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MEASURER'S HANDBOOK: US ARMY AND MARINE CORPS ANTHROPOMETRIC SURVEYS, 2010-2011

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14. ABSTRACT

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 and U.S. Marine Corps men and women. The handbook was prepared by Natick Soldier Research, Development and Engineering Center, with funding from both the Army and the Marine Corps. It contains instructions for the measurement of 94 traditional measures of the body, and for obtaining three-dimensional scan images of the whole body, head/face, and foot. 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 and other equipment (hardware/software) to be used to collect, record, and edit the data in the field. The measurements obtained in this anthropometric survey will form the basis for ensuring that Army and Marine Corps clothing, equipment, vehicle workstations, and systems properly accommodate Army and Marine Corps personnel who run the body-size gamut from small women to large men.

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CLOTHING MEASUREMENT ARMY PERSONNEL INFORMATION RETRIEVAL WHOLE BODY SCAN
EQUIPMENT BODY SCANS ANTHROPOMETRY MARINE CORPS PERSONNEL THREE DIMENSIONAL
SCANNING HANDBOOKS USER MANUALS COMPUTER PROGRAMS BODY MEASUREMENTS
ACCURACY HUMAN BODY SIZES(DIMENSIONS) STANDARDIZATION
ANTHROPOMETRIC SURVEY BODY SIZES SURVEYS
HUMAN FACTORS ENGINEERING ANTHROPOMETRIC MEASUREMENT TOOL

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MEASURER'S HANDBOOK
US ARMY AND MARINE CORPS
ANTHROPOMETRIC SURVEYS, 2010-2011

1. INTRODUCTION

The purpose of this manual is to describe and explain the tools and procedures required for the precise and accurate measurement of Marine Corps (USMC) and Army men and women and to familiarize anthropometrists (measurers) with the landmarks and dimensions of the body essential to accomplish the task. Although really significant learning can only come from actual training and practice, this handbook will serve as an introduction to what the anthropometrist needs to know – chiefly, the basic procedures for finding landmarks and performing measurements correctly.

This handbook was prepared by the Natick Soldier Research, Development and Engineering Center (NSRDEC) between September 2009 and August 2010 with support, provided under contract, from Anthrotech. The effort was jointly funded by the Army (under Program Element 63001, Project 62786/63001, Task 43/30) and the Marine Corps Systems Command.

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

All US military and many foreign services maintain anthropometric databases detailing the body size distribution of their personnel. These data are primarily used 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 and 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.

Anthropometric data describing body size and shape distributions of the Army and USMC populations are maintained at NSRDEC. In the U.S. Army and Marine Corps Anthropometric Surveys of 2010-2011, 94 dimensions, chosen as the most useful ones for meeting current and anticipated Army and USMC needs, will be directly measured. In addition, three-dimensional (3-D) whole body, head, and foot scans will be collected on each individual. These measurements and scans will form the basis for ensuring that Army and USMC clothing, equipment, and systems properly accommodate Army and USMC personnel, who run the spectrum of body sizes from small women to large men.

The results of a 2006/2007 pilot study on 2811 Active, Reserve, and Guard Soldiers showed that increases in body weight since 1988 are so significant that subjects in the 1988 Anthropometric Survey (ANSUR) Database (the Army's most recent anthropometric database) cannot represent today's larger, heavier Soldier sizes even with statistical weighting to account for demographic change. Many current clothing and individual equipment (CIE) sizing systems no longer cover the full range of body sizes in today's Total Army. Additionally, many tariffs are now incorrect such that the Army has had shortages of select sizes of CIE. This required urgent (and expensive) procurements to meet deployment requirements during OIF1.

The last major comprehensive survey of Marines was conducted in 1966. The USMC has most recently been using statistically matched Army anthropometric data for design, sizing and tariffing. However, current Army-USMC differences in anthropometry have become so great that modeling Marines using Army data would result in inefficient sizing systems and inaccurate tariffs for USMC clothing and individual equipment systems. The USMC requires its own comprehensive anthropometric database.

The Army's current anthropometric survey (ANSUR II) effort is integrated with a parallel USMC effort, the Marine Corps - Anthropometric Survey (MC-ANSUR). Both efforts use the same measuring team to execute an identical measurement protocol, providing exceptional compatibility between the USMC and US Army anthropometric databases and supporting leveraged development/acquisition of military systems when appropriate.

In ANSUR II, the measuring team will visit approximately 13 Army posts. The schedule was developed in collaboration with FORSCOM, TRADOC, MEDCOM, ARNG, and USAR personnel. The ANSUR II Survey will measure approximately 13,000 Soldiers using a statistically valid sampling strategy that represents Total Army operational, geographic, and demographic distributions.

In MC-ANSUR, the measuring team will survey a statistically valid sample of the USMC population by physically measuring Active Duty and Reserve Marines. A total of 3,600 Marines will be measured across three USMC locations from May - September 2010.

Data for both the ANSUR II and MC-ANSUR efforts will be collected by a Government research anthropologist and an industry team of highly trained measurers working with Marine and Army liaison officers.

Included in this document are guidelines on how to handle participants (Chapter 2); descriptions of the measuring instruments to be used (Chapter 3); descriptions of the measuring stations to be used (Chapter 4); definitions and illustrations of body landmarks, which serve as the point of origin and termination of the dimensions (Chapter 5); descriptions and illustrations of the dimensions and the instructions for their measurement (Chapter 6); and brief explanations of the intended uses of the data

collected on each dimension (Chapter 7). Also included is a glossary of anatomical and anthropometric terms

Additional information appears in appendices: instructions for the use of the three-dimensional scanners (Appendices A, B, and C), sources and specifications for the anthropometric and landmarking instruments (Appendix D), data forms (Appendix E), a visual index of scanner landmarks (Appendix F), an explanation of allowable error (Appendix G), and a visual index of dimensions (Appendix H). Additional information on the use of the foot scanner can be obtained from the manufacturer's manuals (I-Ware Laboratory Co., Ltd. 2009, 2010).

