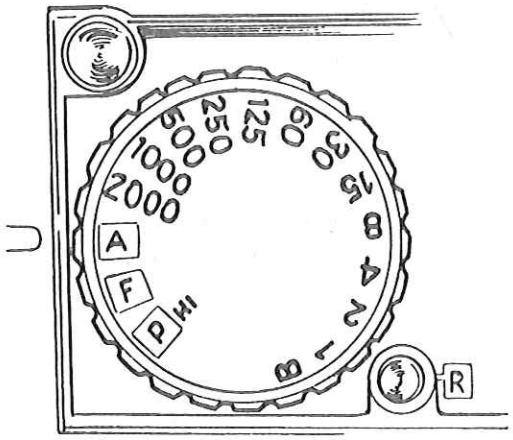


Figure B-13. Shooting mode selector.

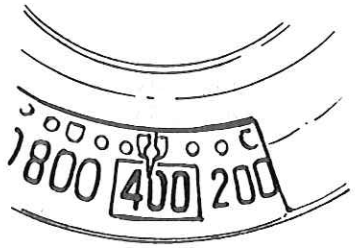


Figure B-14. Film speed ring.

6. The exposure compensation setting should be set at 0 (Figure B-15).

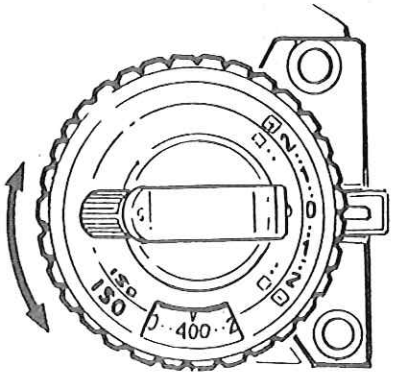


Figure B-15. Exposure compensation setting.

Loading Film

1. Open the camera back by pulling up on the film rewind knob until the camera back springs open (Figure B-16). See Figure B-17 for identification of parts inside the camera.

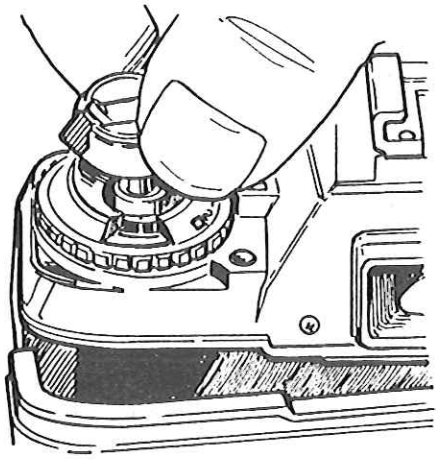


Figure B-16. Opening the camera.

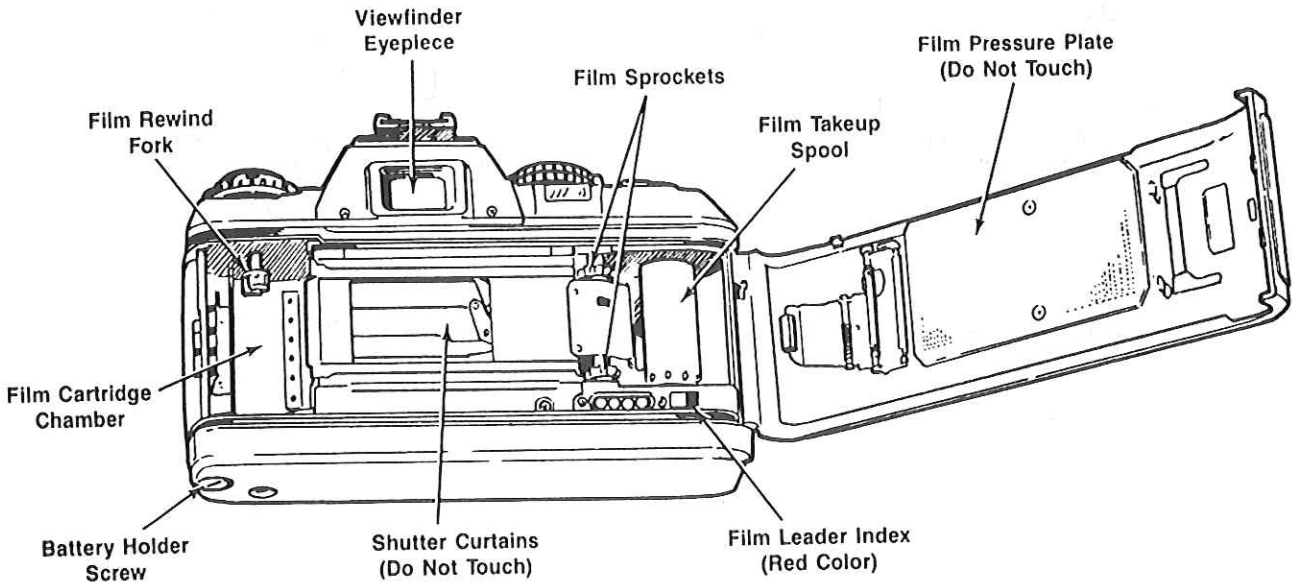


Figure B-17. Internal camera parts.

2. Position the film cartridge (see Figure B-18) so that the slotted end of the cartridge is at the top; lower the rewind knob.

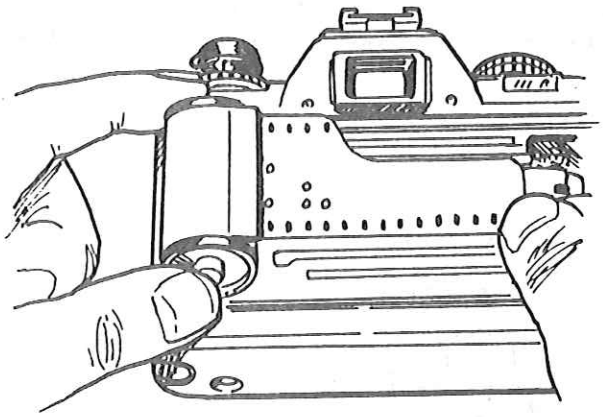


Figure B-18. Positioning the film cartridge.

3. Pull the film leader out to the red index mark (Figure B-19). There should be no slack in the film (Figure B-20).

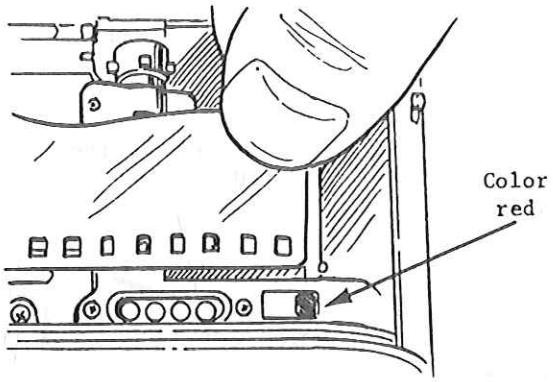


Figure B-19. Pulling out film leader.

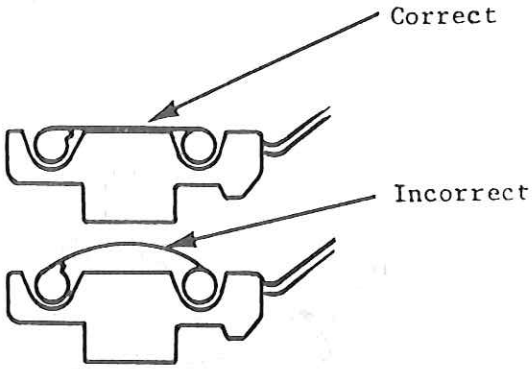


Figure B-20. Loading the film.

4. Close the back of the camera.

5. Press the top of the remote shutter release (Figure B-21) to automatically advance the film to frame "1" (Figure B-22).

Figure B-21. Remote shutter release.

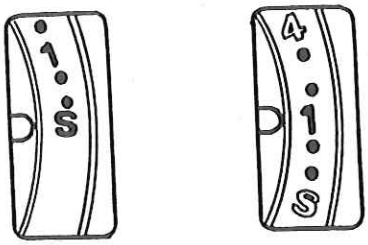


Figure B-22. Frame counter window.

Rewinding Film

When the film has been used up, the red indicator lamp (see Figure B-8) will flash. Rewind the film in the following way:

1. While sliding the film rewind lever to the right, push the film rewind button down (Figure B-23).

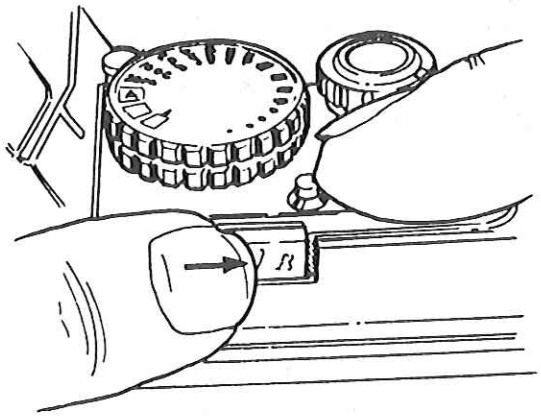


Figure B-23. Film rewind button and lever.

2. Fold out the film rewind crank and rotate it clockwise (Figure B-24) until the film advance indicator (Figure B-25) stops moving.

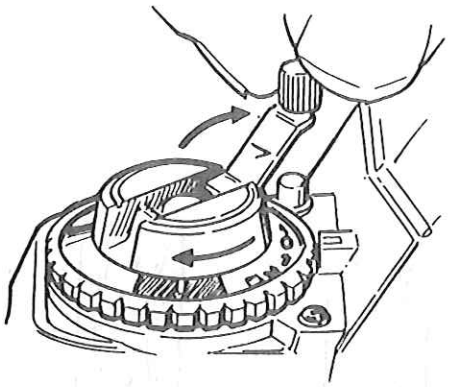


Figure B-24. Film rewind crank.

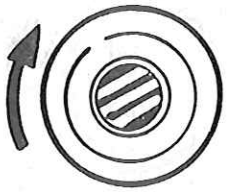


Figure B-25. Film advance indicator.

3. Pull up on the film rewind crank until the camera back springs open and remove film (Figure B-26).

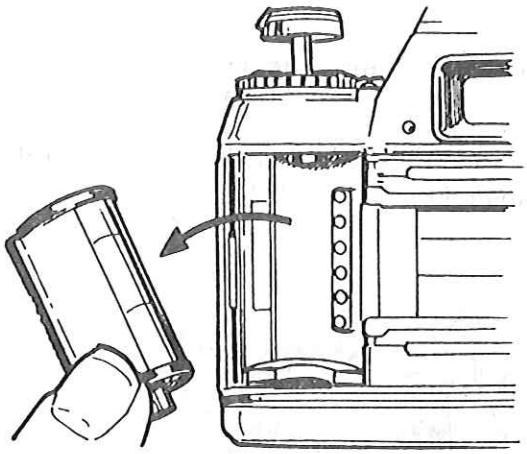


Figure B-26. Removing film.

Replacing Batteries

When the film advance begins to sound sluggish, it is time to change the batteries. This is done in the following way:

1. Use a quarter to remove the battery holder by turning the battery holder screw counterclockwise (Figure B-27).

2. Remove the bracket (Figure B-28).

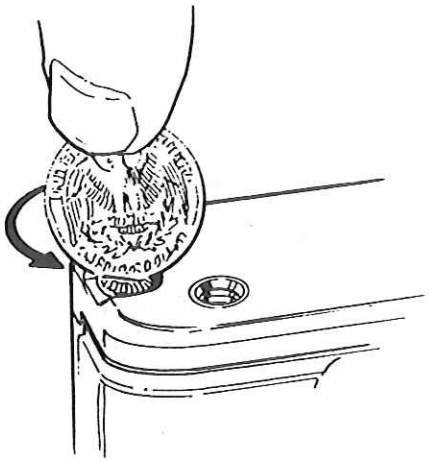


Figure B-27. Removing battery holder.

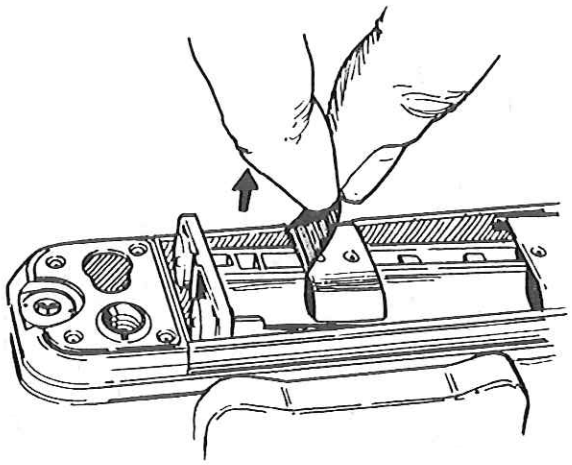


Figure B-28. Removing battery bracket.

3. Install four AAA-type batteries (Figure B-29).

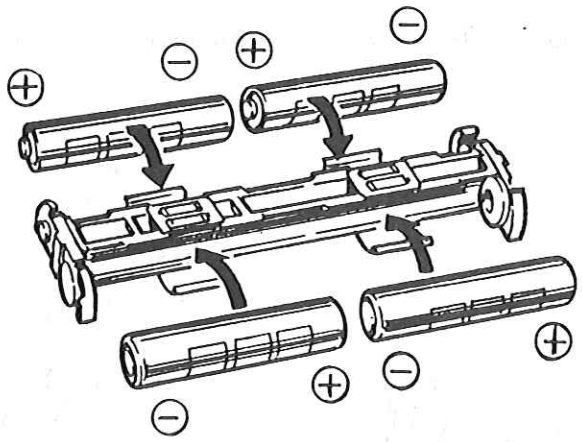


Figure B-29. Installing batteries.

4. Align the white dots and replace the bracket (Figure B-30).

5. Line up the hole in the bottom with the post in the camera base and reattach the battery holder (Figure B-31).

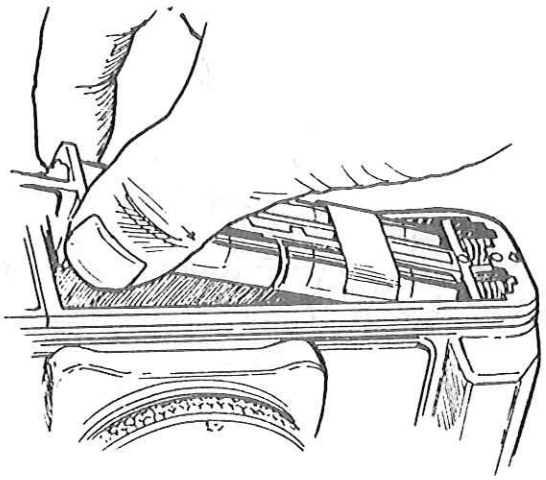


Figure B-30. Replacing battery bracket.

Figure B-31. Reattaching battery holder.

Precautions

1. Replace the view finder eyepiece cover (Figure B-32) whenever the camera is not in use.

2. Never touch the reflex mirror or focusing screen (Figure B-33).

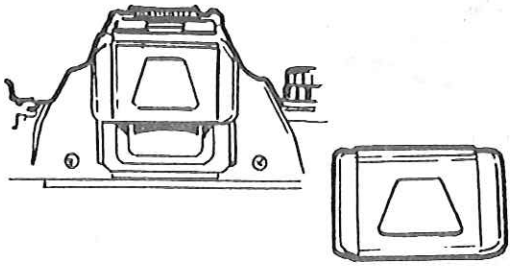


Figure B-32. Viewfinder eyepiece cover.

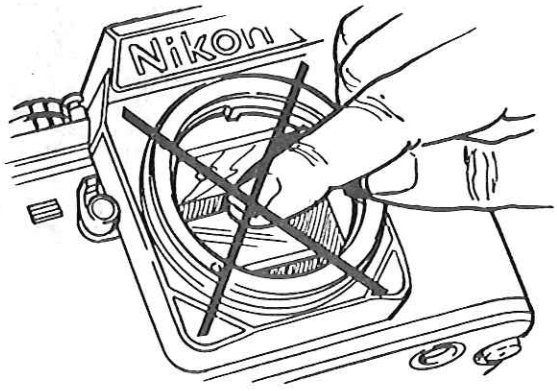


Figure B-33. Do not touch the reflex mirror.

3. Never touch the DX-contacts (Figure B-34).

4. Never touch the shutter curtains (Figure B-35).

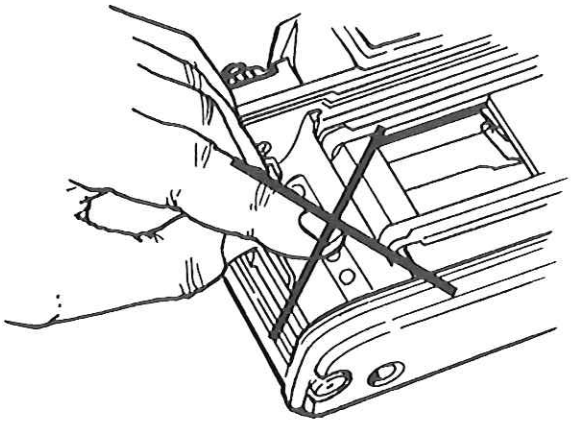


Figure B-34. Do not touch the DX-contacts.

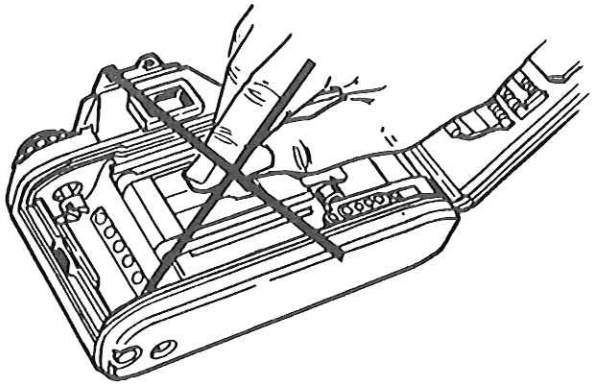


Figure B-35. Do not touch the shutter curtains.

MAINTENANCE

Unless the hand photometric system malfunctions, the only reason the device should be opened is to check for broken parts and to vacuum dust after shipping. The maintenance procedures to be followed when the device is shipped to a new location are as follows:

1. Remove the back of the device by using a 7/16-inch socket wrench.

2. Using a can of canned air (hold it vertically -- the slightest tilt of the can causes liquid to escape), dust off the mirror. CAUTION: The mirror is a very sensitive part of the mechanism and should not be touched.

3. Dust the remaining area (electronic components and floor) with a battery powered vacuum cleaner.

4. Replace the back panel; tightly secure bolts.

5. Check the camera settings (see section on camera instructions).

6. To ensure that the photobox is fully operational, use the Polaroid 35-mm Auto Processor (which is provided) to produce instant slides.

APPENDIX C.

Commercial Sources and Specifications for Anthropometric Instruments

APPENDIX C.

Commercial Sources and Specifications for
Anthropometric Instruments

A number of standard anthropometric instruments as well as a few unique instruments are used in this survey. The standard instruments include:

GPM anthropometer	Catalogue No. 101
base plate	Catalogue No. 101F
sliding caliper	Catalogue No. 104
sliding caliper (Poech type)	Catalogue No. 114
spreading caliper, rounded	Catalogue No. 106
Bicondylar Vernier caliper (Holtain caliper)	Catalogue No. 604

Source: Seritex, Inc., 450 Barell Avenue, Carlstadt, NJ 07072

These instruments are illustrated in Figures C-1 and C-2. In Figure C-1 the anthropometer is illustrated in the two modes in which it can be used: In the center of the picture are the four interconnecting sections which constitute the basic anthropometer with base; on the left the top section of the anthropometer is configured as a beam caliper; on the right is the beam caliper with paddles. In Figure C-2 are shown the tape and calipers: (a) measuring tape, (b) spreading caliper, (c) spreading caliper, (d) Holtain caliper, and (e) Poech caliper.

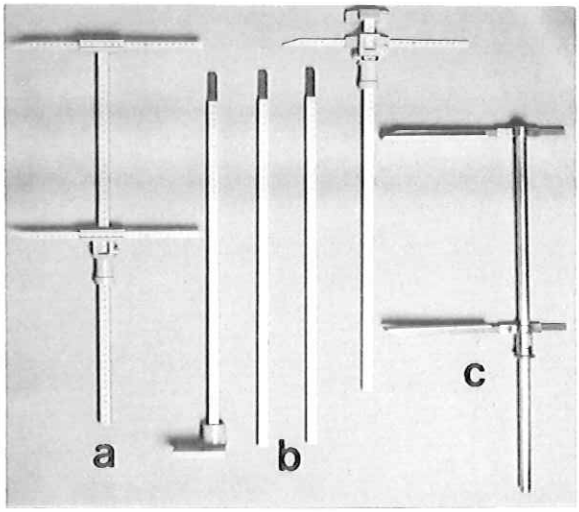


Figure C-1. Anthropometer:
a. beam caliper;
b. four sections of the basic anthropometer;
c. beam caliper with paddles.