2. PARTICIPANTS

While the measurer is the central figure on which the success of these surveys depends, another critical component in the effort is the anthropometric survey participant. Cooperation from the participant will make the job much easier. In this document, the term “participant” refers to the USMC or Army subjects, although during the course of each survey, the participants will be referred to as “Soldiers,” in the case of the Army, or “Marines” in the case of the USMC.

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. Participants 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 (there will be 76 marks drawn on each participant). They will be touched while being measured and while being assisted into the body positions required for particular measurements. Because of nervousness, participants will often perspire even though the measuring room seems cool to the measurer; thus it is a good idea to have tissues available to offer them. They'll appreciate it, and it will make taking the measurements easier.

To relieve natural apprehension, Army and USMC media will extensively publicize the surveys to their personnel before the measuring team arrives. The importance of the surveys will be fully explained, and similar information about the survey process and exactly what the measuring procedures entail will be explained to participants in a briefing before they are measured. A professional demeanor can greatly increase the participant’s level of comfort.

A few pointers on the treatment and handling of participants will make the task easier and enhance participants' cooperation. Check the participant's name and rank from the data form when he or she enters a station. The first time the participant is addressed use the rank and last name, e.g., Corporal Jackson, Sergeant Alexander, Captain Henry, Colonel Rodriguez. After that, just use their military rank. Tables 1 and 2 indicate the proper way to address participants by their rank for enlisted individuals and officers in the Army and USMC.

TABLE 1
Addressing Soldiers by Rank

If rank is:	Then address as:
Enlisted Ranks	
All Privates	Private
Corporal	Corporal
Specialists	Specialist
Sergeant Major	Sergeant Major
First Sergeant	First Sergeant
All Other Grades of Sergeants	Sergeant
Officer Ranks	
First and Second Lieutenants	Lieutenant
Captain	Captain
Major	Major
Lieutenant Colonel and Colonel	Colonel
All Generals (regardless of the number of stars)	General

TABLE 2
Addressing Marines by Rank

If rank is:	Then address as:
Enlisted Ranks	
All Privates	Private
Lance Corporal	Lance Corporal
Corporal	Corporal
Sergeant	Sergeant
Staff Sergeant	Staff Sergeant
Gunnery Sergeant	Gunnery Sergeant/Gunny
Master Sergeant	Master Sergeant/Top
First Sergeant	First Sergeant
Master Gunnery Sergeant	Master Gunnery Sergeant/ Master Guns
Sergeant Major	Sergeant Major
Officer Ranks	
First and Second Lieutenants	Lieutenant
Captain	Captain
Major	Major
Lieutenant Colonel	Lieutenant Colonel
Colonel	Colonel
All Generals (regardless of the number of stars)	General

When locating and drawing landmarks on the body, when taking measurements, and when assisting the participants 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 participants are ticklish. When asking a participant to assume a position for taking a measurement or when giving other instructions, say "please."

Most of the participants will be pleasant and cooperative. Inevitably, there will be a few participants who may be difficult. Some will be highly critical of the survey, of the measurements, or of the way the measurements are taken. Knowledge of the survey will enable measurers to reply to some of the remarks but measurers will not be able, nor should they try, to respond to all of them. Unwelcome personal comments should be ignored whenever possible. Be as pleasant and professional as possible, and get the job done.

2.1 HYGIENE

Measurers and recorders will be in close contact with the participants being measured so good personal hygiene needs to be maintained. There should be no food or drinks at any station and all stations should be kept tidy at all times. High ranking officers may decide to visit the measuring site so all members of the measuring team should be prepared at all times. Chewing gum and wearing hats while working are not acceptable. For sanitary purposes, measurers will cleanse their hands and wipe instruments off with alcohol before each participant is measured.

2.2 PHYSICAL ANOMALIES

The measuring team may encounter Marines and Soldiers with injuries, amputations, etc. who have been returned to duty after combat (or other) injuries. As part of normal variability, 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, participants will be encountered where such differences are obvious and would affect a measurement. If the affected body part is on the participant's right side where most measurements are routinely taken, the landmarker 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 landmarker 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 participant. Therefore, there is no need to question or comment about the matter. Just measure the left side and the recorder will enter into the computer a comment indicating that the dimension was measured on the left side. While the measurer should not initiate such conversation, the participant may well comment on his or her asymmetry or problem, and then talking about the matter is, of course, appropriate.

2.3 SAFETY

There are no procedures required in anthropometry that are in any way threatening or hazardous to participants 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 participant must stand on a platform or table. It is the measurer's or landmarker's responsibility to keep an eye on the participant as he or she is getting on or off the table or platform and to be prepared to assist the participant if he or she should chance to stumble or fall.

At the measuring station where arm reaches are measured, participants are required to place their heels on a line on the floor and lean back so that their shoulders are against a wall. It is the responsibility of the team members at this station to be sure that the standing surface is not a slip hazard.

None of the scanners poses any safety risk, although participants may ask about it. All the scanners collect data on the surface of the body only, and do not penetrate the skin. The head and whole body scanners also use low-power infrared light, while the foot scanner uses a low-power laser, similar to that used in a supermarket checkout line. In the case of the head scanner, there are, in addition to the infrared lights, visible lights which are quite bright. Participants may close their eyes for the head scan if this is bothersome.

None of the measuring instruments offers an inherent threat to the participant or anthropometrist. Care must be taken not to jab a participant with the blades of an anthropometer or caliper. Particular care must be taken when measuring dimensions near the eyes to make certain that an instrument does not touch the eye itself. When measuring EYE HEIGHT, SITTING, tell the participant that the blade of the anthropometer will be near, but not touching, 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 participants 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, some participants may feel faint, especially if the measuring environment is too warm. Inform each participant to let the measurer know if he or she feels faint. If this happens, immediately have the participant sit, and do not continue measuring until the participant states that he or she feels fine and wishes to continue.

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

3. MEASURING INSTRUMENTS

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

Anthropometer
Beam caliper
Spreading caliper
Sliding caliper
Holtain caliper
Poech sliding caliper
Steel tape (and modified)
Scale (weighing)
Pupillometer
Brannock device
Modified height gauge
Wall chart
Whole body scanner
Head scanner
Foot scanner

These are illustrated in Figures 1 through 15.