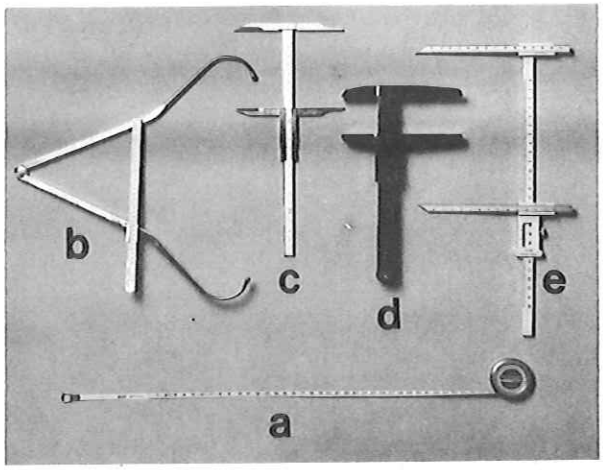


Figure C-2. Calipers and tapes:
a. steel tape;
b. spreading caliper;
c. sliding caliper;
d. Holtain caliper;
e. Poech caliper.

A pupillometer for measuring interpupillary breadth is shown in Figure C-3.

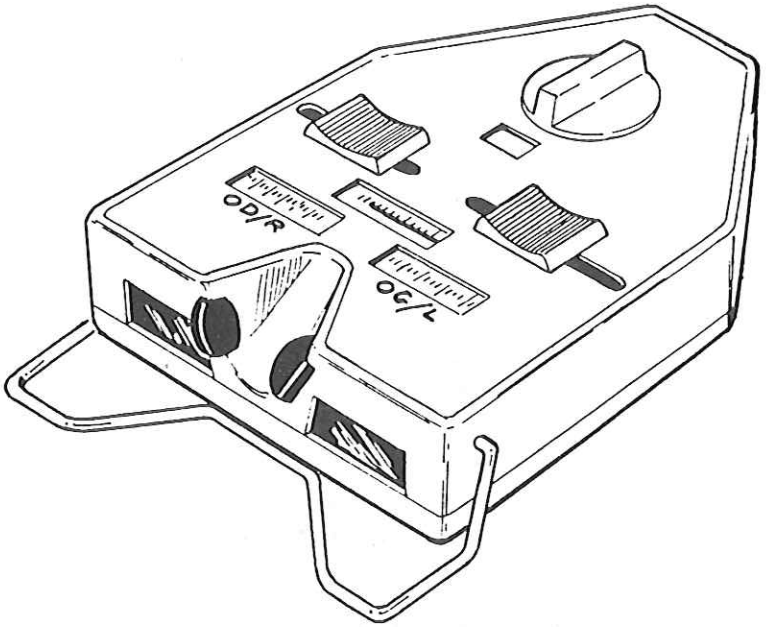


Figure C-3. Pupillometer.

This is a commercial device and can be obtained from: Multi-Optics Corporation, 1153 D. Triton Drive, Foster City, CA 94404.

Measuring instruments that were modified or created for the survey include: functional leg length anthropometer, wall scales, foot measuring boxes, and a modified sliding caliper. Several instruments for use in locating landmarks were also devised.

The functional leg length anthropometer is shown in Figure C-4. This instrument consists of a standard anthropometer mounted vertically to a sole plate. The sole plate is a 20-mm-thick wood base, 327 mm long and 200 mm wide. A heel plate is mounted vertically 40 mm from the rear of the sole plate; an anthropometer base plate is mounted orthogonally to the sole and heel plates. The heel plate, of standard pine stock, is 100 mm high and 200 mm wide. The anthropometer base plate, constructed from 38-mm pine stock, is 105 mm high and 327 mm long.

Two wall graphs are used to measure arm reaches. Both wall graphs are of drafting mm graph paper sealed in mylar sheeting. The graph paper has cm divisions with 5- and 10-cm divisions numbered. The overhead reach graph is 63 cm wide and 150 cm long with the long axes mounted perpendicular to the floor plane. The bottom edge of the graph is mounted 135 cm above the floor plane. The horizontal graph is used to measure arm span and horizontal arm reach. This graph is also 63 cm wide.

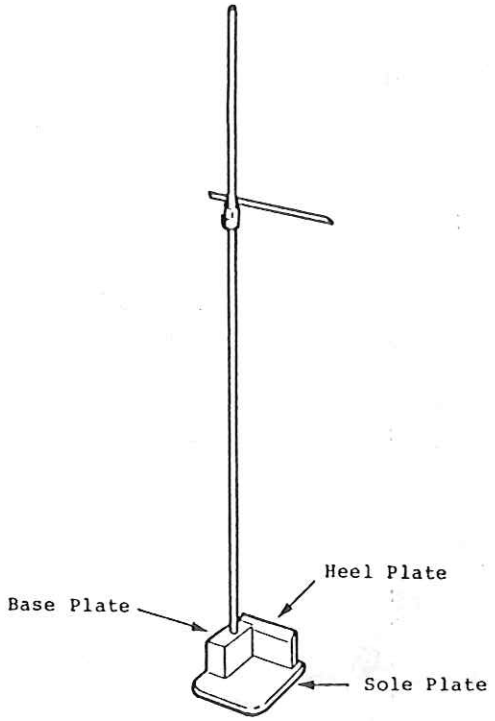


Figure C-4. Functional leg length measuring instrument.

The graph is mounted 100 cm above the floor and 45 cm from an adjacent wall which serves as the back plane for the arm reach measurements. The orientation of the graphs are shown in Figure C-5 with reference to the corner near which it is mounted.

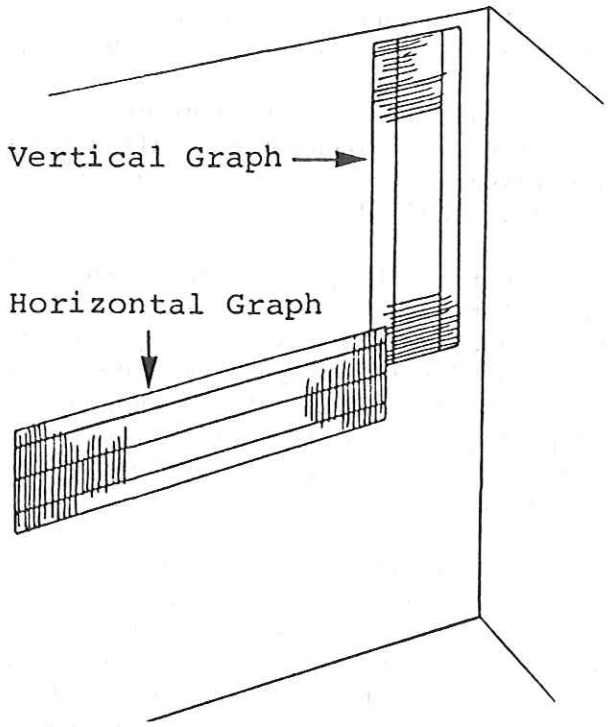


Figure C-5. Orientation of wall-mounted graphs.

The foot measuring boxes, made of 3-mm aluminum stock, are used in measuring linear dimensions of the foot. The two footboxes, a left and a right, are shown in Figure C-6. The sole plate in each box is 390 mm long and 205 mm wide. A vertical heel plate 55 mm high and 205 mm wide is mounted perpendicular to the rear of the sole plate. A side plate 55 mm high and 390 mm long is mounted orthogonally to the sole and heel plates. Graph paper with numbered cm divisions is fixed to the sole plate and covered with a 3-mm thick plexiglass sheet. The origin of the numbering system is the heel plate intersect with the sole plate for foot length measurements and the intersection of the side plate with the sole plate for foot breadth measurements.

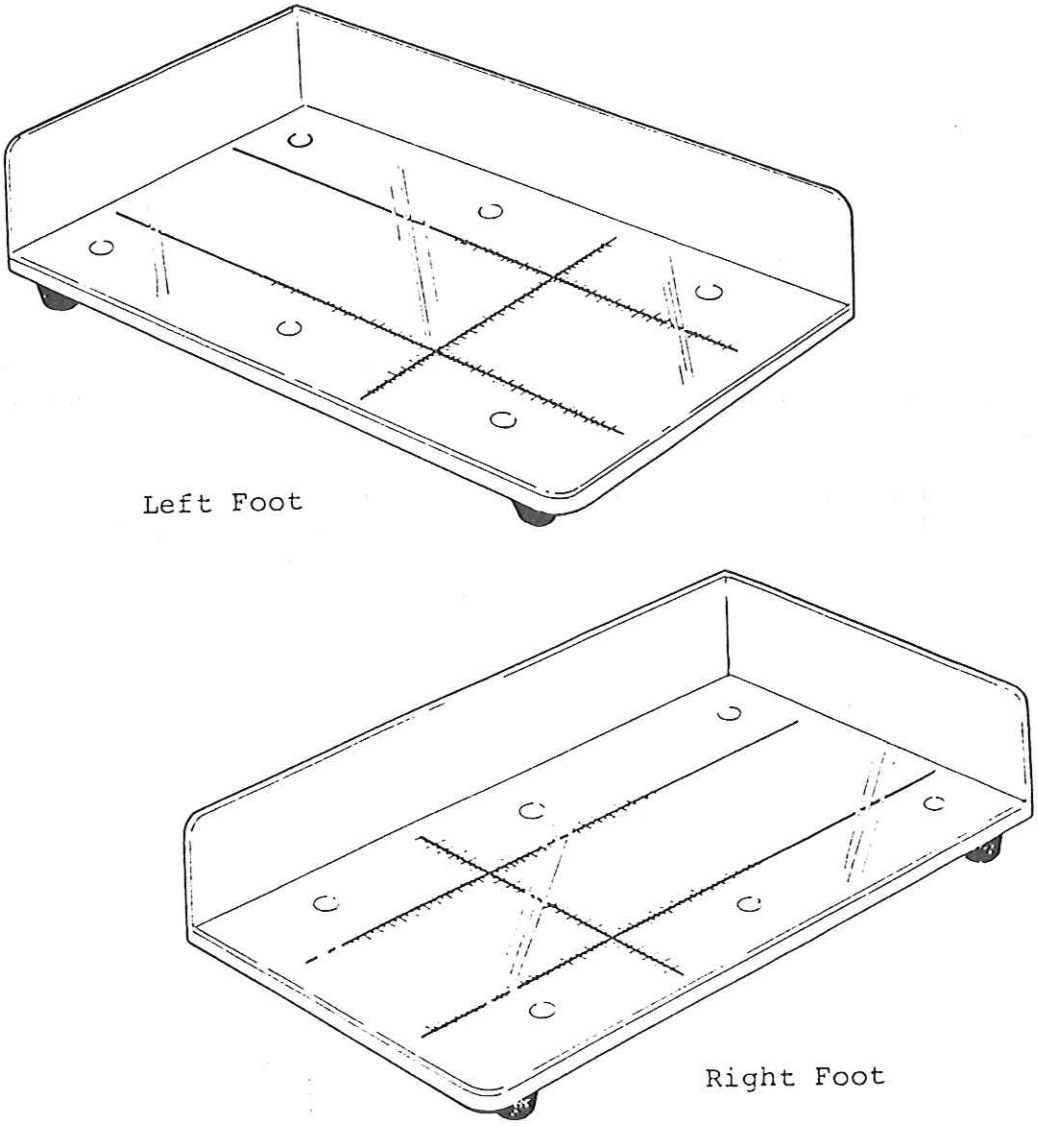


Figure C-6. Foot measuring boxes.

A standard GPM (early series) sliding caliper was modified to use in measuring lateral malleolus height. The sliding caliper was modified by removing the fixed arm and substituting a 77-mm arm for the 51-mm arm. The modified instrument is shown in Figure C-7.

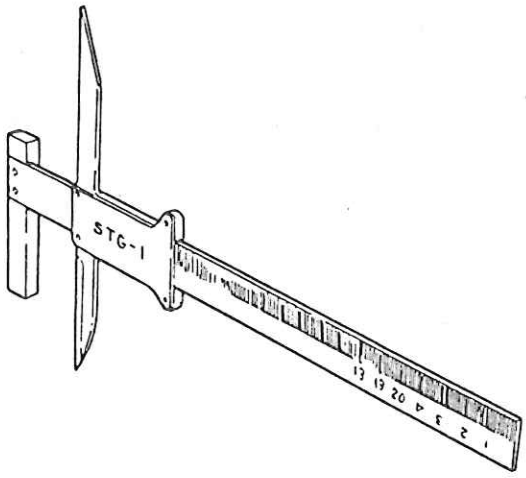


Figure C-7. Modified sliding caliper.

A number of measuring and marking aids are used in this study including a landmark transfer rod and a scye marking aid which were constructed for the purpose.

The landmark transfer rod is shown in Figure C-8. It consists of a 12.7-mm-diameter rod 152.5 mm long, mounted on a triangular base 30.5 mm on each side. The base has three casters on the bottom to permit the device to

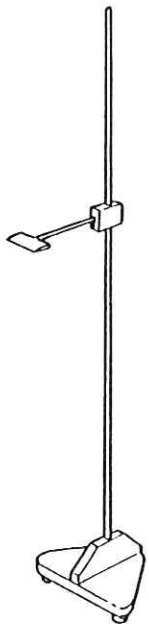


Figure C-8. Landmark transfer rod.

be easily rolled around the subject. On the vertical rod is mounted a slide that can be moved up and down. The slide has a 6.4-mm dowel mounted at a right angle to the slide and rod. A 110-mm-long, thin horizontal plate 35 mm wide is affixed to the end of the dowel. The device is used to transfer landmarks from one side of the body to the same level on another side.

The scye marking aid is a rigid plexiglass straight edge 480 mm long, 35 mm wide, and 3 mm thick. A line level is epoxied to the lower left margin of the straight edge. This device, illustrated in Figure C-9, is used to establish the anterior and posterior scye marks.

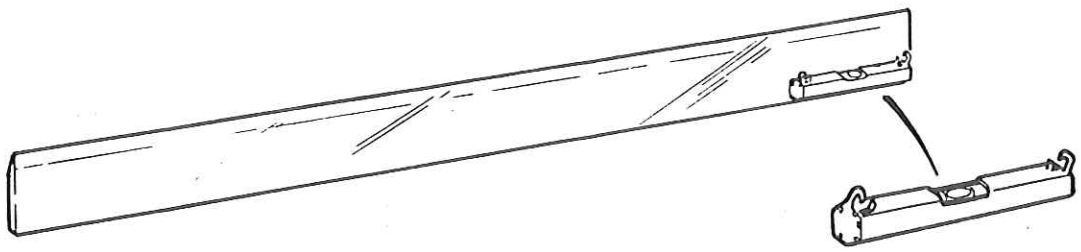


Figure C-9. Scye marking aid.

The modified tape, used for two posterior crotch length measurements, is made by attaching a dowel (5" long by 1/4" in diameter) to the zero end of the standard tape as a hand hold. A 2-cm triangular plastic pennant is affixed at the zero mark of the tape. The instrument is illustrated in Figure C-10.

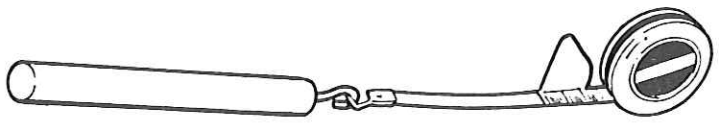


Figure C-10. Modified tape.

APPENDIX D.

Instruction Manual for the Operation and Maintenance of the Automated Headboard Device

APPENDIX D.

Instruction Manual for the Operation and Maintenance
of the Automated Headboard Device

GENERAL DESCRIPTION

The automated headboard device (AHD) was specifically designed and constructed for the measurement of three-dimensional (3-D) coordinates of the head and face. The coordinates are defined in terms of three mutually perpendicular axes (X, Y, and Z) referenced to the intersection of two plane surfaces (headboards) against which a subject's head is positioned for measurement as shown in Figure D-1.

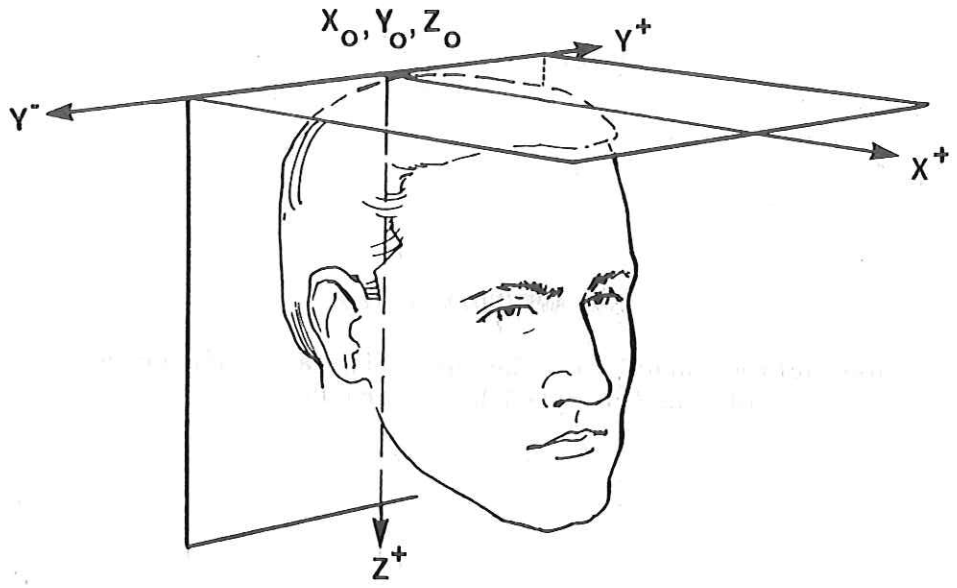


Figure D-1. Axis system for headboard measurements.

The principal components of the AHD are shown in Figure D-2. Basically, the device consists of the tubular steel frame which supports the subject positioning system (SPS), the coordinate measuring system (CMS), and the associated subassemblies necessary for control operations. The support frame is equipped with wheels, and is designed as a transport "dolly" to facilitate movement from site to site in field operations. The molded plastic seat pan is equipped with an electrically powered lift system which raises and lowers a seated subject through a range of 30 cm (12 inches). This range of adjustability permits the AHD to accommodate persons with sitting heights from 74 cm (29 inches) to approximately 104 cm (41 inches).

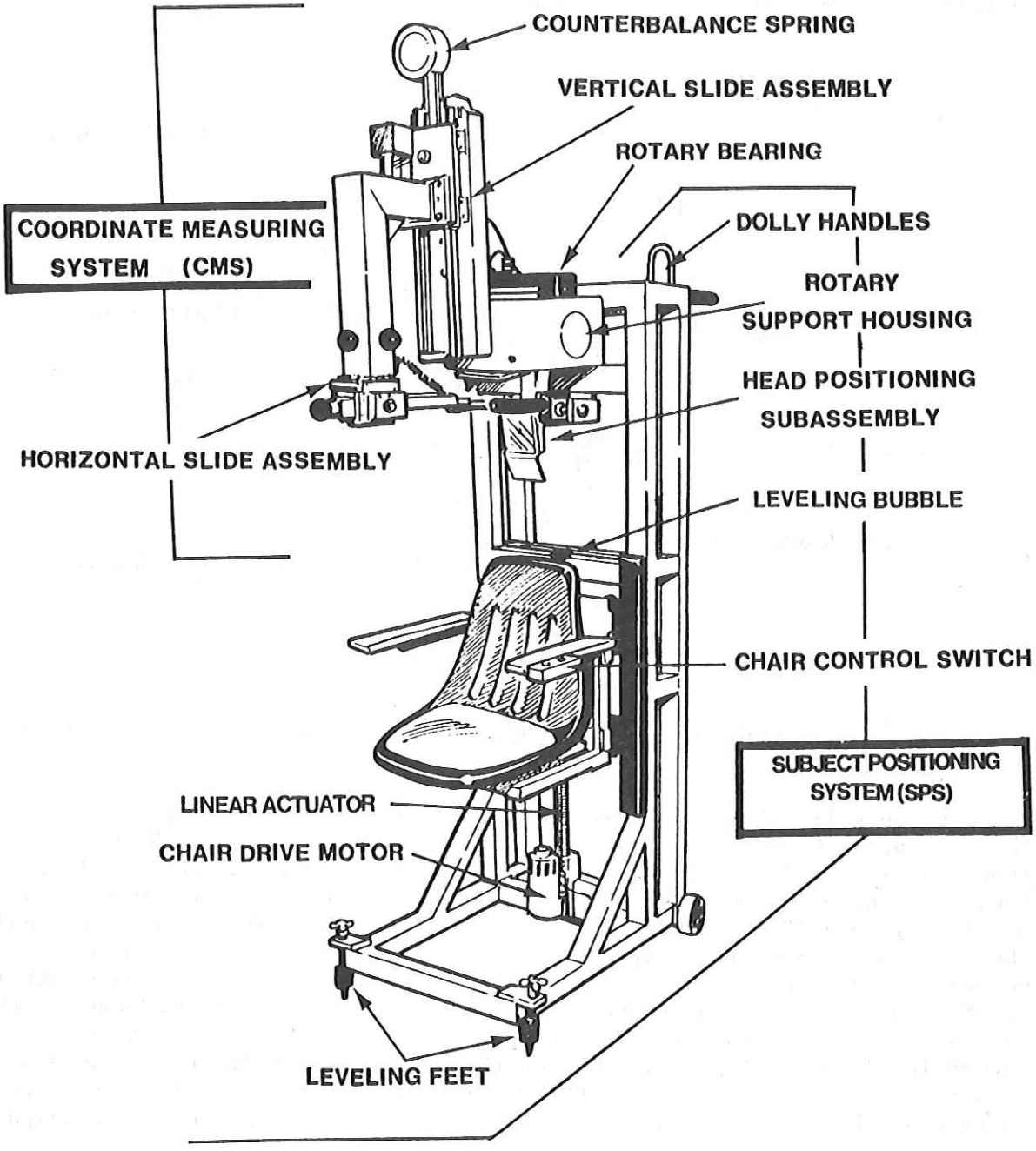


Figure D-2. Principal components of the automated headboard device.

The instrumentation and hardware which comprise the CMS, exclusive of the computer, are suspended from the top aspect of the support frame. Also, immediately under the rounded structure near the top of the AHD (rotary support housing) are the two reference planes (the top and rear headboard pieces) and the adjustable head stabilization clamp, which along with the chair constitute the major components of the SPS. Some of the details of this equipment are illustrated in Figure D-3.

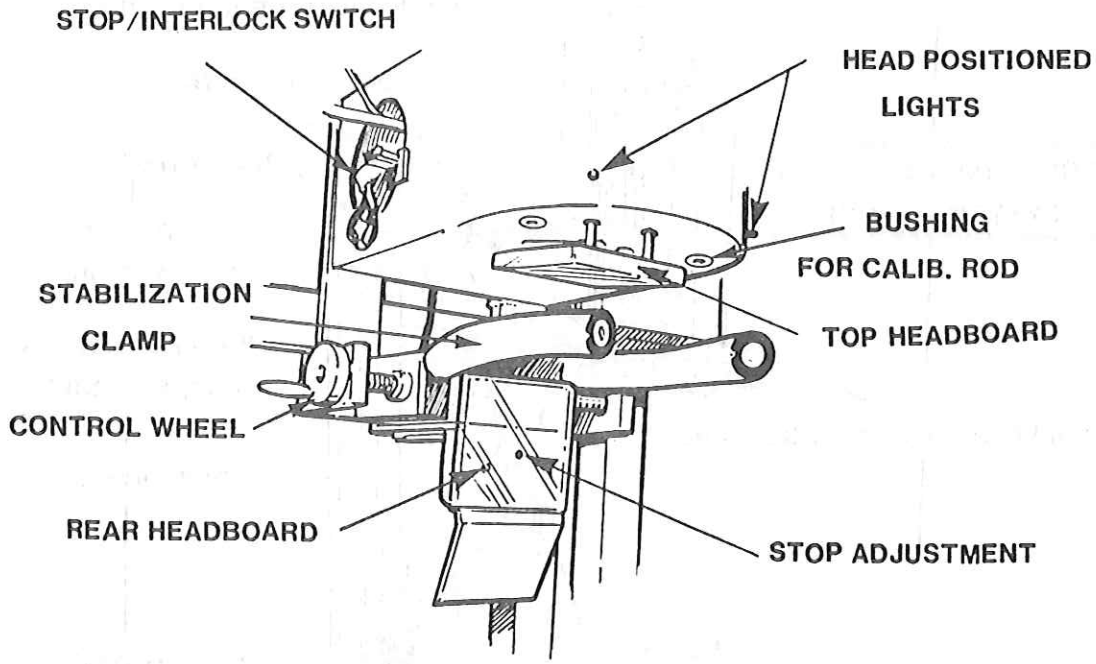


Figure D-3. The reference planes (headboards) and head stabilization clamp.

Mechanically, the CMS consists of a movable arm, which may be rotated through approximately 200° (rotary bearing), moved in or out 220 mm (horizontal slide), or moved up and down nearly 300 mm (vertical slide). These are shown in Figure D-4. In operation, the objective is to bring a small ruby bead (2-mm diameter) located on the touch probe at the inner end of the horizontal slide into light contact with a given point for which coordinates are to be determined. The CMS is calibrated so that the location of the center of the bead relative to the headboard surfaces is known to the nearest 0.1 mm in each axis. Coordinates of a point may be recorded automatically by a slight pressure on the bead stylus (AUTO TRIP mode)* or points may be recorded manually (MANUAL TRIP mode) as the bead contacts the surface of the measured object. Since the AHD was designed to be principally

---

* The CMS, with the exception of the probe, is wired so that the AUTO TRIP mode is an option. The device does not currently use an AUTO TRIP probe. If future users wish to modify the current probe or attach a new probe, the AUTO TRIP mode will be fully functional.

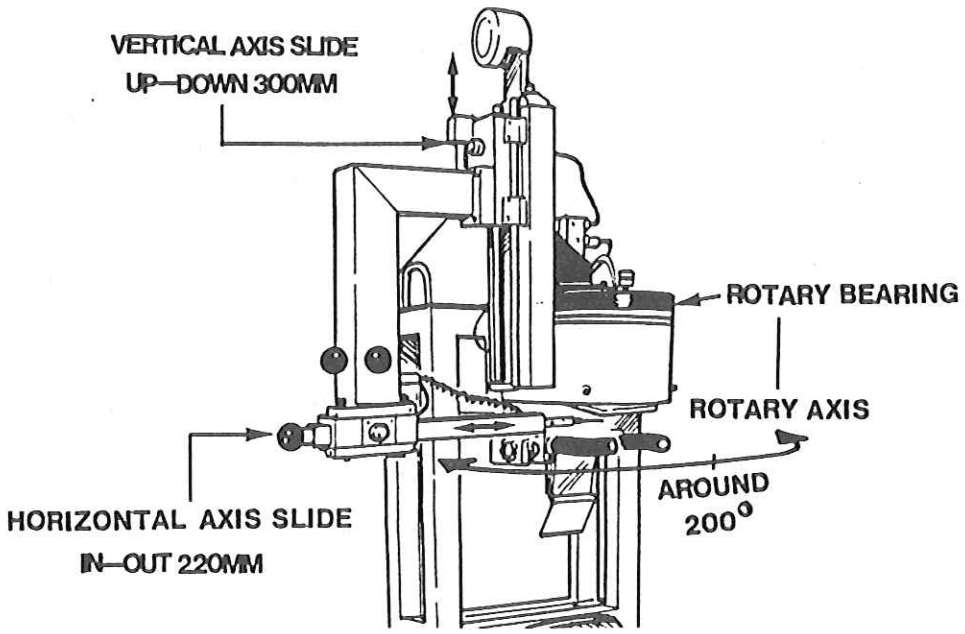


Figure D-4. The axis assemblies of the coordinate measuring system (CMS) and their range of movement.

used with live test subjects, and because the pressure needed to "auto-trip" the touch probe was found to result in an undesirable amount of deformation of soft tissue, the MANUAL TRIP mode is normally used. A remote switch box is provided which may be used to manually "trip" the probe at any time with minimal deformation of the skin.

As the probe is moved around the face to selected points (landmarks), electrical devices called encoders, attached to each of the movable parts of the CMS, act to convert the movements into electrical pulses that are equivalent to distance. In order to convert these analog signals into digital coordinate values for the three axes, the CMS is designed to operate with a personal computer (PC) which has been programmed to perform the analog to digital conversions, total the pulse counts, and perform the necessary trigonometric calculations. So that the values computed accurately reflect distance along each axis from their common origin (see Figure D-1), the CMS must be calibrated periodically using a fixture of precisely known dimensions.

OPERATION OF THE AHD

In the sections of the manual presented below, the recommended procedures to be used in operating the AHD are outlined sequentially, beginning with instructions for unloading and setting up the AHD which will take two people. Although the AHD was constructed to be as rugged as possible and is basically a field device, it contains very sensitive and delicate instrumentation. For this reason, one section of the manual deals with the care and maintenance of the AHD.

Setting Up

1. Make sure the site selected for setting up this device has a firm, smooth, and relatively level surface. Approximately 100 square feet of work area will be required. Convenient access to 110 volts AC to power the AHD and its accompanying computer should be nearby, since the power cords are typically less than 10 feet in length. The connecting cable between the AHD and the computer is approximately 15 feet in length.

2. When the AHD is at the station location, remove any loose items transported on the support frame dolly. Place the support frame in the vertical upright position as shown in Figure D-2. Level the frame by adjusting the leveling feet appropriately. The leveling feet are located at the front of the support frame base (see Figure D-2). A leveling bubble is located on the cross brace just behind the top of the chair. Before proceeding to the next step, make sure the frame is stable.

3. Unlatch and remove the vertical axis assembly from its fiberglass shipping container as shown in Figure D-5. Position the assembly on the two alignment pins found on top of the rotary bearing housing. The housing as it will appear without the assembly in place is shown in the photograph in Figure D-6. The appearance of the assembly by itself is shown in Figure D-7. Since the assembly weighs approximately 10 kg (22 pounds), assistance may be required to lift it into position. When securely in place, insert and tighten the four retainer bolts with a 5/16" Allen wrench provided in the tool kit for the AHD. The locations of the retainer bolts are shown in Figure D-8. Next, attach and secure the computer cable connector as shown in Figure D-8.

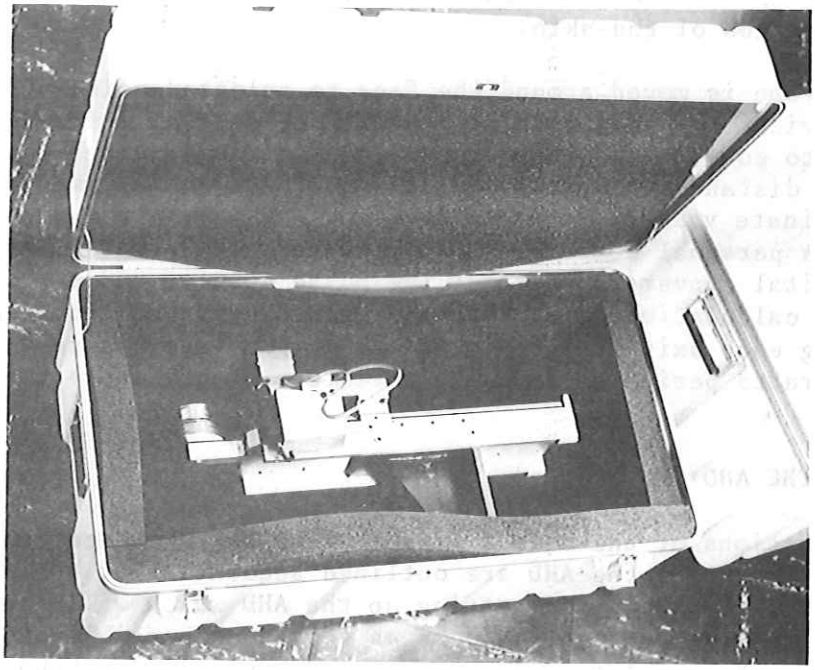


Figure D-5. The vertical slide assembly shown partially unpacked in its shipping container.

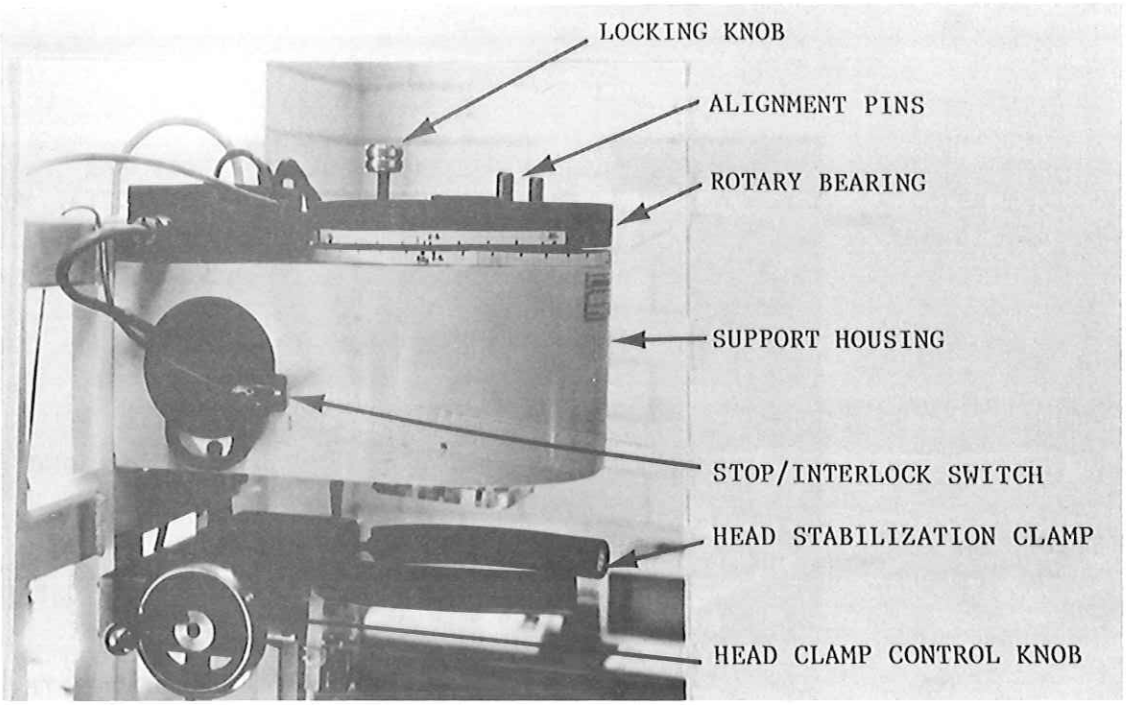


Figure D-6. The rotary bearing and the support housing with the vertical axis assembly removed.

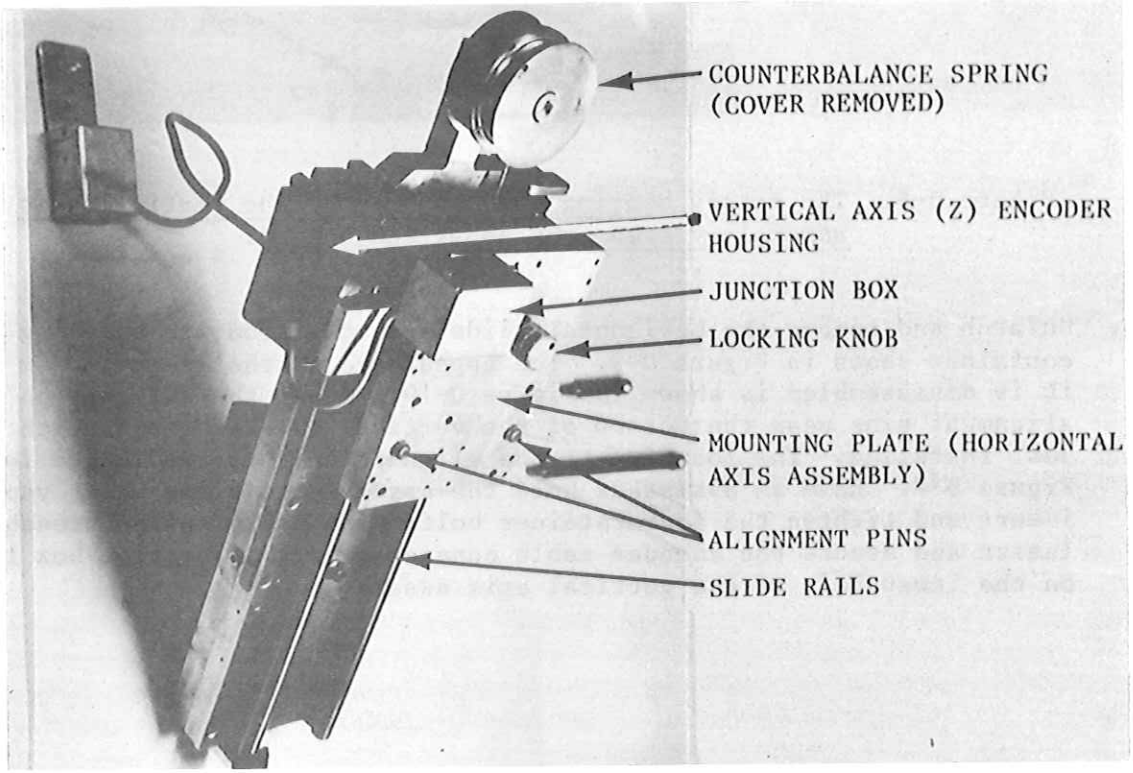


Figure D-7. The vertical axis assembly.

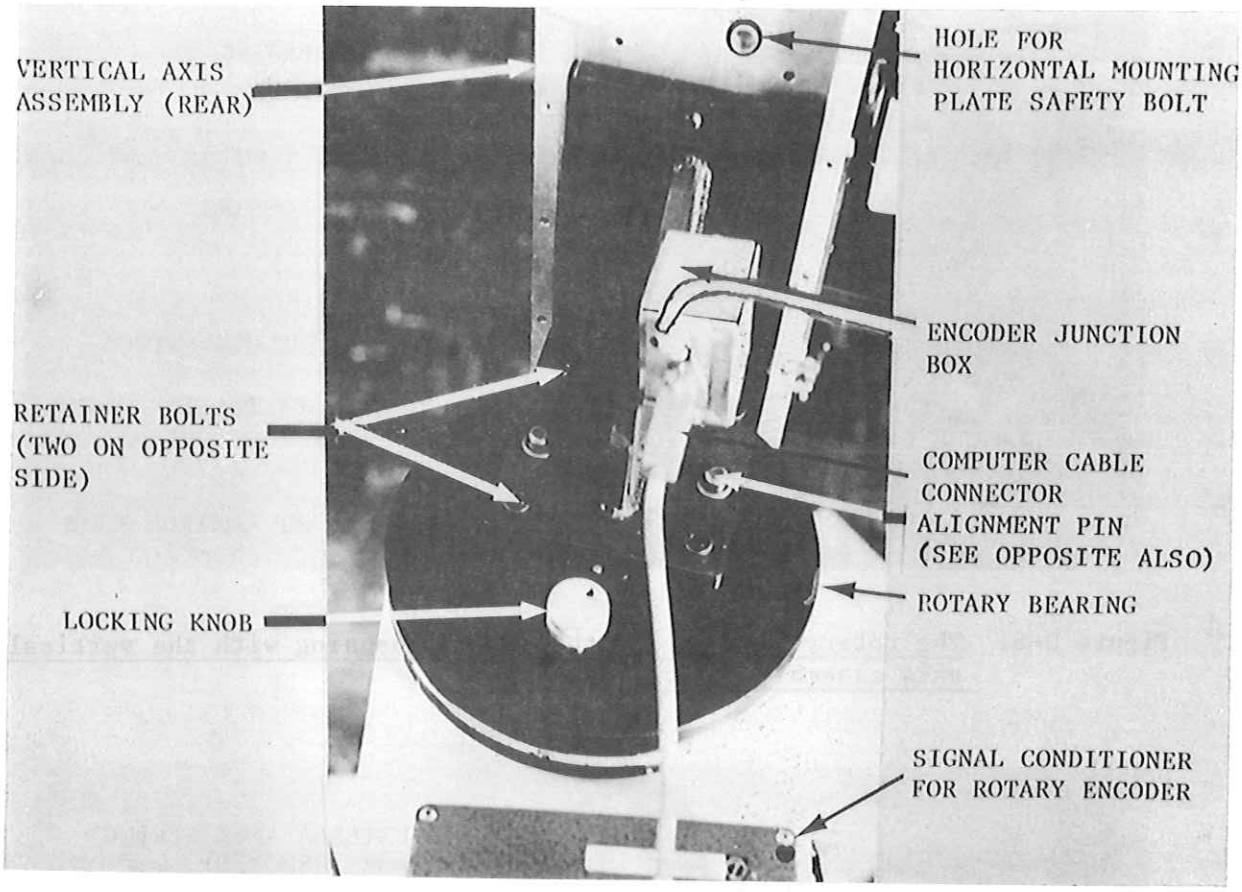


Figure D-8. The rotary bearing and the back of the vertical axis assembly viewed from above and behind.

4. Unlatch and remove the horizontal slide assembly from its shipping container shown in Figure D-9. The appearance of the assembly arm when it is disassembled is shown in Figure D-10. Mount the assembly on the alignment pins near the bottom of the vertical axis assembly which was just installed. The location of the alignment pins is indicated in Figure D-7. Have an assistant hold the assembly in place while you insert and tighten the four retainer bolts with a 1/4" Allen wrench. Insert and secure the encoder cable connector on the junction box located on the lower left of the vertical axis assembly.