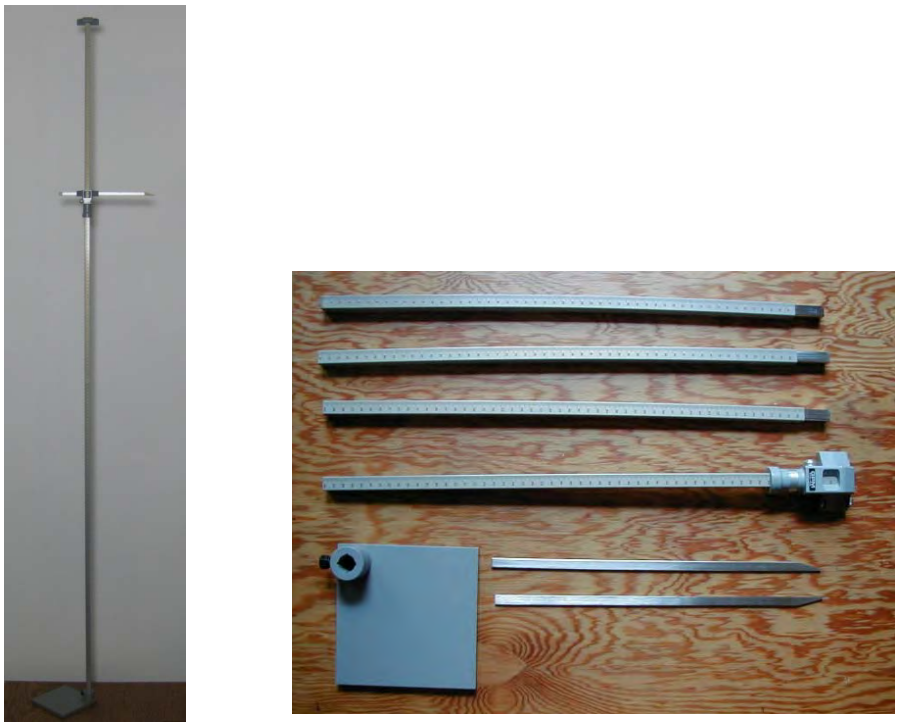


FIGURE 1
Anthropometer: Assembled and in Parts

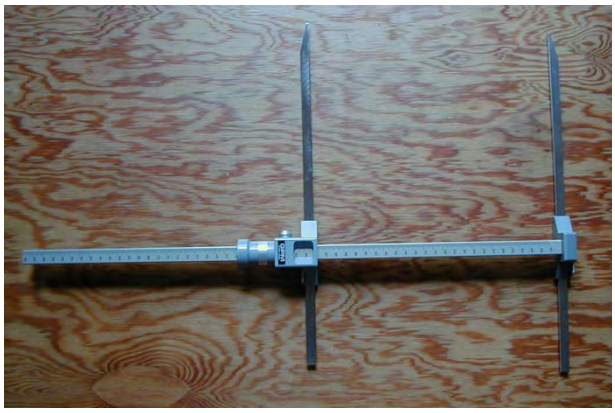


FIGURE 2
Beam Caliper

FIGURE 3
Spreading Caliper

FIGURE 4
Sliding Caliper

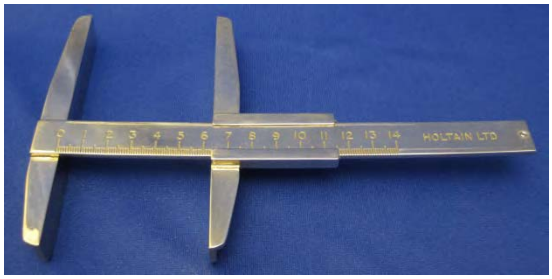


FIGURE 5
Holtain Caliper

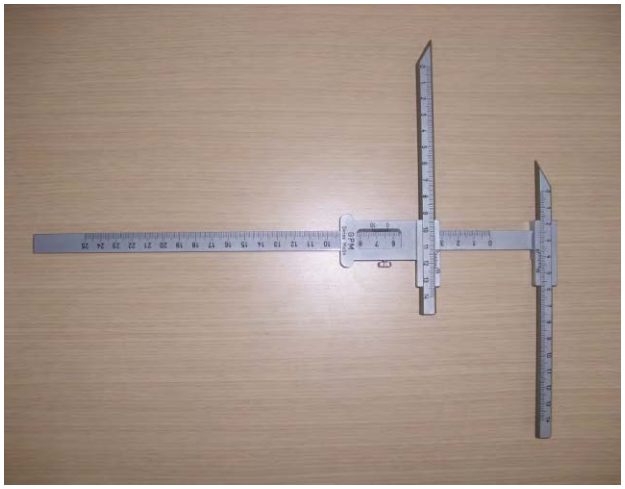
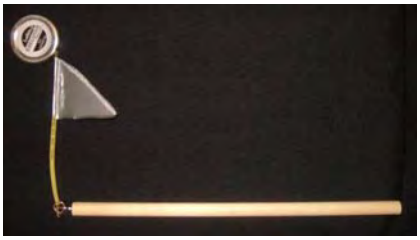


FIGURE 6
Poech Sliding Caliper

(a)



(b)

FIGURE 7
Steel Tape (a) and
Modified Steel Tape (b)