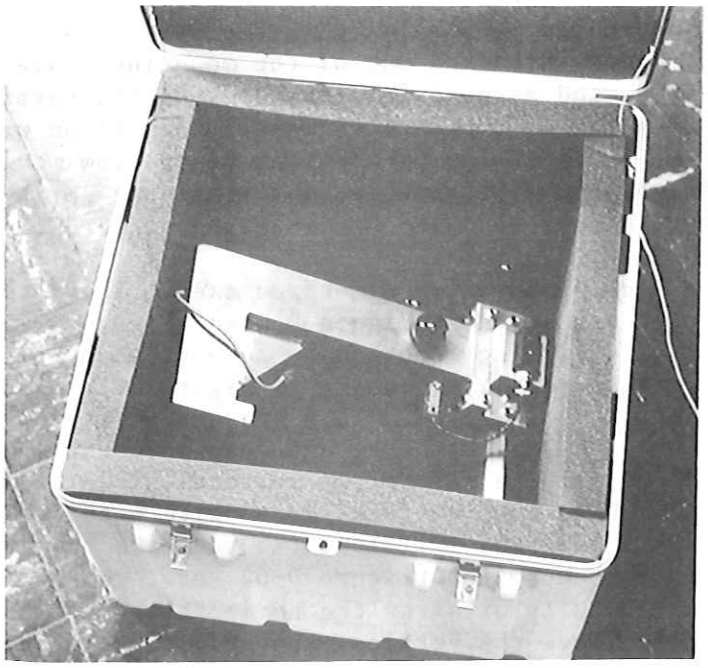


Figure D-9. The horizontal axis slide assembly and arm in its shipping container.

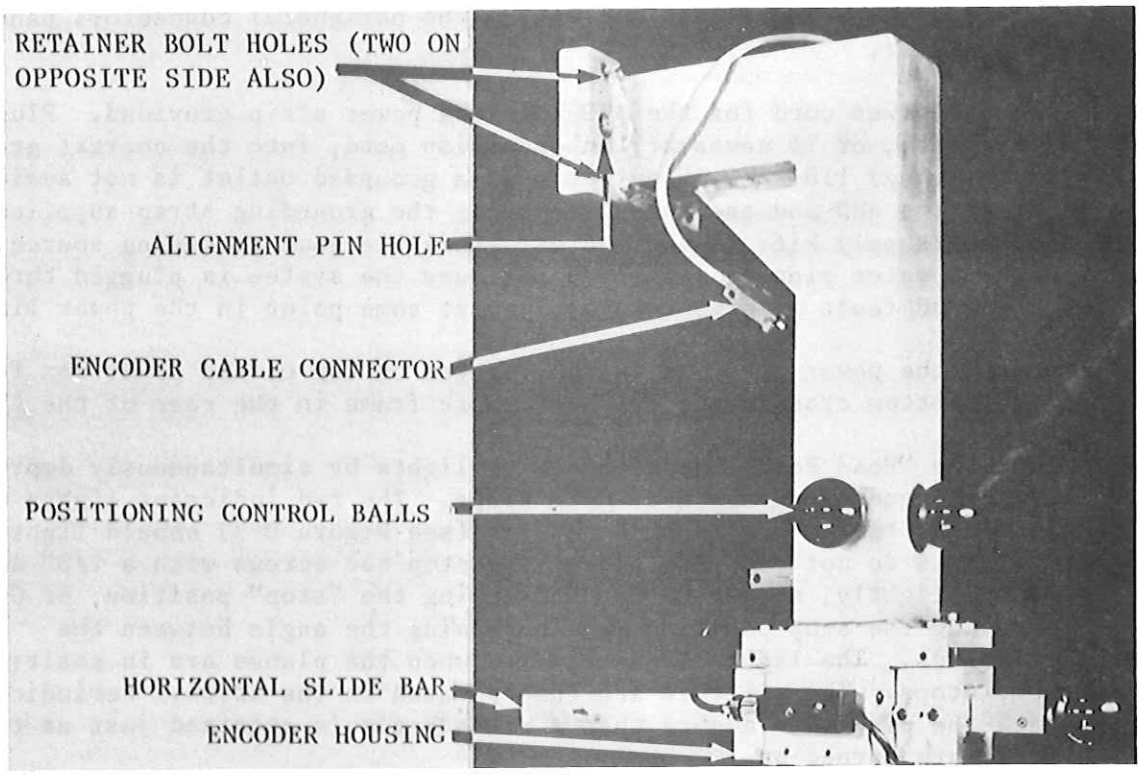


Figure D-10. The horizontal axis slide assembly and its mounting arm.

5. Locate the hole for the safety bolt on the rear of the vertical axis assembly structure. The hole is marked (see Figure D-8). The double action set screw is backed out of the mounting plate for the horizontal axis assembly, and screwed into the body of the vertical axis assembly by turning the screw clockwise (CW) with a 1/4" Allen wrench. This screw prevents the horizontal axis mounting plate from moving during shipment or setup due to "pull" from the counterbalance spring. (NOTE: The safety bolt is restored into the mounting plate during disassembly.)

6. Loosen the locking knobs on all three axes. The rotary and vertical locking knobs are shown in Figure D-6 and Figure D-7, respectively. The horizontal axis locking knob can be seen (though it is not labeled) on the horizontal axis slide housing in Figure D-4. In order to loosen the locking knobs, turn approximately one quarter turn, counterclockwise (CCW). Test each axis for free and easy movement and then lightly apply a few drops of machine oil to the vertical slide bar and the horizontal slide rails. Wipe both surfaces clean with a soft, lint-free cloth. Position the arm in the full left (as you face the AHD) position against the stop/interlock switch (Figure D-6) and then tighten the rotary locking knob. Fully withdraw the horizontal slide and tighten its locking knob. Move the vertical assembly tightly against its upper stop and, while holding it in place, tighten the locking knob. This positioning of the slide assemblies is called the BEGIN-END condition.

7. Recheck all encoder connectors to make sure they are all secure. Plug in and secure the main connector for the computer cable (see Figure D-8). At this time the remote (or manual) touch probe switch may also be plugged in to a small jack located on the peripheral connectors panel of the computer.

8. Plug the power cord for the AHD into the power strip provided. Plug the power strip, or if necessary an extension cord, into the nearest grounded (three-prong) 110-volt AC outlet. If a grounded outlet is not available, connect the AHD and the computer, using the grounding strap supplied with the tool/supply kit, to the nearest available good grounding source, e.g., conduit, water pipe or radiator. Be sure the system is plugged through the ground fault interruptor supplied at some point in the power line.

9. Turn on the power with the switch located on top of the power box found on the bottom cross brace of the support frame in the rear of the AHD.

10. Check the "Head Positioned" indicator lights by simultaneously depressing both the headboards against their stops. The red indicator lights located on the rotary support housing (see Figure D-3) should light. If the lights do not come on, adjust the stop set screws with a 1/8" Allen wrench slightly, either CW for increasing the "stop" position, or CCW for lessening the stop position and increasing the angle between the headboards. The lights are activated when the planes are in position against their stops. The switches are incorporated in the stops. Periodically, check the planes to ensure that a right angle is obtained just as the lights are turned on.

11. Check the chair lift for proper action by depressing the UP-DOWN switch button located in the chair arm rest to the operator's right. As a safety factor, the chair cannot be lowered unless the CMS arm is against

the stop/interlock switch located on the left side of the housing (see Figure D-6). If the chair lift still does not work, check that the AHD has power and that the breaker in the power center box has not been tripped.

12. Remove the touch probe from its storage box and screw it into the end of the horizontal axis slide bar (see Figure D-11). The probe is extremely delicate and expensive so great care should be taken when handling it.

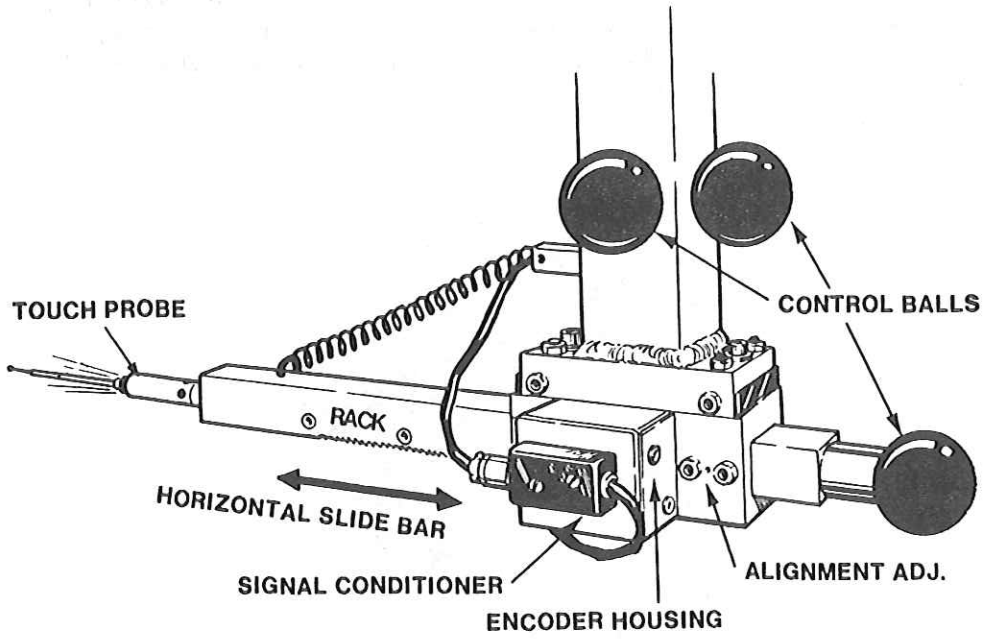


Figure D-11. Horizontal slide assembly showing the touch probe and the measurement instrumentation.

13. You are now ready to set up the computer in preparation for calibrating the CMS.

Loading the Program

The coordinate measuring system (CMS) is designed to operate in conjunction with a COMPAQ II portable computer in which there has already been installed a printed circuit board containing the necessary components for processing the pulses coming from the encoders. For the location of the expansion slots refer to the Operator's Guide for the computer. Additional software needed for the computation and display of the coordinates, calibration of the system, listing of the landmarks to be sampled, storage and printout of the data collected, and other functions is contained on a 5 1/4" double density disk. In booting the system for the measurement of coordinates, the diskette should be loaded into the computer.

Before turning on the computer and the printer, make sure the CMS and printer cables are plugged into the appropriate connectors located on the peripherals panel of the computer. The arm of the CMS must be positioned

tight against the stop/interlock switch with the horizontal slide fully retracted and the vertical slide against the upper stop. This is the BEGIN-END position. The CMS must be in this position each time the computer is turned on, since a position value for the rotary encoder is placed in the software at that time. If you should fail to start with the arm in the BEGIN-END position, calibration values will be wrong. Turn off the computer, position the arm correctly, and restart the program. If not already installed, the hand (trip) switch box should be plugged into the end of the CMS board at this time. If an assistant is to use the switch to enter coordinates for each point into the computer, place the small toggle switch at the expansion slot in the DOWN position. As noted previously, with the switch in the UP position a properly equipped touch probe may also be "auto-tripped". The remote hand switch is shown in Figure D-12.

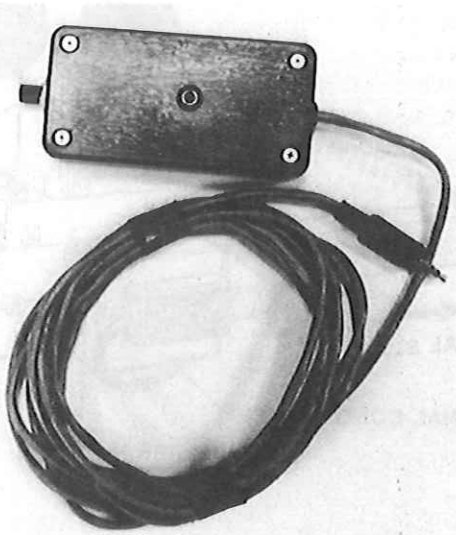


Figure D-12. Remote hand switch for manual recording of coordinates.

Insert the CMS program disk into DRIVE A and power up the computer and printer. The Disk Operating System* (DOS) displays a date -- usually the current one -- and asks for a new date. If the date on the screen is correct, press the key marked "enter;" otherwise, type the correct date, and then press "enter." Next, DOS displays a time. If the time is correct, press "enter;" if it is not, type the correct time, and then press "enter."

When the date and time are entered, a prompt will be displayed on the left side of the screen: **A>**.

At this point, before the AHD program is loaded, the directory of the station disk should be checked. This need not always be done, but when you use a new station disk for the first time it is best to verify that several

---

* Compaq Personal Computer MS-DOS, Version 3.20

files are on the disk. To do this, type "DIR" after the prompt, and press "enter." DOS will respond with a list of the files on the disk in drive A:

COMMAND.COM

START.COM

POINTS.TXT

REG

These may appear in any order. If the disk has been used before, a file named **GAGE.PRM** will also be present. **GAGE.PRM** is created by the calibration procedure within the AHD program, and it is deleted and recreated each time the machine is calibrated. If only **GAGE.PRM** is missing, you may load the AHD program as described below; if any of the other four files are missing, you should replace the disk with one which contains all four before loading the program.

To start the AHD program, type "start" at the DOS prompt and press "enter". The program takes a few seconds to load. Once loaded, it automatically begins with the calibration procedure, which is described in detail below (see CALIBRATING THE CMS). After calibration has been completed, the monitor will display the menu options and the XYZ values ($\pm$ 2 mm) shown below:

X 60

Y -216

Z 13

---

1. calibrate

2. record points

3. retest a subject

4. print a file

5. display Subject.Num file

6. display machine coordinates

7. terminate program

This display is the main menu, from which any of seven operations can be chosen. To select an operation, press the corresponding number on the keyboard. The purpose and function of each operation is described on the following pages.

Three of the operations listed on the menu -- **record points, retest a subject**, and **print a file** -- use the subject number to generate data file names or to locate existing data files. You will be asked to enter the subject number one time for each subject; most often this will occur when you select **record points**, because that is usually the first of the three procedures to be run on a subject.

Each time they are called, these procedures read the subject number from the "Subject.Num" file on the subject's disk. The program also retains in memory the subject number it read from the disk for the previous subject. Whenever the new subject number does not match the number in the memory, the program asks you to verify the new number by typing it in.

The program is designed to flag such errors as mis-entering a subject's number or recording data on the wrong disk. It provides a number of error messages and "second chances" to enable the operator to make the indicated corrections.

The seven menu items are individually described below:

1. **Calibrate**: As noted, the CMS must be calibrated before the seven-point menu appears. However, **calibrate** may be selected at any point later in the procedure if the X, Y, or Z values displayed above the menu items fall outside the $\pm$ 2-mm range, indicating the need for recalibration.

The procedure begins with the display: **Set axes to fixture? (y/n).** If you press "N", "n", or "-" (the minus sign), the program will return to the main menu. If you press "Y", "y", or "+", the program will ask you to input certain coordinates as described in the next section, CALIBRATING THE CMS. After the calibration is complete, the program returns to the main menu.

2. **Record points**: Following the calibration procedure and for each subject who is measured, this menu item prepares the system to receive and record a specific list of head-face landmark coordinates in a specific order. The program prompts the measurer by displaying the name and number of each landmark on the screen. As each successive landmark is measured, the name of the next landmark will appear. When the measurement of a given subject is complete, the program "edits" the data by checking to make sure that the relative positions of the measured points with respect to each other are reasonable. If they are not, subjects are remeasured. The coordinate values for each landmark are recorded and stored on the subject diskette in Drive B.

3. **Retest a subject**: This item is included so that the operator may choose to remeasure a subject. Using a different data file name (automatically generated in the computer), it receives and records points in the same order as in the **record points** procedure.

4. **Print a file**: At the conclusion of a series of measurements, the subject's data are printed on his or her data form. In order to do this, the **print a file** procedure first displays a list of the names of the existing data files, from which the operator selects one to print. When the file has been printed, the program returns to the main menu.

5. **Display Subject.Num file**: Each subject's data disk contains a file named "Subject.Num" which includes the subject's sex and subject number. The program reads this information from the subject's disk in Drive B in order to create AHD data file names and to facilitate data analysis. This menu item displays the "Subject.Num" file in the upper half of the screen, so that it may be checked if necessary.

6. **Display machine coordinates**: This item is used primarily in testing the operation of the CMS encoders. It should be used if inaccuracies in calibration and/or scaling persist (e.g., numbers change radically, or fail to change at all when the probe is moved around). Normally, during measurement, the X and Y coordinates displayed are linear horizontal distances forward of and lateral to the center of the back headboard; these are rectangular coordinates calculated by the program from information provided in polar coordinates by the encoders. During the **display machine coordinates** operation, the X and Y coordinates displayed are those relative to the center of rotation of the system and not the headboard surfaces. Therefore, the information is not displayed in terms of X and Y, but rather in terms of the polar coordinate system in which radius r is always associated with the position of the horizontal slide, and angle ϕ always describes the position of the rotary encoder. With respect to the BEGIN-END position in both the rectangular and polar systems, the Z axis is associated with the vertical distance encoder.

Since the output of each encoder is examined individually, failure of any one of the encoders can be noted immediately. Movement of the CMS probe along any of the axes should cause the value appearing in the monitor display to change. If no such changes are observed for a particular movement, the encoder for that axis may be defective. Such information is important and should be reported to the design engineer promptly.

7. **Terminate program**: This item ends the program, returning control to the DOS. It should be executed before the computer is turned off. Although the program may be terminated between subjects during a measurement session, this is not recommended because it will require time-consuming recalibration of the machine when the program is started again.

CALIBRATING THE CMS

Whenever the AHD program is started, the **calibrate** procedure must be performed. During measurement sessions, periodic calibration checks should be made. Calibration can be verified throughout the day in the following way:

Visually check the XYZ coordinates on the monitor when the arm is in the BEGIN-END position. The following values -- ± 2 mm* -- should be displayed:

X = 60

Y = -216

Z = 13

If the displayed values are within limits, the calibration is assumed to be good. Any values which fall beyond these limits indicate the need for recalibration.

The purpose of the calibration procedure is to install precise scaling factors into the main program memory. Two support rods and a special fixture are used. The software has "prior knowledge" of certain aspects of the fixture relative to the two reference planes when it is properly positioned. Before installing the rods, the head stabilization clamp is closed so that the distance between the arms of the clamp is at a minimum in order to clear the bushings for insertion of the rods. Turn the head clamp control knob to tighten (see Figure D-6). Next, the support rods are screwed into the bushings on the bottom surface of the support housing as indicated in Figure D-13.

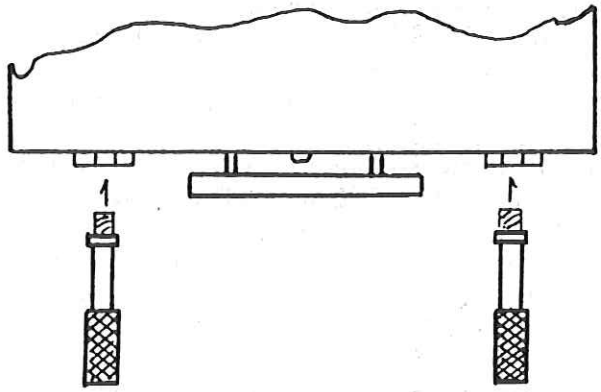


Figure D-13. Support rods in position for installation.

The location of the two bushings is also shown in Figure D-14. The rods should be screwed into the bushings until they are finger tight.

---

* The ± 2 mm is principally related to the inability to restore the exact BEGIN-END position each time. The Z axis is likely to be the most variable since the stop is padded with rubber. The compressibility of the rubber may vary with temperature, hence affecting the absolute position of the vertical slide when at rest on the stop. The Z axis calibration value may also be affected by variation in the stylus positioning.

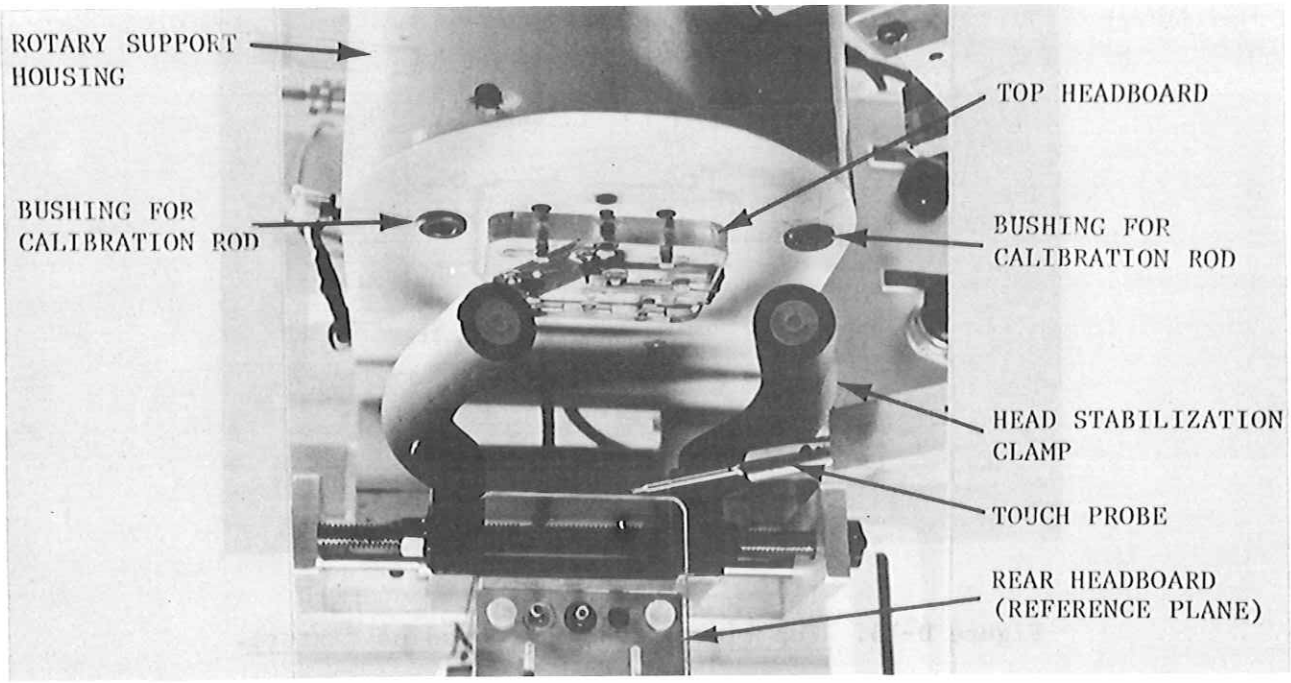


Figure D-14. Front view of the rotary support housing showing locations of bushings where calibration rods are installed.

Once the rods are in place, the next step is to position and secure the fixed radius fixture (See Figure D-15). The fixed radius fixture is machined from two, half-inch-thick aluminum plates. One plate includes portions of a circle of precisely known diameter (diameter = 164.846 mm, radius = 82.423 mm). This plate is attached to the second or mounting plate of the same thickness and material. As indicated in Figure D-15, the fixture has been labelled to assist in the installation process. Because the fixture must be installed exactly the same way on each occasion, use the procedure outlined below:

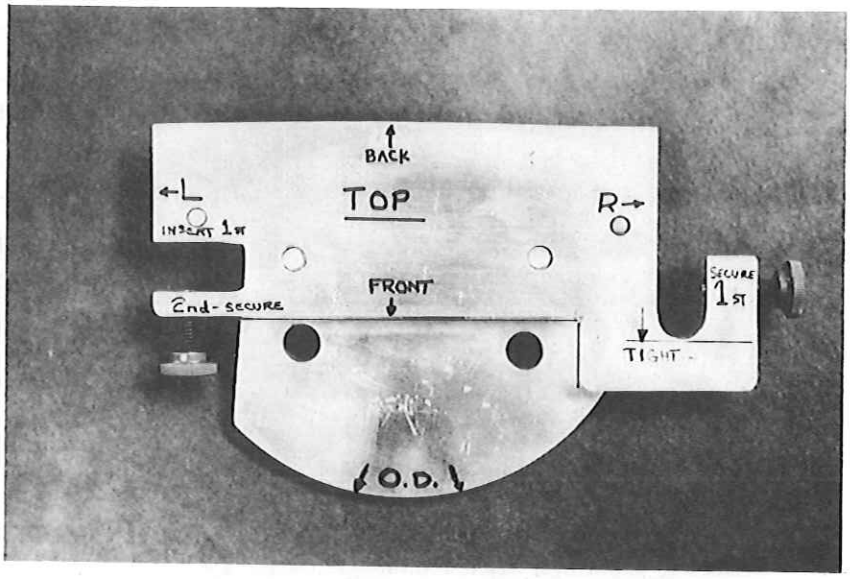


Figure D-15. Top view of the fixed radius fixture.

1. Loosen the thumb screws so that the two cutouts on the fixture are clear of the protruding set screw.

2. Orient the fixture with the top side up and insert the left-hand cutout onto the rod on the left. Move the fixture left until the right-hand cutout can be slipped onto the rod on the right.

3. With both rods in their respective cutouts, position the right side tight against the rod and raise the fixture until the top headboard is tight against its stop.

4. Next, align the fixture so that it is flush with the top headboard surface while the headboard is tight against its stop. Check for fixture/headboard contact over the respective surfaces and then tighten the right-hand set screw on the rod.

5. Without allowing the fixture to move, tighten the left hand set screw on its rod.

6. Check the fixture/headboard alignment and readjust as necessary.

The calibration equipment (including an earlier version of the support rods) is shown after installation in Figure D-16.

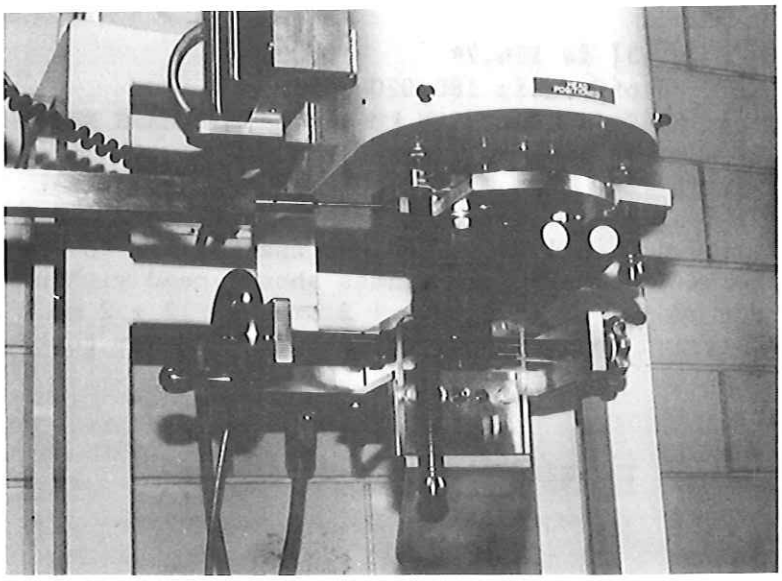


Figure D-16. Front view of the headboard area showing the calibration equipment in place.

When the fixture has been properly installed, the **calibrate** procedure can be completed. The monitor will display the prompt: **set axes to fixture? (y/n).** Respond by entering "Y" for yes. The display will return the prompt: **take a point on the od* of the fixture.**

Unlock all three axes of the CMS and proceed to touch the bead to the curved portion on the front center of the fixture. If an AUTO-TRIP probe is used (switch on the computer peripherals panel in the UP position), the point will be entered automatically when the surface is touched. If the same switch is DOWN, the point may be manually recorded by depressing the switch on the remote hand-trip box while the bead is in contact with the fixture "od" surface. When the point is recorded, a beep will sound and the display will update and appear as follows:

take a point on the bottom of the fixture
current radius is 10.000**
radial offset is 100.00**

---

* **od** here refers to the "outside diameter" of the curved aspect of the fixture.

** Sample values.

As instructed, contact or touch the probe to the bottom surface of the fixture by maneuvering the bead into position. When the point is recorded, the computer will beep and the display will change to read:

x [3] is 114.7* 8.030*
Z offset is 180.0200.523*
PRESS ENTER TWICE TO PROCEED TO MAIN MENU

When ENTER is depressed, the calibration is complete and the program will return to display the original menu. Return the CMS arm to the BEGIN-END position and lock the axes. The XYZ values should read within the limits given earlier: x = 60 ± 2 mm; Y = -216 ± 2 mm; Z = 13 ± 2 mm. Remove the fixed radius fixture and the support rods and return them to their storage box.

PREPARATIONS FOR MAKING THE MEASUREMENTS

Preparing the computer

1. When a subject arrives, insert his/her disk in Drive B.

2. Select item #2, **record points**, from the menu. The first thing the computer checks is the sex variable in the "Subject.Num" file on the subject's disk. Provided that the subject is the same sex as the previous subject, you will not be aware that the computer is doing this. However, if there is a change -- if this is the first subject after the AHD program was started, or if the previous subject was of the opposite sex -- the computer will display a message to verify the current subject's sex, for example:

   Now measuring MEN.

   OK? (y/n)

   If you respond with "N", "n", or "-", the program will inform you that there may be something wrong with the subject's disk, and eventually return you to the main menu. From the menu you should use option #5 (**display Subject.Num File**) to try to determine the problem. A response of "Y", "y", or "+" leads to a request for the subject's number.

3. Type the subject number, with or without leading zeros, and press "<return>." The program responds with a check on the number you entered, for example:

   Subject number 12345.

   OK? (y/n)

   Responding "N", "n", or "-" gives you a chance to re-enter a mistyped subject number. Responding with "Y", "y", or "+" leads to the **record points** procedure.

4. As the **record points** procedure comes up, the top portion of the screen will appear as follows:

X	60
Y	-216
Z	13

FILE: B:SNO1441.YS*
Press <s> to close file
Press <*> to cancel last point taken
Press <!> to abort point recording

MALE*

1. R Tragion

The numbers appearing in the XYZ graphic depend upon the current position of the touch probe bead; however, the CMS arm should be in the BEGIN-END position.

The number and name of each successive landmark to be measured will appear on the monitor. "R Tragion", shown above, indicates the first point to be measured. R and L refer in this case to the subject's right and left, not the operator's!

In order to hand trip the points, the recorder must make sure the small switch on the CMS computer peripherals panel is in the "down" position. This will activate the remote hand switch box. A small red light on the box indicates that the switch is activated.

Final preparations - AHD

While the recorder prepares the computer, as outlined above, the operator prepares the AHD to receive the first subject. The recommended steps are outlined below:

1. THE ARM OF THE CMS SHOULD BE IN THE BEGIN/END POSITION!

2. Depress the DOWN button on the seat control on the right arm of the chair and lower the seat to near the bottom limit. Try to stop the seat drive motor before the bottom limit is reached. A clicking sound will be heard when this happens. Repeatedly running the motor against the stops (at either end) may ultimately damage the motor.

3. Clean subject contact surfaces such as the headboard surfaces, the head clamp pads, the touch probe bead, and the chair arms with an alcohol swab. Repeat the alcohol cleaning procedure before each subject.

---

* Sample subject number and sex.

4. Since the head clamp may be in the calibration position (fully in), open the head clamp widely enough to clear the subject's head easily.

5. Recheck the HEAD-POSITION lights by fully depressing both headboards simultaneously.

6. Place the foot rest in position by slipping the end "cutouts" over the front rail of the support frame.

Preparing the Subject

The nature and purpose of the procedure must be described briefly to each subject as he or she reports to the station. This orientation may be given by either member of the team, and it may be completed while the landmarks are being drawn.

Coordinates for a total of 26 drawn landmarks are to be measured with the AHD in the 1987-1988 Army Survey. Some of these (tragion, right and left; infraorbitale, right; crinion; sellion; and menton) will already have been drawn on the subject's face for other head/face measurements and must be checked. An additional 20 landmarks, shown on Figure D-17, must be placed on the subject's face by the operator at the headboard station. Using a surgical marking pen, place small dots (no larger than 2 mm in diameter) to mark all the remaining landmarks.

The legend in Figure D-17 is organized in the order in which coordinates are to be measured. Points #27 and #28, it will be noted, are repeats of points measured earlier. The order of measurements was designed to minimize the number of passes about the subject's eyes and to offer the shortest route of travel between successive points. The software for this survey was designed to accept the points only in the order listed.

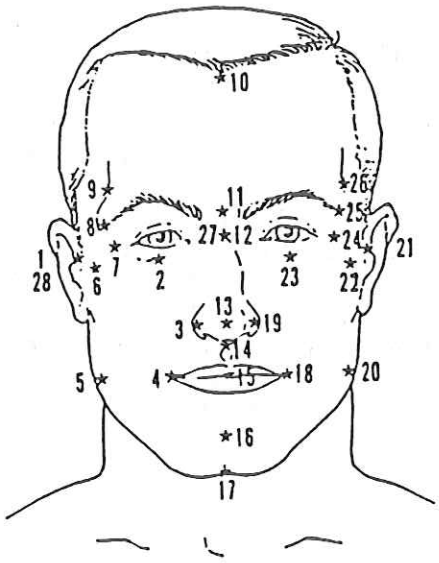
Positioning the Subject

The following conditions should exist at this time: The CMS arm in the BEGIN-END position, the seat in a low position, and the head clamp wide open. The steps for positioning the subjects for measurement are outlined below.

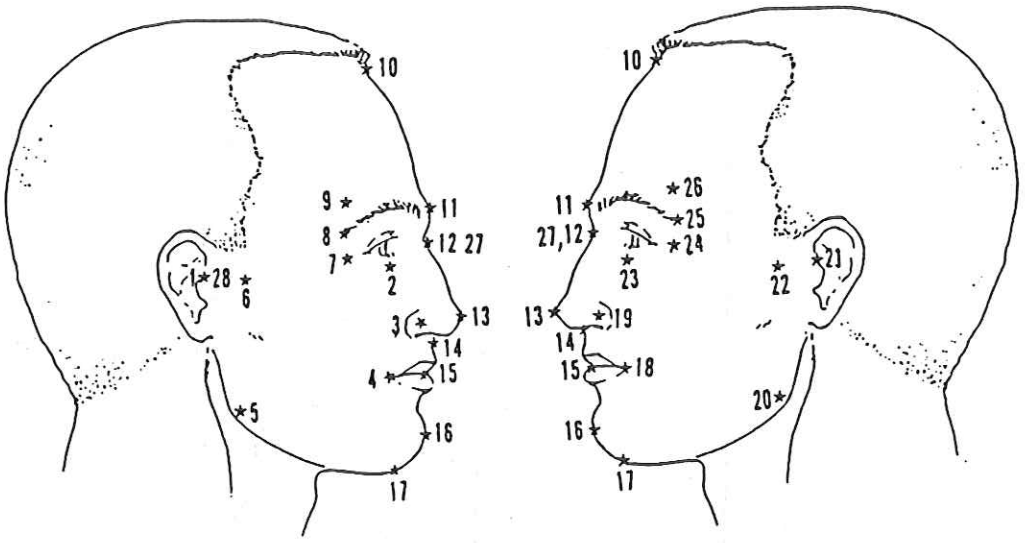
1. Instruct the subject to be seated. Determine the required size of safety glasses (large-wide or small-narrow) and assist the subject in positioning the glasses on the face. The lenses are plastic and not vision-corrective.

2. Ask the subject to relax when fully seated. Encourage the subject to assume a slightly slumped position.

1. R Tragion
2. R Infraorbitale
3. R Alare
4. R Cheilion
5. R Gonion
6. R Zygion
7. R Ectoorbitale
8. R Zygofrontale
9. R Frontotemporale
10. Crinion
11. Glabella
12. Sellion
13. Pronasale
14. Subnasale



15. Stomion
16. Promenton
17. Menton
18. L Cheilion
19. L Alare
20. L Gonion
21. L Tragion
22. L Zygion
23. L Infraorbitale
24. L Ectoorbitale
25. L Zygofrontale
26. L Frontotemporale
27. Sellion (repeat)
28. R Tragion (repeat)



SUBJECT'S RIGHT SIDE

SUBJECT'S LEFT SIDE

Figure D-17. The landmark locations and the order of measurement of coordinates.

3. Ask the subject to operate the chair lift by depressing the UP button located in the arm of the chair on the subject's left. As the chair ascends, guide the subject's head into position by gently holding it by the sides and sliding it against the rear headboard surface.

4. As the subject's head contacts the top headboard, the chair will automatically stop. Reassure the subject that this will happen.

5. The two small red HEAD POSITIONED lights on the lower front aspect of the rotary support housing should now be lighted. Manually align the subject's head as nearly as possible into the Frankfort plane (Figure D-18). It may be necessary for the subject to sit more erect and to make a conscious effort to keep the head pressed against the reference planes in order to keep the lights lighted throughout the measurement procedure. The lights indicate that the headboard pieces are at right angles and that the head is fully in contact with both surfaces.

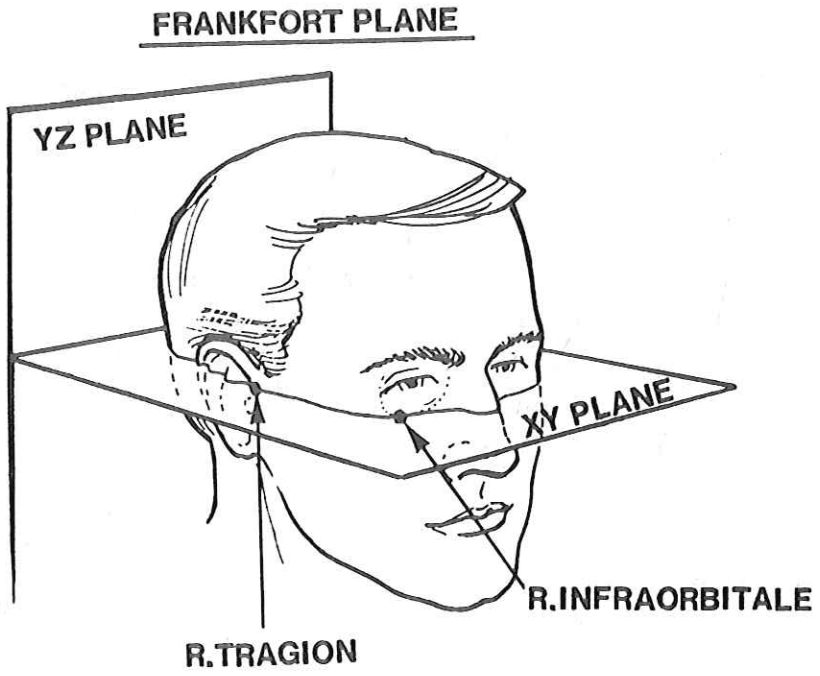


Figure D-18. Frankfort plane.

6. Ask the subject to hold the position while you loosen the rotary locking knob and the vertical axis locking knob of the CMS. See Figure D-6 and Figure D-7, respectively.

7. Unlock the horizontal slide and position the bead directly on the R Tragion landmark. With the bead still aligned with the landmark, lock the vertical axis and quickly swing the arm to check the Z level of the R Infraorbitale landmark. If infraorbitale is above or below tragion level by more than a few millimeters, ask subjects to lower or raise their heads accordingly and hold the position while you recheck R. Tragion and alignment along the XZ plane, i.e., L. Infraorbitale should be at the same level as R. Infraorbitale. After the Frankfort plane is established, position the arm out of your way and as quickly as possible tighten the head clamp by turning the control knob CCW. Ask the subject to tell you when the clamp is snug, but not uncomfortable. Make sure the "HEAD POSITIONED" lights are on as the clamp is tightened.

8. When you are satisfied that the head position is correct and the lights are on, make sure that the AUTO/MANUAL trip switch on the computer peripherals panel is in the "down" position.

9. Make sure the subject's diskette has been inserted in disk DRIVE B. You are now ready to measure coordinates.

MEASURING COORDINATES

Collecting and Processing the Data

After the subject's head has been properly positioned and secured, loosen the locking knobs on all three axes. The CMS is now free to move from point to point. Following the order listed in the legend on Figure D-17 and shown on the monitor, maneuver the CMS arm around, in and out, and up and down as necessary, to gently touch each landmark in succession. Do not dimple the skin any more than necessary to ensure that contact is established. When you are sure that you have the bead centered on the landmark to be measured, instruct the recorder to depress the hand switch in order to record the coordinates. The recorder may assist by naming aloud each landmark as it appears on the monitor screen.

Since the possible ways you may contact a given landmark are dictated by the degrees of freedom of movement in the CMS arm, each point will generally be touched in the same manner on all subjects. For example, the bilateral landmarks on the right and left side of the face are typically contacted on the inner (toward the subject) aspect of the bead. Those lying on the midsagittal line, or nearly so, are touched with the tip of the bead or topmost aspect of the bead as follows: those touched with the tip of the bead include crinion, glabella, sellion, pronasale, stomion, and promenton; subnasale and menton are approached by coming up from below the landmark and are, therefore, contacted with the topmost aspect of the bead. The software includes corrections for the bead diameter (remember that the bead center is the zero calibration point) and the direction of contact. Therefore, it is important to touch landmarks as instructed in order to get accurate measurements. With practice, operators learn to move from point to point

quite easily and rapidly; however, it is important to remember at all times not to frighten or injure a subject. Obviously, this is particularly true while working around the eyes.

If a point is recorded erroneously, the XYZ values may be deleted by depressing the "*" key on the keyboard. The erroneous values are automatically cleared and the point is remeasured. When all points are recorded, the program will not accept any more.

Close the file by pressing the "s" key. The program will take several seconds to analyze the data in the file. During this time the subject should remain in position, unless he/she has already been measured twice. The program will display a message indicating whether the measurements were **good** (all points reasonably located with respect to one another) or not.

If all the points in the first set of measurements were good, the message remains on the screen while the program writes two additional files on the subject's disk. The program prepares itself for another operation and returns to the main menu.