FIGURE 8
Scale

FIGURE 9
Pupillometer

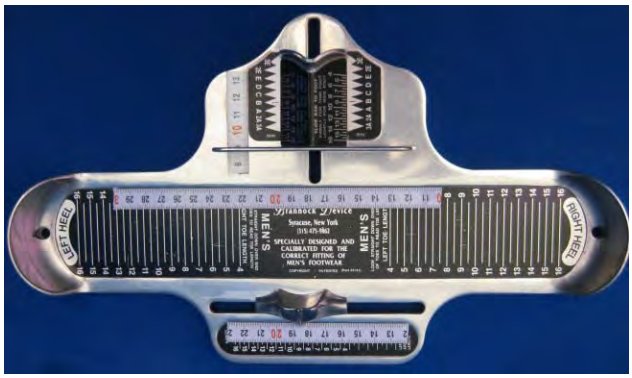


FIGURE 10
Modified Brannock Device

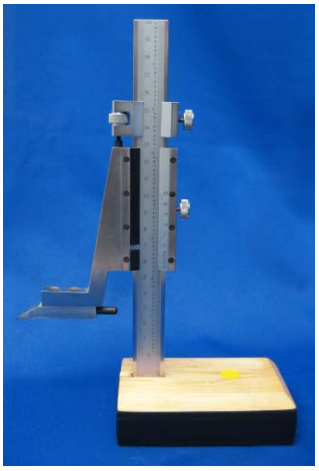


FIGURE 11
Modified Height Gauge

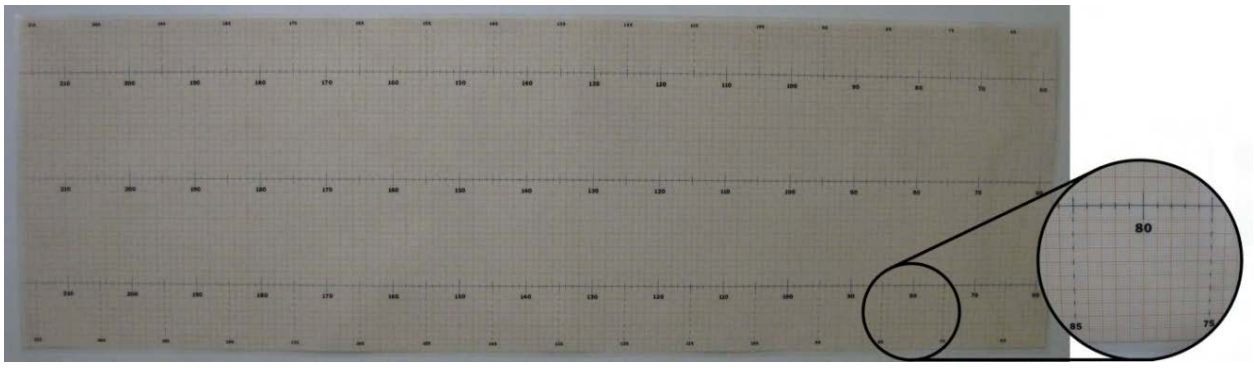


FIGURE 12
Wall Chart

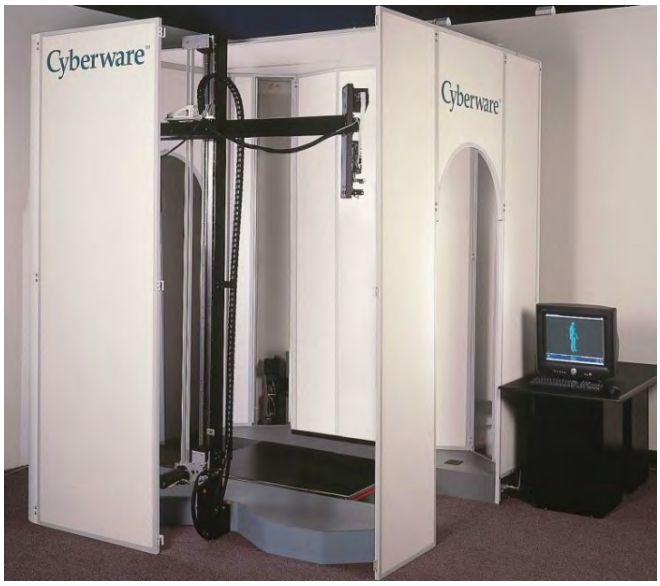


FIGURE 13
Whole Body Scanner (WBX)

FIGURE 14
Head Scanner (PX)

FIGURE 15
Foot Scanner

The anthropometer is the basic tool of the anthropometrist and is used to measure all linear dimensions. The bottom portion of the anthropometer is detachable for use in 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 participant. The detached upper half forms a beam caliper to measure breadths, depths, and body segment lengths. For FOREARM-CENTER OF GRIP LENGTH, a dowel is mounted on the blade of the beam caliper. The dowel was modified by making a groove so that the

calibrated edge of the blade is in the center of the dowel. The modified height gauge is used for shorter distances and heights.

The smaller sliding, spreading, Holtain, and Poech sliding calipers are used primarily for measuring dimensions of the head, face, and hands. The 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 Brannock device facilitates positioning and measuring of the foot. The scale is used for measuring weight.

The more complex measuring systems include the pupillometer (the use of which is described in the measurement description for INTERPUPILLARY BREADTH), the whole body scanner, the head scanner, and the foot scanner (described in detail in Appendices A, B, and C). Sources for the standard instruments and specifications for the custom-made instruments are given in Appendix D.

3.1 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 of the anthropometer segments. 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. An optional base may be used to help ensure that the anthropometer is vertical. The measurer may place his or her hand or foot on the anthropometer base to aid in this process.

3.2 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 (Figure 16). A damaged instrument must be repaired or replaced.

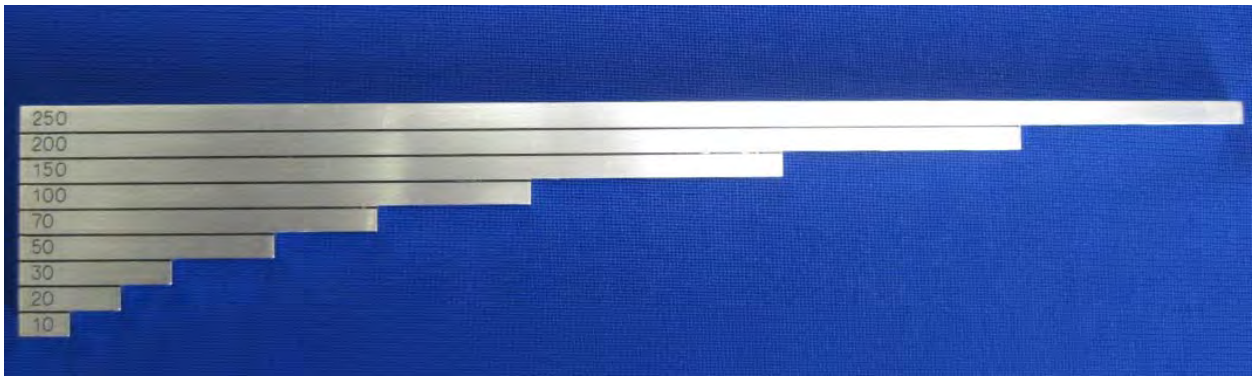


FIGURE 16
Caliper Gauge

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 participant is measured.