If one or more points from the first set of measurements are found to be out of range, the program will ask that the subject be remeasured. The entire set of measurements is repeated since, if the subject has moved between measurements, the location of a single remeasured point would probably not be within editing range with respect to the points in the original data set.

When remeasurement is required, the program does not return to the main menu, but instead goes back to the **record points** display of XYZ graphic, file name and commands, and the prompt for R. Tragion. Before starting the remeasurement, verify that the subject's head is still in the Frankfort plane.

To print the subject's data file on his/her disk, select option #4, **print a file**, from the main menu. The program will provide a numbered list of the available data files (in most cases, there will be only one). Enter the number of the file to be printed, or enter "*" to return to the main menu without printing anything. Check the printer to be sure that it is on line (an orange light on the printer control panel will be lit) and that the subject's data form is properly inserted. When everything is ready, press "<enter>" once more to start printing.

After the file is printed, the program returns to the main menu.

Dismissing the Subject

Upon successfully completing all the measurements, the subject is ready to be released. The following steps should be followed:

1. Position the CMS arm in the BEGIN-END position. (This will permit the chair to be lowered.) With the arm tight against the stop/interlock switch, tighten the rotary locking nut. Withdraw the horizontal slide to the stop and tighten the locking nut. Raise the arm against the vertical slide stop and tighten the locking nut.

2. Loosen the head clamp to the full open position. Help the subject to remove the safety glasses.

3. Have the subject depress the chair DOWN button. Assist the subject to clear the clamp-headboard area, and help him/her from the chair.

4. Present the subject with his/her diskette and the data blank on which the data have been printed.

5. Clean the contact surface in preparation for the next subject.

6. Check the BEGIN-END values displayed on the monitor. If X, Y, or Z are outside the range listed, recalibrate the CMS in preparation for the next subject.

Disassembling the AHD for shipment

Upon completion of the measurements at a given site, the AHD must be disassembled and prepared for shipment. The procedure is basically the reverse of the setup process. The recommended procedure includes the following sequence of steps:

1. Disconnect all power sources and the computer cable from the AHD.

2. Remove the touch probe and place in its shipping container. Position the horizontal slide in midposition and lock.

3. Lift and align the vertical axis assembly (arm) with the safety bolt access hole (see Figure D-19). Using a 1/4" Allen wrench and by turning the bolt CCW, run the safety bolt into the horizontal axis assembly until it is securely locked into position. Tighten the locking nut.

4. Using a 5/16" Allen wrench, loosen and remove the four bolts that attach the horizontal axis assembly (see Figure D-10). Disconnect the encoder cable (see Figure D-10).

5. Carefully remove the assembly from its alignment pins and place the assembly into its shipping container. Position the foam rubber packing. Close and latch the lid. Some assistance may be required to remove and pack the assembly.

6. Lock the rotary and, using a 5/16" Allen wrench, loosen and remove the four bolts that secure the vertical axis assembly (see Figure D-19). Disconnect the computer cable at the junction box (see Figure D-19). Carefully remove the assembly from its alignment pins and place it into its shipping container. Since the assembly weighs over 20 pounds, you should ask for assistance to handle it safely. Position the foam rubber padding and latch the container lid in place.

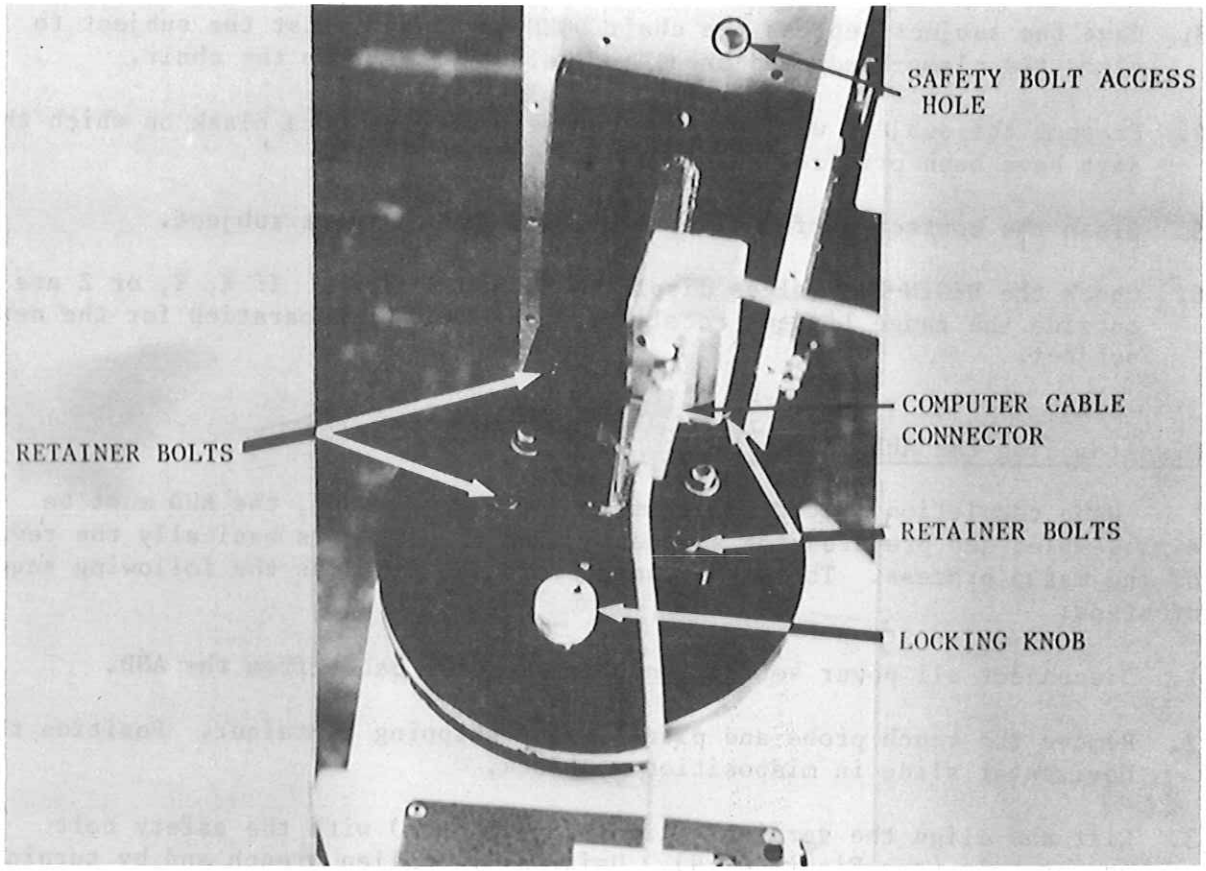


Figure D-19. Rotary bearing area showing the retainer bolts, the computer cable, and safety bolt access port (see also Figure D-8).

CARE AND MAINTENANCE

Although the AHD was ruggedly constructed for use in field survey conditions, it contains a number of very delicate and sensitive features. Most of these features are associated with the CMS and in order for the device to continue to provide reliable and accurate measurement of 3-D coordinates over an extended period of time, the operators should perform a number of routine maintenance tasks. Some aspects of the maintenance will need to be performed daily; others will only be required periodically. Lists of these tasks are given below. Also provided are lists of the items included in the tool kit, the supplies, and the replacement parts and accessories provided with the AHD.

Daily

When setting up, and each day during operation, the following routine maintenance should be performed using the equipment supplied:

1. Wipe clean the horizontal slide bar and the vertical slide rails (see Figures D-7 and D-10) with a clean, dry, lint-free cloth to remove fingerprints.

2. Once clean, apply a light coat of machine oil and wipe the surface with a lint-free cloth.

3. Using one of the small brushes provided, sweep any debris from the racks for both slides. This will help to ensure smooth operation of the encoder pinion gears.

Periodic

1. Inspect all encoder cables and their connectors. Any evidence of wear or impending failure should be reported to the design engineer.

2. Inspect and replace, as needed, the foam padding on the head stabilization clamp. Remove the worn pads and use them to size the replacement pads. Simply slip the padding off or on the head clamp arms. Save and reuse the plugs for the front end of each pad.

3. Check the CMS, chair lift, and other moving parts for proper operation before the first subject of the day arrives at the station. Make corrections and repairs as needed. Contact the design engineer if assistance is required.

4. Check the headboard angle as the HEAD POSITIONED lights come on using the plastic triangle from the tool kit. The headboard surfaces should be positioned at 90^{o} when they are against their stops. If the angle is visibly more or less than 90^{o}, adjust the stop screws using a 1/8" Allen wrench until a right angle is reestablished. Make sure the HEAD POSITIONED lights are on when the headboards are against their stops. The stop set screws also serve as the contact switches for these lights.

5. Vacuum chair pads.

6. Inspect all calibration equipment for wear. Repair and/or replace as necessary.

7. Polish the exposed surfaces of the slide assemblies to remove any aluminum oxide build-up. Use the aluminum polish supplied and a rag. Do not use the same rags used for cleaning the slides!

8. Inspect the counter balance cable for wear. Do not replace this yourself. Notify the design engineer if replacement is required.

9. Generally clean and dust the AHD frame.

Tool Kit

1 set of Allen wrenches - 1/32" thru 3/8"
1 set of small screwdrivers
1 small, medium and large blade screwdriver
1 medium size Phillips screwdriver
1 small adjustable wrench, 4" crescent
1 medium adjustable wrench, 6" crescent
1 standard pliers, 6"
1 needle nose pliers
1 wire cutter, small
1 solder iron
1 roll of solder
2 combination locks (for shipping containers)
1 height gauge, 30 cm
2 small cleaning brushes for racks
1 6" clamp
1 box of miscellaneous crimp-ons
1 crimping tool
1 pair of scissors
1 plastic drafting triangle

Supplies

6 lint-free cleaning cloths
1 can of light machine oil
1 can of teflon spray
1 can of silicone
1 container of aluminum polish
25 ft. of braided grounding strap
1 25-ft. power cord, with ground
1 100-ft. power cord, with ground
miscellaneous cleaning brushes
2 12-oz. bottles of 70% ethyl alcohol
2 packages of 2" x 2" gauze sponges
1 4-slot, 3-prong power strip
1 ground fault interruptor
1 hand vacuum cleaner
neoprene foam insulation tubing (head clamp padding)
encoder cable wire

Spare Parts and Accessories

1 printed circuit board (CMS computer board)
1 Spaulding encoder
1 set of calibration fixture support rods, spare
1 touch probe, spare
1 replacement thumb screw for calibration fixture
2 miniature lights, 12 volts DC, (HEAD POSITIONED lights)
miscellaneous replacement connectors for encoder cables
1 1-cm-thick rear headboard spacer block
1 set of AHD blueprints with parts lists

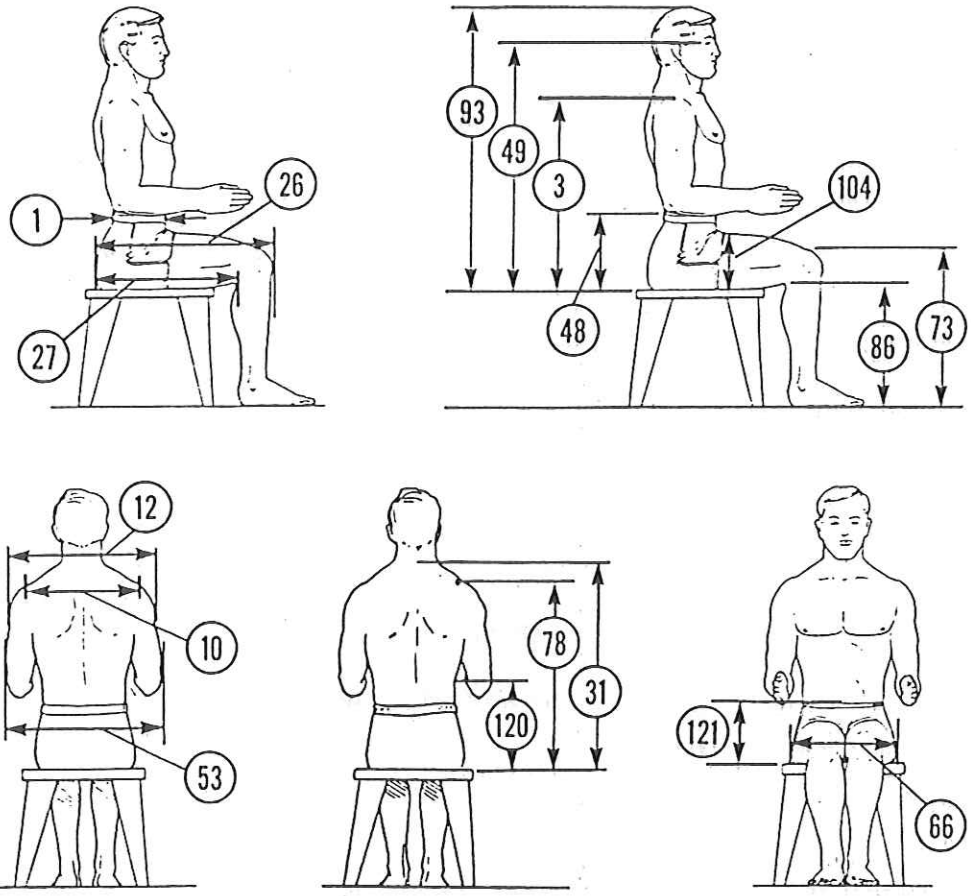
Spare Parts and Accessories

1 spare computer cable
1 foot rest
2 pairs safety glasses (large and small)

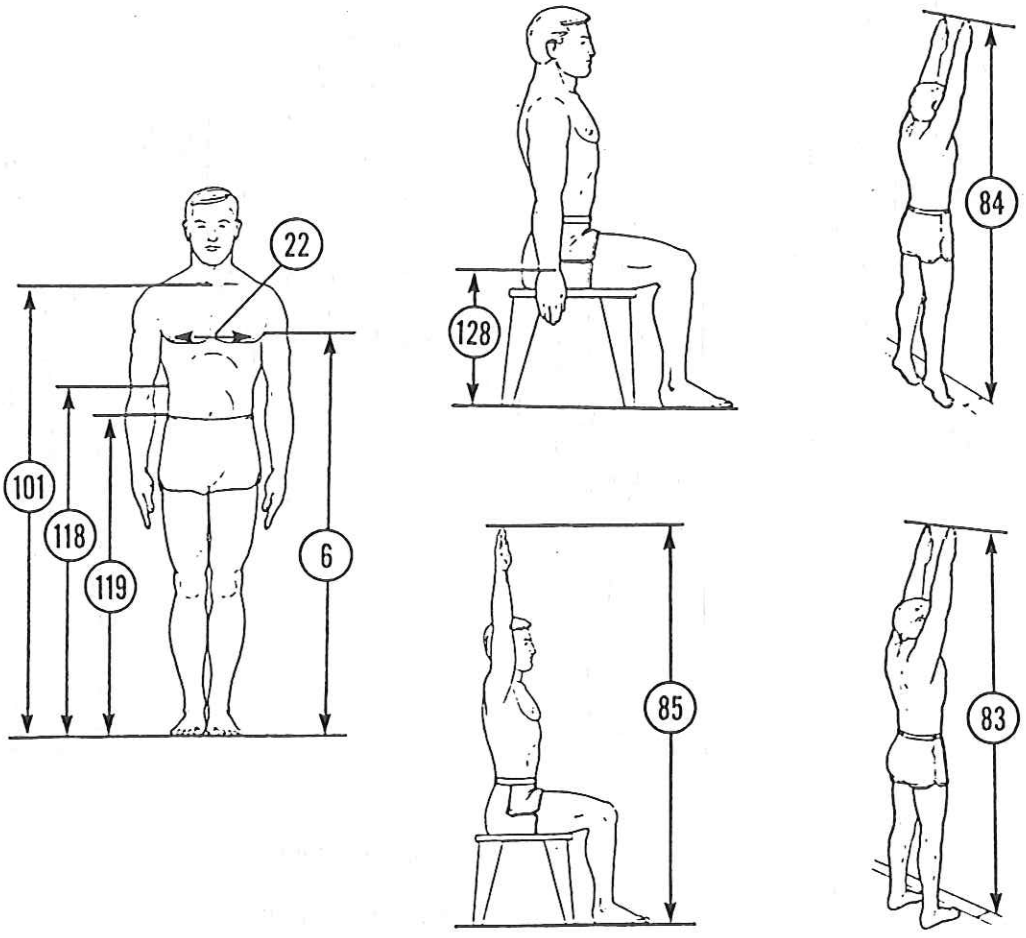
APPENDIX E.

The Visual Index

THE VISUAL INDEX



1. ABDOMINAL EXTENSION DEPTH, SITTING
3. ACROMIAL HEIGHT, SITTING
10. BIACROMIAL BREADTH
12. BIDELTOID BREADTH
26. BUTTOCK-KNEE LENGTH
27. BUTTOCK-POPLITEAL LENGTH
31. CERVICALE HEIGHT, SITTING
48. ELBOW REST HEIGHT
49. EYE HEIGHT, SITTING
53. FOREARM-FOREARM BREADTH
66. HIP BREADTH, SITTING
73. KNEE HEIGHT, SITTING
78. MIDSHOULDER HEIGHT, SITTING
86. POPLITEAL HEIGHT
93. SITTING HEIGHT
104. THIGH CLEARANCE
120. WAIST HEIGHT, SITTING (NATURAL INDENTATION)
121. WAIST HEIGHT, SITTING (OMPHALION)



6. AXILLA HEIGHT

22. BUSTPOINT/THELION-BUSTPOINT/THELION BREADTH

83. OVERHEAD FINGERTIP REACH

84. OVERHEAD FINGERTIP REACH, EXTENDED

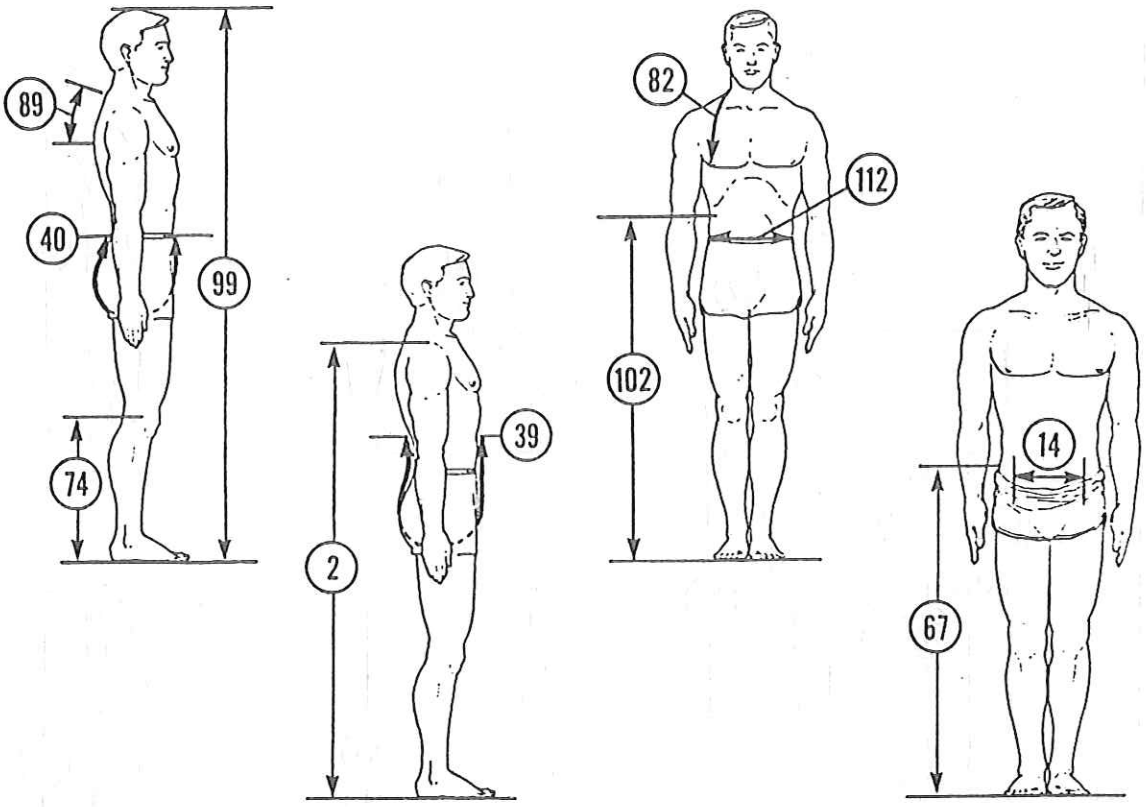
85. OVERHEAD FINGERTIP REACH, SITTING

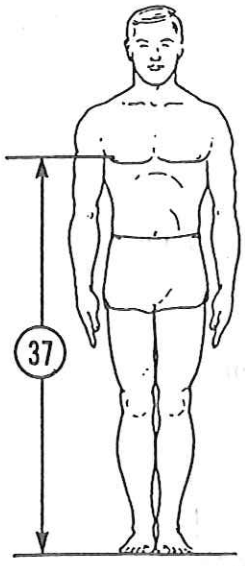
101. SUPRASTERNALE HEIGHT

118. WAIST HEIGHT (NATURAL INDENTATION)

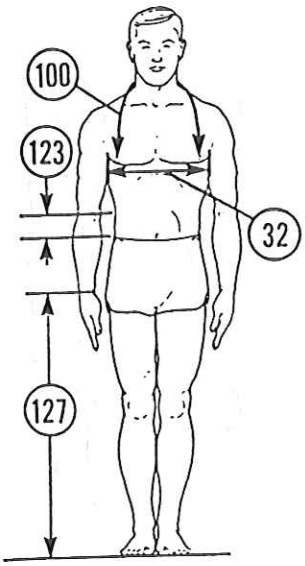
119. WAIST HEIGHT (OMPHALION)