The batteries of the Hoya pupillometer are placed in a compartment located on the front of the instrument and closed by a sliding cover. The nose pads are of flexible material and should be cleaned with isopropyl alcohol after each use.

3.3 LANDMARKING 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 the other side, a straight edge with level for locating several scye landmarks, and a variety of plastic rules.

4. MEASURING STATIONS

Survey participants will proceed through a number of stations: in-processing, landmarking, body measuring, scanning, biographical data entry, and out-processing.

4.1 IN-PROCESSING

Participants arriving at the measuring site will be briefed on the general purposes and procedures of the survey. Their biographic/demographic data form will be scanned to generate the measurement data sheets needed for each participant. Participants will carry these measurement data forms (see Appendix E) to the measuring stations where dimensional data will be recorded on them. At in-processing, Soldiers and Marines of both sexes will be issued survey shorts. Males will be measured bare-chested. Females will be measured wearing their own bras, but will be scanned with a sports bra worn over their own bra, if they have not arrived in a sports bra. All participants will be issued tank tops for moving between stations. Participants will proceed to a dressing room for changing. Laundry baskets will be provided for temporary storage of participants' personal gear.

4.2 BIOGRAPHICAL DATA ENTRY

Prior to in-processing, participants will have filled out forms for demographic and biographic information (name, age, race, etc.). A team member assigned to biographic/ demographic data entry will be responsible for entering that information into a portable computer, either while participants wait at in-processing, or while they wait between stations elsewhere.

4.3 LANDMARKING

After in-processing, each participant will visit landmarking stations where 76 anatomical marks will be made on the body. These landmarks are divided between two stations and are sequenced as follows:

Landmarking Station #1

Glabella
Sellion
Tragion, right and left
Orbitale, right and left
Menton
Submandibular
Ectoorbitale, right and left
Frontotemporale, right and left
Zygofrontale, right and left
Zygion, right and left
Gonion, right and left
Infrathyroid
Neck, anterior, right lateral, and left lateral
Trapezius point, right and left
Clavicle point, right and left
Acromion, right and left
Midshoulder, right
Cervicale
Anterior scye on torso, right
Posterior horizontal scye, right and left
Posterior vertical scye, right and left
Posterior diagonal scye, right and left
Midscye, right and left
Axillary fold: right posterior and left posterior
Midspine
Suprasternale
Deltoid point, right and left

Landmarking Station #2

Chest point, anterior, right
Tenth rib, right
Iliocristale, right and left
Olecranon, center
Biceps point, right
Radiale, right
Stylion, Dorsal stylion, and Ventral stylion, right
Metacarpale II, right
Metacarpale V, right
Waist (omphalion), right, left, anterior, and posterior
Buttock point, right lateral and left lateral
Inner thigh, right
Lateral femoral epicondyle, sitting, right
Trochanter, right
Gluteal furrow point, right
Trochanterion, right
Lateral femoral epicondyle, standing, right
Tibiale, right
Suprapatella, right
Midpatella, right
Dorsal juncture of foot and leg, right
Lateral malleolus, right
First metatarsophalangeal protrusion, right
Fifth metatarsophalangeal protrusion, right

Landmarks (definitions in Chapter 5) are identified by palpation, by sight, and in some instances with the aid of a specialized device. The marks are drawn with a hypo-allergenic surgical marker, available in a number of colors suited to different skin tones.

4.4 BODY MEASUREMENTS

The measurements to be taken in this survey have been divided into four manageable groups; each group will be measured at a specific station. Participants will visit the stations in an order that minimizes wait-time, determined by a team member assigned to this task. The dimensions assigned to each station, in order of measurement, are as follows.

Head, Hand, and Foot Station

Hand Circumference
Hand Breadth
Hand Length
Palm Length
Interpupillary Breadth
Tragion-Top of Head
Menton-Sellion Length
Ear Length
Ear Breadth
Ear Protrusion
Head Length
Head Breadth
Bizygomatic Breadth
Bitragion Chin Arc
Bitragion Submandibular Arc
Head Circumference
Calf Circumference
Ankle Circumference
Heel Ankle Circumference
Ball of Foot Circumference
Bimalleolar Breadth
Heel Breadth
Lateral Malleolus Height
Ball of Foot Length
Foot Length
Foot Breadth, Horizontal

Reaches Station

Sitting Height
Eye Height, Sitting
Elbow Rest Height
Thigh Clearance
Knee Height, Sitting
Popliteal Height
Buttock-Knee Length
Buttock-Popliteal Length
Waist Front Length, Sitting
Biacromial Breadth
Bideltoid Breadth
Forearm-Forearm Breadth
Abdominal Extension Depth, Sitting
Hip Breadth, Sitting
Functional Leg Length
Overhead Fingertip Reach, Sitting
Acromion-Wall Depth
Span
Thumbtip Reach

Standing Station

Stature
Cervicale Height
Acromial Height
Suprasternale Height
Axilla Height
Tenth Rib Height
Iliocristale Height
Waist Height (Omphalion)
Wrist Height
Acromion-Radiale Length
Radiale-Stylion Length
Shoulder-Elbow Length
Forearm-Hand Length
Forearm-Center of Grip Length
Neck Circumference
Neck Circumference, Base
Waist Back Length (Omphalion)
Sleeve Length: Spine-Wrist
Interscye I
Interscye II
Shoulder Length
Sleeve Outseam
Biceps Circumference, Flexed
Forearm Circumference, Flexed
Wrist Circumference
Weight

Torso Station

Shoulder Circumference
Chest Circumference
Waist Circumference (Omphalion)
Vertical Trunk Circumference (USA)
Chest Breadth
Waist Breadth
Bicristal Breadth
Chest Depth
Waist Depth
Chest Height
Trochanterion Height
Buttock Height
Lateral Femoral Epicondyle Height
Knee Height, Midpatella
Tibial Height
Crotch Height
Buttock Depth
Hip Breadth
Buttock Circumference
Thigh Circumference
Lower Thigh Circumference
Crotch Length (Omphalion)
Crotch Length, Posterior (Omphalion)

4.5 SCANNING STATION

All three 3-D scanners are placed into one station, although space limitations at some locations may require the station be physically spread over more than one room. At the scanning station, operators will be assigned to each of the three scanners. A team member will be assigned to prepare participants for the scans. For the head and whole body scanners, this preparation includes issuing wig caps, and verifying that all hair is tucked under the cap. The preparer will also place quarter-inch orange adhesive dots over each of the head and face landmarks. For the whole body scanner the preparation includes asking the participants to change into the scan wear, and verifying that the donned scan wear is free of wrinkles. Half-inch orange adhesive dots will be placed over some of the marked landmarks for the whole body scan. The landmarks dotted for head and whole body scanning are seen below, in the dotting sequence. A visual index illustrating these landmarks appears in Appendix F.

Opisthocranion
Acromion, right and left
Glabella
Sellion
Menton
Ectoorbitale, right and left
Frontotemporale, right and left
Zygofrontale, right and left
Zygion, right and left
Tragion, right and left
Gonion, right and left
Orbitale, right and left
Cervicale
Neck, anterior, right lateral, and left lateral
Suprasternale
Deltoid point, right
Clavicle point, right and left
Anterior scye on torso, right
Chest point anterior, right
Tenth rib, right
Iliocristale, right and left
Omphalion, anterior
Olecranon, center, right
Radiale, right
Stylion, right
Trochanterion, right
Lateral femoral epicondyle standing, right
Lateral malleolus, right
Tibiale, right
Midpatella, right

Participants will also be briefed on the proper body position for the body scan. This brief will be aided by illustrations (Figure 17) mounted on the wall of the scanning station. Specifically, the position requires that participants stand erect without stiffness. The feet are 30 cm apart and parallel, the arms straight, and held away from the body with fists clenched. The head is in the Frankfurt plane. Refer to Appendix A for a more detailed description of preparing and positioning the participant as well as operation of the whole body scanner. Appendix B provides additional details for the operation and participant positioning for the head scanner.

In preparation for foot scanning, the team member will verify that the right foot is clean and dry (without perspiration). If the participant has noticeable leg hair, the participant will be asked to put on a stocking from ankle to knee to compress the hair to prevent scan distortion. For all participants, sanitary protective paper will be wrapped around the leg just below the knee where the scanner will close around the leg. Appendix C contains more detailed instructions for the operation of the foot scanner.

FIGURE 17
Posture for WBX

Team members will direct participants to each of the three scanners in a sequence that minimizes wait time.

4.6 OUT-PROCESSING

When the measuring and scanning stations are completed, the participant will proceed to the out-processing station. A team member will scan the bar code on the participant's demographic form to check that he/she has visited all measuring and

scanning stations. If not, he/she will be asked to go back to the missing station. The team member will also double check to make sure all the information on the demographic form has been entered correctly into the computer, at which time the form will be shredded in compliance with military privacy regulations. If information is complete the participant will be asked to turn in all clothing items, thanked, and dismissed.

At the out-processing station a subset of participants will be selected for remeasure. These participants will visit one measuring or the scanning station a second time for the collection of interobserver error data. On the second visit the participant will be measured or scanned by a different team member. Altogether, approximately 20% of participants will be remeasured for one station.

A flow diagram for the processing of participants is shown in Figure 18.

4.7 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. The editing program will flag unusual values that may be in error. The recorder will then ask the measurer to take the measurement again.

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 is vertical), and to make certain that the participant 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. In general, the recorder does not remain seated at his/her desk throughout the measuring process. It is important to move around the measuring space to be able to see each dimension as it is measured and to assist in the measurement process. Each anthropometrist/recorder pair will work out between themselves how best to do that.