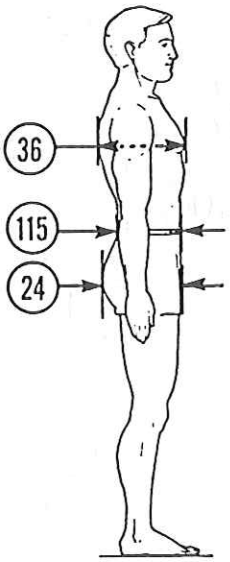
128. WRIST HEIGHT, SITTING

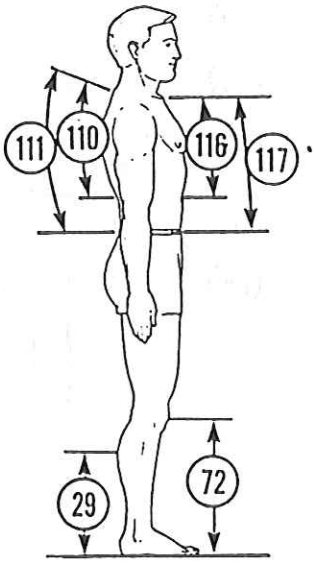


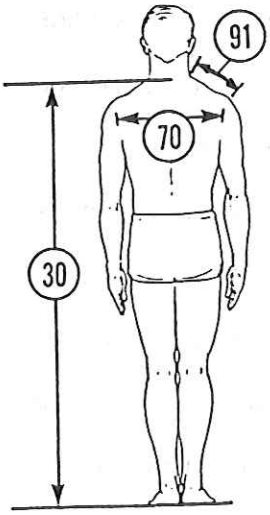


2. ACROMIAL HEIGHT
14. BISPINOUS BREADTH
37. CHEST HEIGHT
39. CROTCH LENGTH (NATURAL INDENTATION)
40. CROTCH LENGTH (OMPHALION)
67. ILIOCRISTALE HEIGHT
74. LATERAL FEMORAL EPICONDYLE HEIGHT
82. NECK-BUSTPOINT/THELION LENGTH
89. SCYE DEPTH
99. STATURE
102. TENTH RIB HEIGHT
112. WAIST BREADTH









24. BUTTOCK DEPTH

29. CALF HEIGHT

30. CERVICALE HEIGHT

32. CHEST BREADTH

36. CHEST DEPTH

70. INTERSCYE II

72. KNEE HEIGHT, MIDPATELLA

91. SHOULDER LENGTH

100. STRAP LENGTH

110. WAIST BACK LENGTH (NATURAL INDENTATION)

111. WAIST BACK LENGTH (OMPHALION)

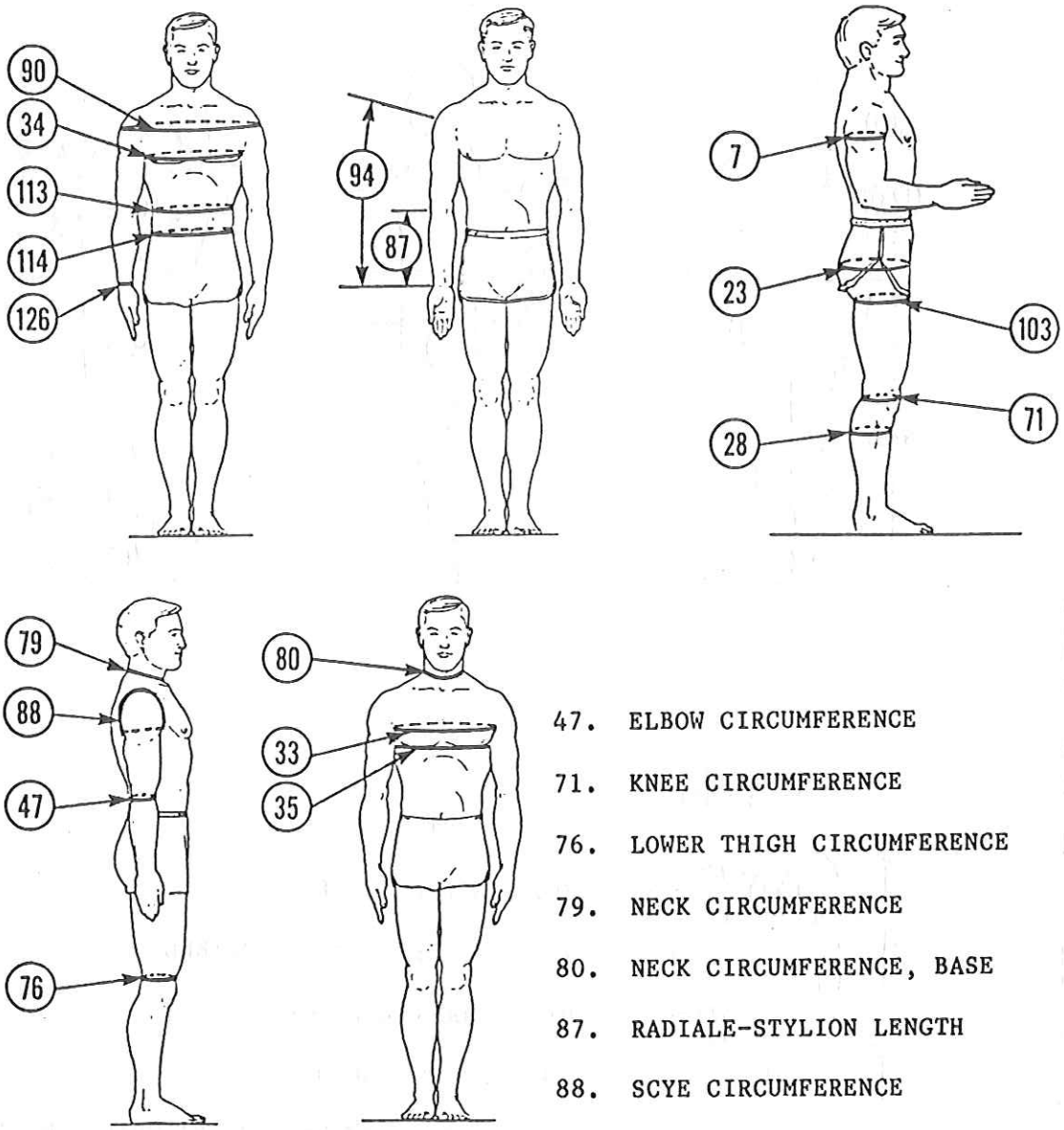
115. WAIST DEPTH

116. WAIST FRONT LENGTH (NATURAL INDENTATION)

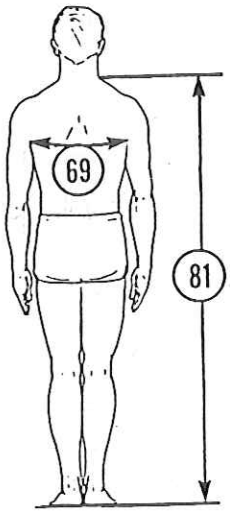
117. WAIST FRONT LENGTH (OMPHALION)

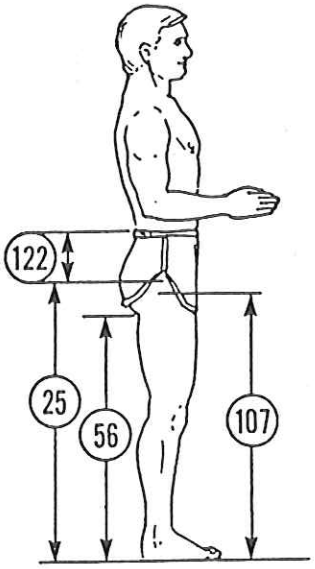
123. WAIST (NATURAL INDENTATION) TO WAIST (OMPHALION) LENGTH

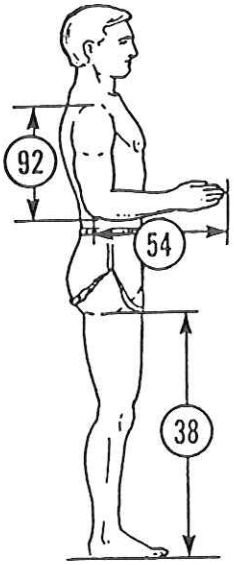
127. WRIST HEIGHT

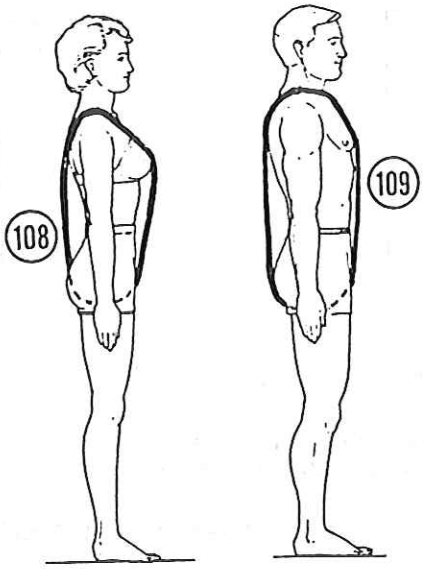


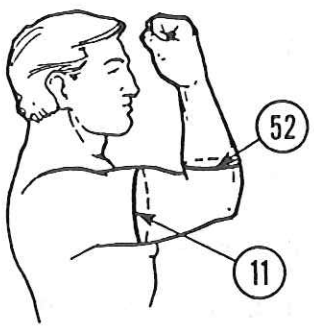
7. AXILLARY ARM CIRCUMFERENCE
23. BUTTOCK CIRCUMFERENCE
28. CALF CIRCUMFERENCE
33. CHEST CIRCUMFERENCE AT SCYE
34. CHEST CIRCUMFERENCE
35. CHEST CIRCUMFERENCE BELOW BREAST
47. ELBOW CIRCUMFERENCE
71. KNEE CIRCUMFERENCE
76. LOWER THIGH CIRCUMFERENCE
79. NECK CIRCUMFERENCE
80. NECK CIRCUMFERENCE, BASE
87. RADIALE-STYLION LENGTH
88. SCYE CIRCUMFERENCE
90. SHOULDER CIRCUMFERENCE
94. SLEEVE OUTSEAM
103. THIGH CIRCUMFERENCE
113. WAIST CIRCUMFERENCE (NATURAL INDENTATION)
114. WAIST CIRCUMFERENCE (OMPHALION)
126. WRIST CIRCUMFERENCE



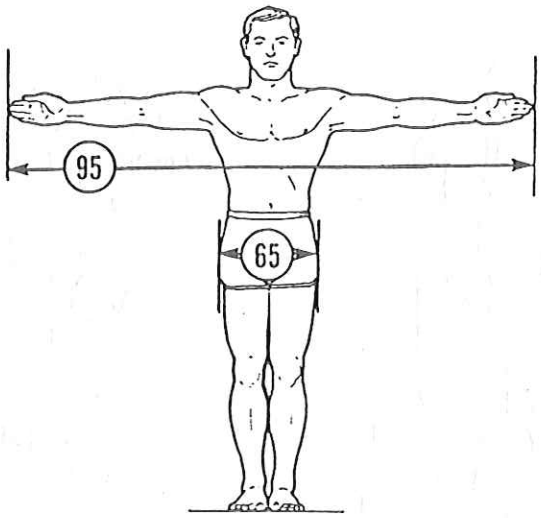


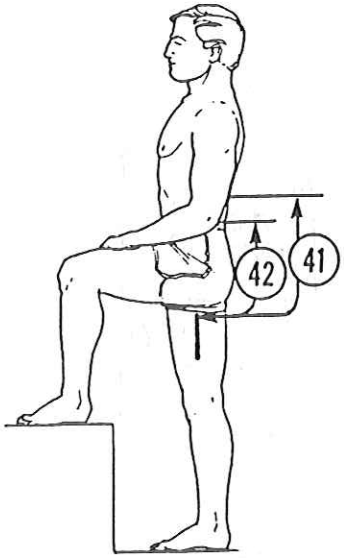


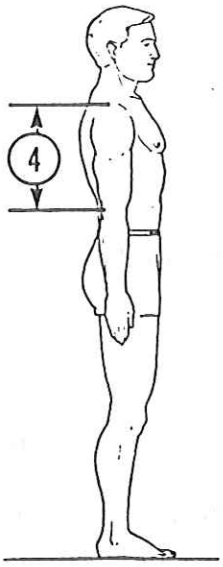


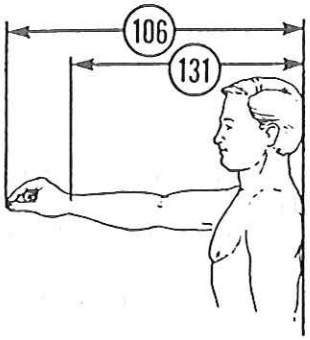


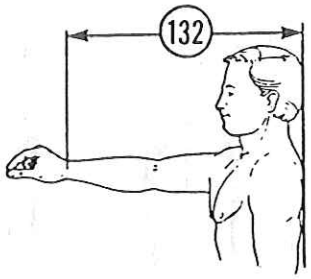
11. BICEPS CIRCUMFERENCE, FLEXED
25. BUTTOCK HEIGHT
38. CROTCH HEIGHT
52. FOREARM CIRCUMFERENCE, FLEXED
54. FOREARM-HAND LENGTH
56. GLUTEAL FURROW HEIGHT
69. INTERSCYE I
81. NECK HEIGHT, LATERAL
92. SHOULDER-ELBOW LENGTH
107. TROCHANTERIC HEIGHT
108. VERTICAL TRUNK CIRCUMFERENCE (ASCC)
109. VERTICAL TRUNK CIRCUMFERENCE (USA)
122. WAIST-HIP LENGTH

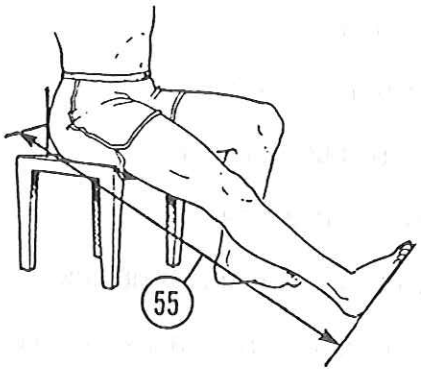












4. ACROMION-RADIALE LENGTH

41. CROTCH LENGTH, POSTERIOR (NATURAL INDENTATION)

42. CROTCH LENGTH, POSTERIOR (OMPHALION)

55. FUNCTIONAL LEG LENGTH

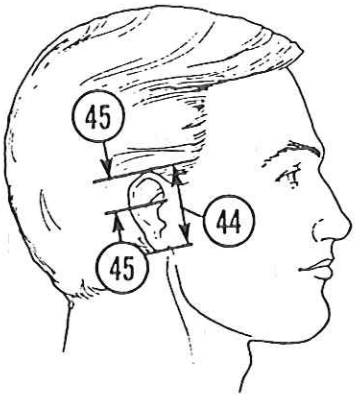
65. HIP BREADTH

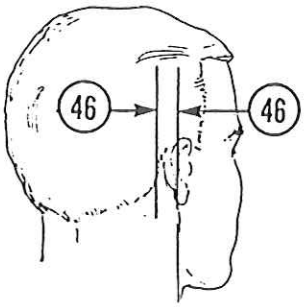
95. SPAN

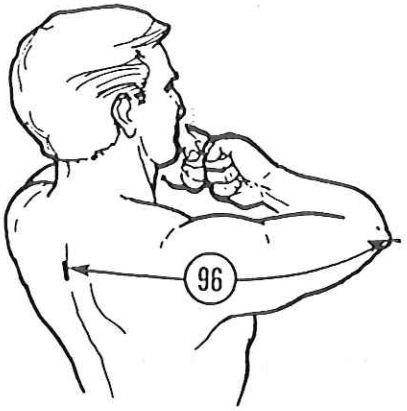
106. THUMBTIP REACH

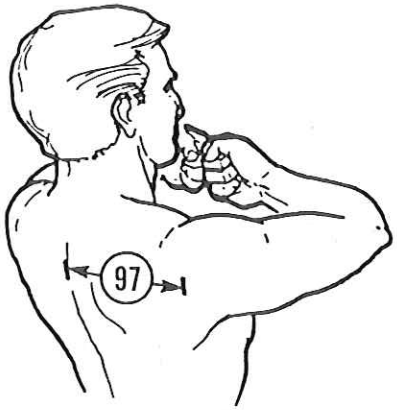
131. WRIST-WALL LENGTH

132. WRIST-WALL LENGTH, EXTENDED









44. EAR LENGTH

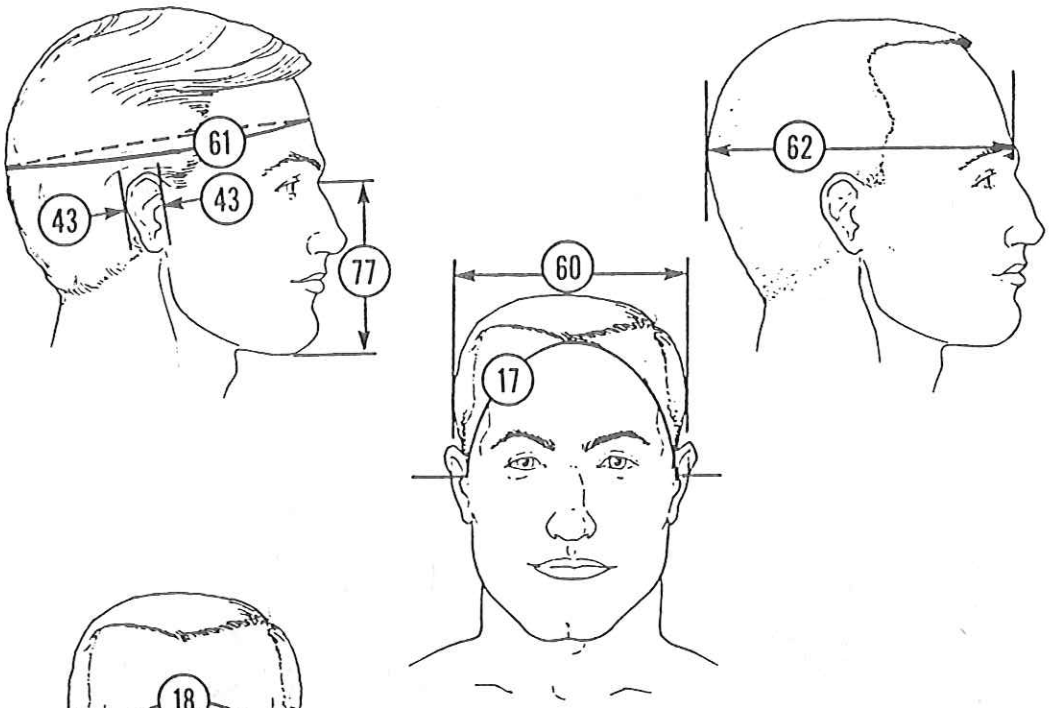
45. EAR LENGTH ABOVE TRAGION

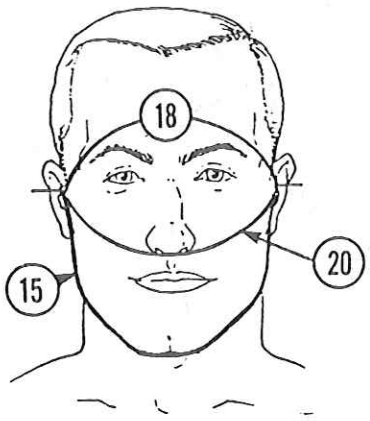
46. EAR PROTRUSION

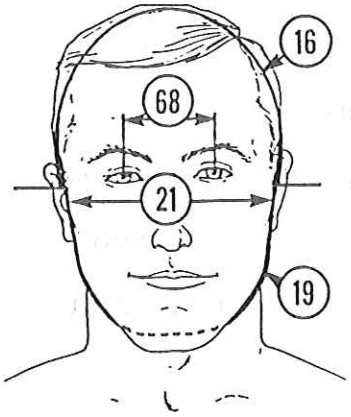
96. SLEEVE LENGTH: SPINE-ELBOW

97. SLEEVE LENGTH: SPINE-SCYE

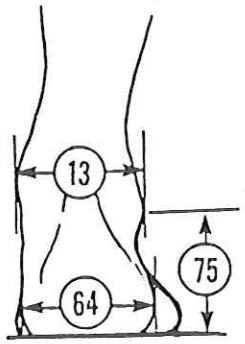
98. SLEEVE LENGTH: SPINE-WRIST

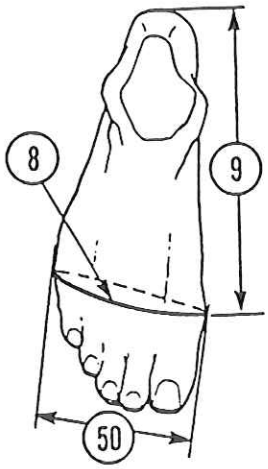


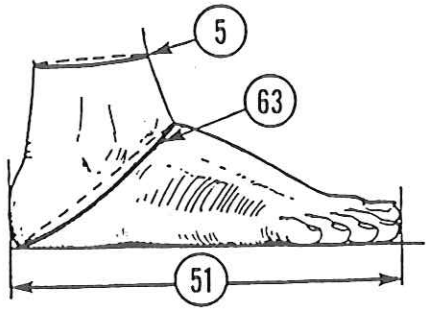


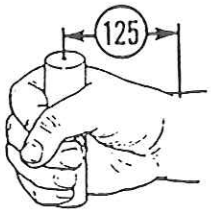


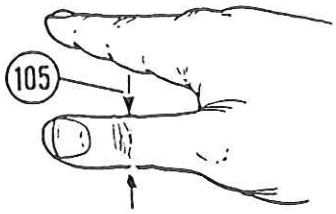
15. BITRAGION CHIN ARC
16. BITRAGION CORONAL ARC
17. BITRAGION CRINION ARC
18. BITRAGION FRONTAL ARC
19. BITRAGION SUBMANDIBULAR ARC
20. BITRAGION SUBNASALE ARC
21. BIZYGOMATIC BREADTH
43. EAR BREADTH
60. HEAD BREADTH
61. HEAD CIRCUMFERENCE
62. HEAD LENGTH
68. INTERPUPILLARY BREADTH
77. MENTON-SELLION LENGTH

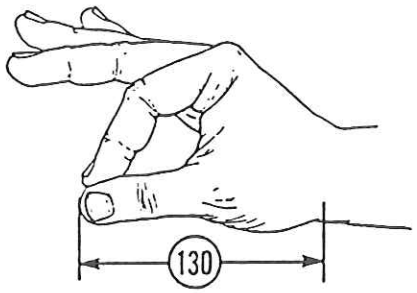


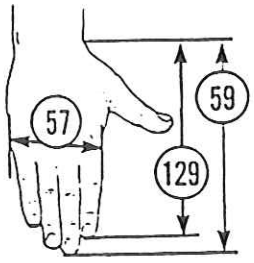


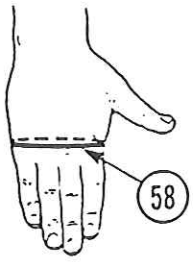












5. ANKLE CIRCUMFERENCE
8. BALL OF FOOT CIRCUMFERENCE
9. BALL OF FOOT LENGTH
13. BIMALLEOLAR BREADTH
50. FOOT BREADTH, HORIZONTAL
51. FOOT LENGTH
57. HAND BREADTH
58. HAND CIRCUMFERENCE
59. HAND LENGTH
63. HEEL ANKLE CIRCUMFERENCE
64. HEEL BREADTH
75. LATERAL MALLEOLUS HEIGHT
105. THUMB BREADTH
125. WRIST-CENTER OF GRIP LENGTH
129. WRIST-INDEX FINGER LENGTH
130. WRIST-THUMBTIP LENGTH

APPENDIX F.

Allowable Observer Error

APPENDIX F.

Allowable Observer Error

Control of observer error in anthropometric surveys is a critical factor in the reliability of the resulting data. Nevertheless, data on observer error has been only infrequently collected during such surveys because to do so is costly, time-consuming, and often a source of irritation for measurer and subject alike. The problem is particularly acute in military surveys, since subject time is always in lieu of duty time. Some studies of inter-observer error have been conducted, but usually only after the survey has been completed. These data are useful in assessing results, but cannot affect them. The U.S. Army has set limits for observer error in advance, and will track measurer performance throughout the data collection phase of the upcoming survey.

USES

The acceptable observer errors reported here will be used for three purposes. First, they will be used during the initial training period, as an indicator that measurers have successfully learned their tasks. Team members will make practice measurements on a group of subjects to learn their assigned dimensions. After the initial practice runs, data will be collected and retained for analysis. Intra- and interobserver error results will be calculated regularly to assess the ability of each measurer to repeat measurements within fixed limitations and the ability of each pair of measurers to achieve interobserver consistency.

The second use of the acceptable observer error levels will be to "recalibrate" the team at the beginning of each new survey location. Because the team will be traveling by car and van to each new location, there may be a period of several days between measuring sessions. In order to ensure consistency from one location to the next, and in order to minimize measurer "drift" during the course of the survey, error trials will be conducted on the first day in each new location. A group of subjects will be measured and then remeasured and observer error will be checked. Practice sessions will be held until the observer error on each dimension is lower than the value reported here.

The third and final use of the values reported here is as a comparison against the daily error checks. At each station, twice a day, a subject will be repeated to give error data on actual subjects collected during the course of the survey. These data will be examined daily and analyzed weekly. If a measuring pair exceeds the observer error established in this report, the cause of the drift will be sought, and corrective action taken. These values in a very real sense establish the minimum reliability for the data collected in the survey.

DETERMINATION OF OBSERVER ERROR

The dimensions to be measured in the Army survey were measured eight times each on 10 subjects. The eight measurement sessions were divided in the following way: four experienced anthropologists each measured each

subject twice. Because a single measurement session took between one and two hours, each subject was measured four times in one day by the four measurers, and four times a second day, again by all four measurers. On a given day, each subject was marked only once.

After the data were collected, they were entered into computer files and subjected to gross editing to eliminate large discrepancies, such as those that resulted from obvious misreadings of instruments. After editing, the data were analyzed in the following way: For every pair of measurers (six pairs in all) the differences between measurers were calculated for each subject for each dimension. The mean of the absolute values of those differences was calculated for each pair of investigators, for each dimension. These procedures were carried out separately for each of the two trials.

In general, the recommended allowable error was set at the maximum of the twelve interobserver means. The rationale was that the four measurers are experts. Differences between them would be expected to be the minimum differences between individuals who are not so highly trained.

As will be noted on Table F-1 below, the amount of allowable error varies considerably among the dimensions. The higher values are generally associated with those measurements in which it is difficult to fully achieve standardization. These include measurements involving the breathing cycle (e.g. chest measurements); those in which it is difficult to get consistency in subject position (e.g. a number of sitting dimensions); those involving subject motivation (e.g. reach dimensions); and those involving differential pressure applied to soft tissue (e.g. crotch measurements). Overall, larger dimensions also have higher error allowances.

TABLE F-1. Allowable Observer Error for Dimensions in the U.S. Army 1987-1988 Anthropometric Survey (values in mm).

Dimension	Allowable Error
Abdominal Extension Depth, Sitting	10
Acromial Height	7
Acromial Height, Sitting	9
Acromion-Radiale Length	4
Ankle Circumference	4
Axilla Height	10
Axillary Arm Circumference	8
Ball of Foot Circumference	4
Ball of Foot Length	6
Biacromial Breadth	8
Biceps Circumference, Flexed	6
Bideltoid Breadth	8
Bimalleolar Breadth	2
Bispinous Breadth	3
Bitragion Chin Arc	8
Bitragion Coronal Arc	7
Bitragion Crinion Arc	5
Bitragion Frontal Arc	5
Bitragion Submandibular Arc	6
Bitragion Subnasale Arc	6
Bizygomatic Breadth	2
Bustpoint/Thelion-Bustpoint/Thelion Breadth	10
Buttock Circumference	12
Buttock Depth	8
Buttock Height	7
Buttock-Knee Length	6
Buttock-Popliteal Length	7
Calf Circumference	5
Calf Height	3
Cervicale Height	7
Cervicale Height, Sitting	10
Chest Breadth	8
Chest Circumference	15
Chest Circumference at Scye	15
Chest Circumference below Breast	16
Chest Depth	4

TABLE F-1 (cont'd)

Dimension	Allowable Error
Chest Height	11
Crotch Height	10
Crotch Length (Natural Indentation)	16
Crotch Length (Omphalion)	18
Crotch Length, Posterior (Natural Indentation)	11
Crotch Length, Posterior (Omphalion)	11
Ear Breadth	3
Ear Length	2
Ear Length above Tragion	2
Ear Protrusion	3
Elbow Circumference	4
Elbow Rest Height	10
Eye Height, Sitting	8
Foot Breadth, Horizontal	2
Foot Length	3
Forearm Circumference, Flexed	5
Forearm-Forearm Breadth	17
Forearm-Hand Length	4
Functional Leg Length	17
Gluteal Furrow Height	6
Hand Breadth	2
Hand Circumference	4
Hand Length	3
Head Breadth	2
Head Circumference	5
Head Length	2
Heel Ankle Circumference	6
Heel Breadth	2
Hip Breadth	7
Hip Breadth, Sitting	6
Iliocristale Height	5
Interpupillary Breadth	2
Interscye I	10
Interscye II	13
Knee Circumference	4
Knee Height, Midpatella	6
Knee Height, Sitting	2
Lateral Femoral Epicondyle Height	3
Lateral Malleolus Height	3
Lower Thigh Circumference	4
Menton-Sellion Length	3
Midshoulder Height, Sitting	9

TABLE F-1 (cont'd)

Dimension	Allowable Error
Neck-Bustpoint/Thelion Length	8
Neck Circumference	6
Neck Circumference, Base	11
Neck Height, Lateral	7
Overhead Fingertip Reach	20
Overhead Fingertip Reach, Extended	20
Overhead Fingertip Reach, Sitting	20
Popliteal Height	7
Radiale-Stylion Length	6
Scye Circumference	13
Scye Depth	4
Shoulder Circumference	22
Shoulder-Elbow Length	6
Shoulder Length	3
Sitting Height	6
Sleeve Length: Spine-Elbow	10
Sleeve Length: Spine-Scye	11
Sleeve Length: Spine-Wrist	9
Sleeve Outseam	6
Span	10
Stature	10
Strap Length	12
Suprasternale Height	5
Tenth Rib Height	5
Thigh Circumference	6
Thigh Clearance	3
Thumb Breadth	2
Thumbtip Reach	20
Trochanteric Height	7
Vertical Trunk Circumference (ASCC)	22
Vertical Trunk Circumference (USA)	24
Waist Back Length (Natural Indentation)	5
Waist Back Length (Omphalion)	5
Waist Breadth	6
Waist Circumference (Natural Indentation)	11
Waist Circumference (Omphalion)	12
Waist Depth	8
Waist Front Length (Natural Indentation)	5
Waist Front Length (Omphalion)	5
Waist Height (Natural Indentation)	4
Waist Height (Omphalion)	7
Waist Height, Sitting (Natural Indentation)	6

TABLE F-1 (cont'd)

Dimension	Allowable Error
Waist Height, Sitting (Omphalion)	8
Waist-Hip Length	6
Waist (Natural Indentation) - Waist (Omphalion)	3
Weight	0.3 kg
Wrist-Center of Grip Length	4
Wrist Circumference	5
Wrist Height	11
Wrist Height, Sitting	10
Wrist-Index Finger Length	4
Wrist-Thumbtip Length	3
Wrist-Wall Length	20
Wrist-Wall Length, Extended	20

INDEX

	Page
ABDOMINAL EXTENSION DEPTH, SITTING	70
Abdominal point, anterior landmark	65
ACROMIAL HEIGHT	71
ACROMIAL HEIGHT, SITTING	72
Acromion landmarks	18
ACROMION-RADIALE LENGTH	73
Acropodion landmarks	65
Alare landmarks	63
ANKLE CIRCUMFERENCE	74
Anterior superior iliac spine landmarks	19
Anthropometer	5, 6, 256
Automated headboard device	5, 8, 13, 263
AXILLA HEIGHT	75
AXILLARY ARM CIRCUMFERENCE	76
Axillary fold, posterior landmarks	65
BALL OF FOOT CIRCUMFERENCE	77
BALL OF FOOT LENGTH	78
Beam caliper	5, 6, 256
BIACROMIAL BREADTH	79
BICEPS CIRCUMFERENCE, FLEXED	80
Biceps point landmark	20
BIDELTOID BREADTH	81
BIMALLEOLAR BREADTH	82
BISPINOUS BREADTH	83
BITRAGION CHIN ARC	84
BITRAGION CORONAL ARC	85
BITRAGION CRINION ARC	86
BITRAGION FRONTAL ARC	87
BITRAGION SUBMANDIBULAR ARC	88
BITRAGION SUBNASALE ARC	89
BIZYGOMATIC BREADTH	90
Blocks	5, 7

	Page
Bustpoint landmarks	21
BUSTPOINT/THELION-BUSTPOINT/THELION BREADTH	91
BUTTOCK CIRCUMFERENCE	92
BUTTOCK DEPTH	93
BUTTOCK HEIGHT	94
BUTTOCK-KNEE LENGTH	95
Buttock point landmarks	22, 65
BUTTOCK-POPLITEAL LENGTH	96
Calf landmark	23
CALF CIRCUMFERENCE	97
CALF HEIGHT	98
Cervicale landmark	24
CERVICALE HEIGHT	99
CERVICALE HEIGHT, SITTING	100
Cheilion landmarks	63
CHEST BREADTH	101
CHEST CIRCUMFERENCE	102
CHEST CIRCUMFERENCE AT SCYE	103
CHEST CIRCUMFERENCE BELOW BREAST	104
CHEST DEPTH	105
CHEST HEIGHT	106
Chin landmark	65
Clavicle point landmarks	25
Compaq computer	216
Crinion landmark	26
CROTCH HEIGHT	107
CROTCH LENGTH (NATURAL INDENTATION)	108
CROTCH LENGTH (OMPHALION)	109
CROTCH LENGTH, POSTERIOR (NATURAL INDENTATION)	110
CROTCH LENGTH, POSTERIOR (OMPHALION)	111
Dactylion II landmark	65
Dactylion III landmark	65
Deltoid point landmarks	27

	Page
Dorsal juncture, calf and thigh landmark	65
Dorsal juncture, foot and leg landmark	28
Ear, bottom landmark	65
EAR BREADTH	112
EAR LENGTH	113
EAR LENGTH ABOVE TRAGION	114
Ear point landmark	65
EAR PROTRUSION	115
Ear top landmark	65
Ectocanthus	65
Ectoorbitale landmarks	63
ELBOW CIRCUMFERENCE	116
Elbow crease landmark	65
ELBOW REST HEIGHT	117
EYE HEIGHT, SITTING	118
Fifth metatarsophalangeal protrusion landmark	29
First metatarsophalangeal protrusion landmark	30
Footbox	5, 7, 259
FOOT BREADTH, HORIZONTAL	119
FOOT LENGTH	120
FOREARM CIRCUMFERENCE, FLEXED	121
FOREARM-FOREARM BREADTH	122
FOREARM-HAND LENGTH	123
Frontotemporale landmarks	63
FUNCTIONAL LEG LENGTH	124
Functional leg length anthropometer	5, 6, 257, 258
Glabella landmark	63
GLUTEAL FURROW HEIGHT	125
Gluteal furrow point landmark	31
Gonion landmarks	63

	Page
HAND BREADTH	126
HAND CIRCUMFERENCE	127
HAND LENGTH	128
Hand photometric system	5, 7, 13, 237
Headboard (see Automated headboard device)	
HEAD BREADTH	129
HEAD CIRCUMFERENCE	130
HEAD LENGTH	131
HEEL ANKLE CIRCUMFERENCE	132
HEEL BREADTH	133
Heel point landmarks	65
HIP BREADTH	134
HIP BREADTH, SITTING	135
Holtain caliper	5, 6, 256
Iliocristale landmark	32
ILIOCRISTALE HEIGHT	136
Inferior breast point landmark	66
Infraorbitale landmarks	33, 63
Infrathyroid landmark	34
Inner thigh landmark	35
INTERPUPILLARY BREADTH	137
INTERSCYE I	138
INTERSCYE II	139
KNEE CIRCUMFERENCE	140
KNEE HEIGHT, MIDPATELLA	141
KNEE HEIGHT, SITTING	142
Knee point, anterior landmark	66
Landmark transfer rod	9, 10, 260
LATERAL FEMORAL EPICONDYLE HEIGHT	143
Lateral femoral epicondyle landmark	36
Lateral malleolus landmark	37
LATERAL MALLEOLUS HEIGHT	144
LOWER THIGH CIRCUMFERENCE	145

	Page
Medial malleolus landmark	66
Menton landmark	38
MENTON-SELLION LENGTH	146
Metacarpale II landmark	39
Metacarpale V landmark	40
Midpatella landmark	41
Midshoulder landmark	42
MIDSHOULDER HEIGHT, SITTING	147
Midspine landmark	43
NECK-BUSTPOINT/THELION LENGTH	148
Neck landmarks	44
NECK CIRCUMFERENCE	149
NECK CIRCUMFERENCE, BASE	150
NECK HEIGHT, LATERAL	151
Olecranon landmark	45, 66
Otobasion superior landmark	66
OVERHEAD FINGERTIP REACH	152
OVERHEAD FINGERTIP REACH, EXTENDED	153
OVERHEAD FINGERTIP REACH, SITTING	154
Photobox (see Hand photometric system)	
Poech caliper	5, 6, 256
POPLITEAL HEIGHT	155
Posterior Superior Iliac Spine Landmark	66
Promenton landmark	63
Pronasale landmark	63
Pternion landmark	66
Pupillometer	5, 6, 9, 137, 257
Radiale landmark	46
RADIALE-STYLION LENGTH	156
Right angle	67, 68
Rules	9, 10

	Page
Scye landmarks	47
SCYE CIRCUMFERENCE	157
SCYE DEPTH	158
Sellion landmark	50
SHOULDER CIRCUMFERENCE	159
SHOULDER-ELBOW LENGTH	160
SHOULDER LENGTH	161
SITTING HEIGHT	162
SLEEVE LENGTH: SPINE-ELBOW	163
SLEEVE LENGTH: SPINE-SCYE	164
SLEEVE LENGTH: SPINE-WRIST	165
SLEEVE OUTSEAM	166
Sliding caliper	5, 6, 256
SPAN	167
Spreading caliper	5, 6, 256
STATURE	168
Stomion landmark	63
STRAP LENGTH	169
Stylion landmark	51
Submandibular landmark	52, 66
Subnasale landmark	63
Suprapatella landmark	53
Suprasternale landmark	54
SUPRASTERNALE HEIGHT	170
Tape	5, 6, 256
Tenth rib landmark	55
TENTH RIB HEIGHT	171
Thelion landmarks	66
THIGH CIRCUMFERENCE	172
THIGH CLEARANCE	173
Thigh point, top landmark	66
THUMB BREADTH	174
Thumbtip landmark	66
THUMBTIP REACH	175

	Page
Top of head landmark	66
Tragion landmarks	56
Trapezius point landmarks	57
Trochanter landmark	58
Trochanterion landmark	59
TROCHANTERIC HEIGHT	176
VERTICAL TRUNK CIRCUMFERENCE (ASCC)	177
VERTICAL TRUNK CIRCUMFERENCE (USA)	178
WAIST BACK LENGTH (NATURAL INDENTATION)	179
WAIST BACK LENGTH (OMPHALION)	180
WAIST BREADTH	181
WAIST CIRCUMFERENCE (NATURAL INDENTATION)	182
WAIST CIRCUMFERENCE (OMPHALION)	183
WAIST DEPTH	184
WAIST FRONT LENGTH (NATURAL INDENTATION)	185
WAIST FRONT LENGTH (OMPHALION)	186
WAIST HEIGHT (NATURAL INDENTATION)	187
WAIST HEIGHT (OMPHALION)	188
WAIST HEIGHT, SITTING (NATURAL INDENTATION)	189
WAIST HEIGHT, SITTING (OMPHALION)	190
Waist (natural indentation) landmarks	60
Waist (omphalion) landmarks	61
WAIST-HIP LENGTH	191
WAIST (NATURAL INDENTATION)-WAIST (OMPHALION) LENGTH	192
Wall scale	5, 7, 258
WEIGHT	193
WRIST-CENTER OF GRIP LENGTH	194
WRIST CIRCUMFERENCE	195
Wrist, dorsal landmark	62
WRIST HEIGHT	196
WRIST HEIGHT, SITTING	197
WRIST-INDEX FINGER LENGTH	198
WRIST-THUMBTIP LENGTH	199

	Page
WRIST-WALL LENGTH	200
WRIST-WALL LENGTH, EXTENDED	201
Zygion landmarks	63
Zygofrontale landmarks	63

☆ U.S. GOVERNMENT PRINTING OFFICE:1988-501-559:60061