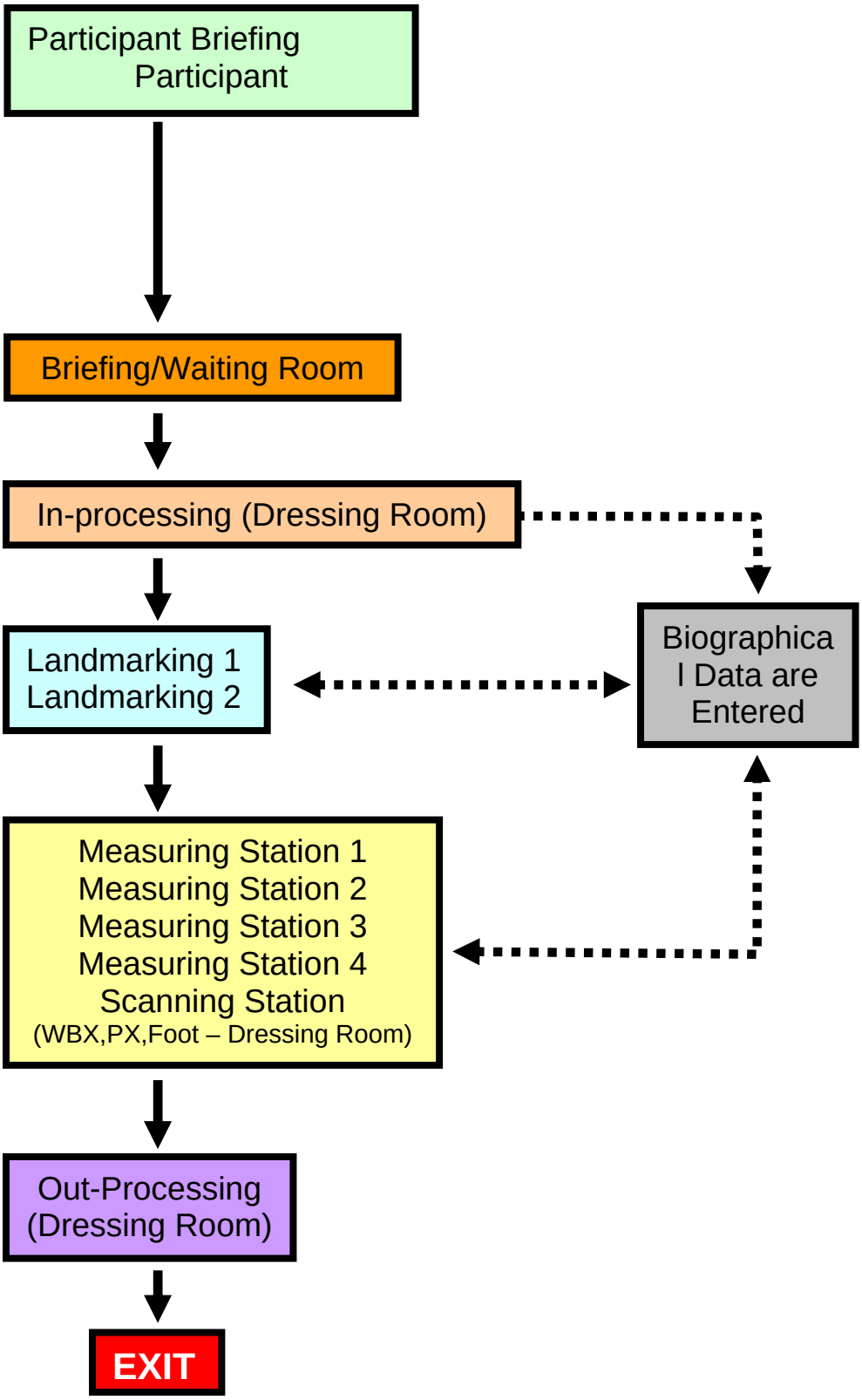


FIGURE 18
Participant Flow

5. THE LANDMARKS

Dimensions are measured from one point on the body (or a fixed surface such as the 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 participant to participant, dimensions are defined in terms of body landmarks that serve as their origin, termination, or level of measurement.

Two categories of landmarks are described in this section: (1) drawn landmarks (designated by lines, crosses, and dots) that will be placed on each participant at the landmarking stations in advance of the measuring and (2) 29 easily identified landmarks (e.g., dactylion III, which is the tip of the middle finger) cited in the measurement descriptions that will not be drawn on the participant's body. Many of these descriptions are from Clauser et al. (1988) and Gordon et al. (1989).

5.1 UNDRAWN LANDMARKS

Some landmarks such as "the tip of the thumb," "bottom of the ear," or "the lowest point of the elbow bent 90°" are obvious and easy to locate from participant to participant. 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. These will not be located by the landmarkers. 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 as follows:

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

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

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

Center of pupil, right and left - center of the pupil of the eye.

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

Crotch - the point at the level of the lower edge of the pubis bone of the *os coxa*.

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

Digit III, base - center of the crease at the base of the middle finger.

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°.

Euryon, right and left - the most lateral point in the region above the ear.

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).

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

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

Olecranon, bottom - the lowest point of the elbow with the elbow flexed 90°.

Olecranon, rear - the rearmost point of the elbow with the elbow flexed 90°

Opisthocranion - the posterior point on the back of the head. This landmark is undrawn for head length but is marked on the wig cap prior to scanning.

Otobasion, superior - the anterior superior point of the juncture between the right ear and the head.

Popliteal fossa at the dorsal juncture of the calf and thigh - bottom surface of the thigh just behind the knee.

Pternion - the posterior point on the heel of the foot.

Thelion, right and left - center of the nipple.

Thigh point, top - the highest point of the top of the right thigh of a seated individual.

Thumbtip, right - the tip of the thumb.

Top of head (vertex) - the highest point on the head when the head is in the Frankfurt plane.

5.2 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. Each of the following sections describes 1 of the 48 landmarks (and 76 total marks) drawn on the body and gives instructions for its location and marking. Each section includes a diagram (or diagrams) of the location of the landmark(s) and the following categories of information, when applicable: description, required landmarks, procedure, required instruments, and caution.

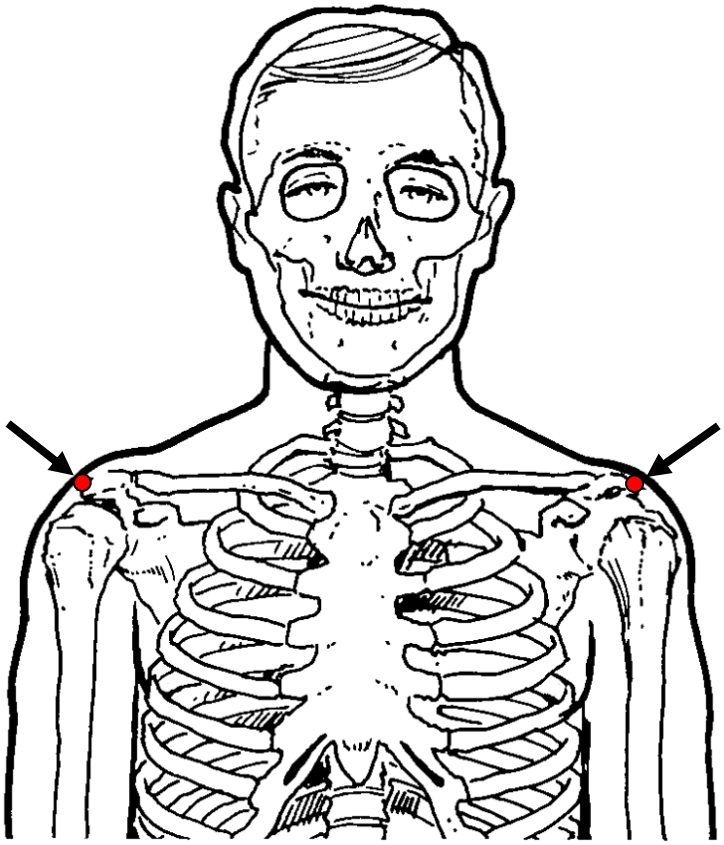
5.2.1 Acromion, Right and Left

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.

REQUIRED LANDMARKS: Trapezius point; Clavicle point.

PROCEDURE: Participant is in the anthropometric standing position. Stand behind the participant 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 participant, 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.

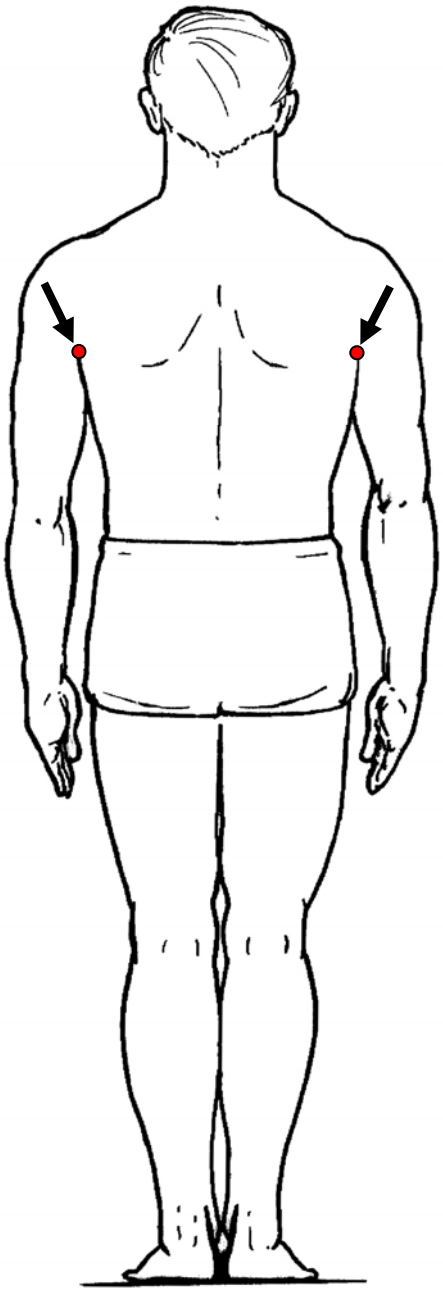
REQUIRED INSTRUMENTS: Tape.



5.2.2 Axillary Fold: Right Posterior and Left Posterior

DESCRIPTION: The highest point of the right and left axillary folds on the back.

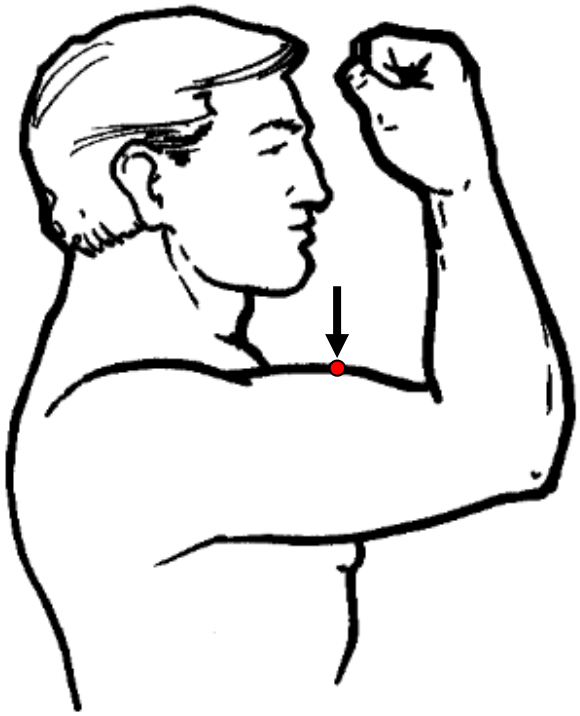
PROCEDURE: The participant stands in the anthropometric standing position. Stand behind the participant and draw a cross (+) at the highest point of the right axillary fold. Repeat this process on the left side.



5.2.3 Biceps Point, Right

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

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

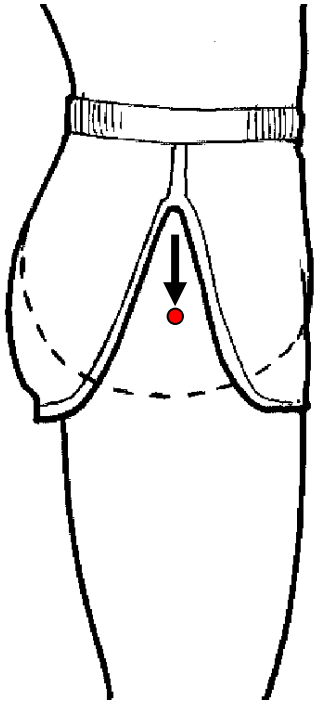


5.2.4 Buttock Point, Right Lateral and Left Lateral

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

PROCEDURE: Participant is in the anthropometric standing position. Stand at the right of the participant 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 participant and draw short horizontal marks on each side.

REQUIRED INSTRUMENTS: Landmark transfer rod.

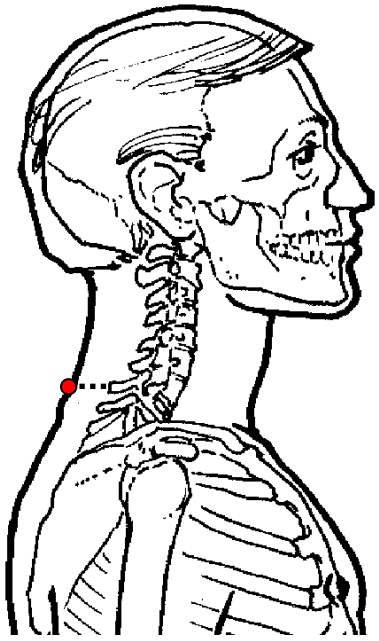


5.2.5 Cervicale

DESCRIPTION: The most prominent palpable point of the spine of the seventh cervical vertebra[1].

PROCEDURE: Participant is in the anthropometric standing position with the head in the Frankfurt 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 participant bend the head downwards. Stand behind the participant and with the pad of the index finger, palpate the most prominent spine. Have the participant slowly bring the head up to the Frankfurt plane while intermittently touching the spine. When the head is in place, locate the most prominent point of the spine of the seventh cervical vertebra. Draw a cross (+) through the landmark.

CAUTION: A few participants will be encountered on whom no cervical spine prominence is detectable. On such participants, estimate the point as nearly as possible with respect to the neck and shoulders. A few participants 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 Frankfurt plane when the landmark is drawn.



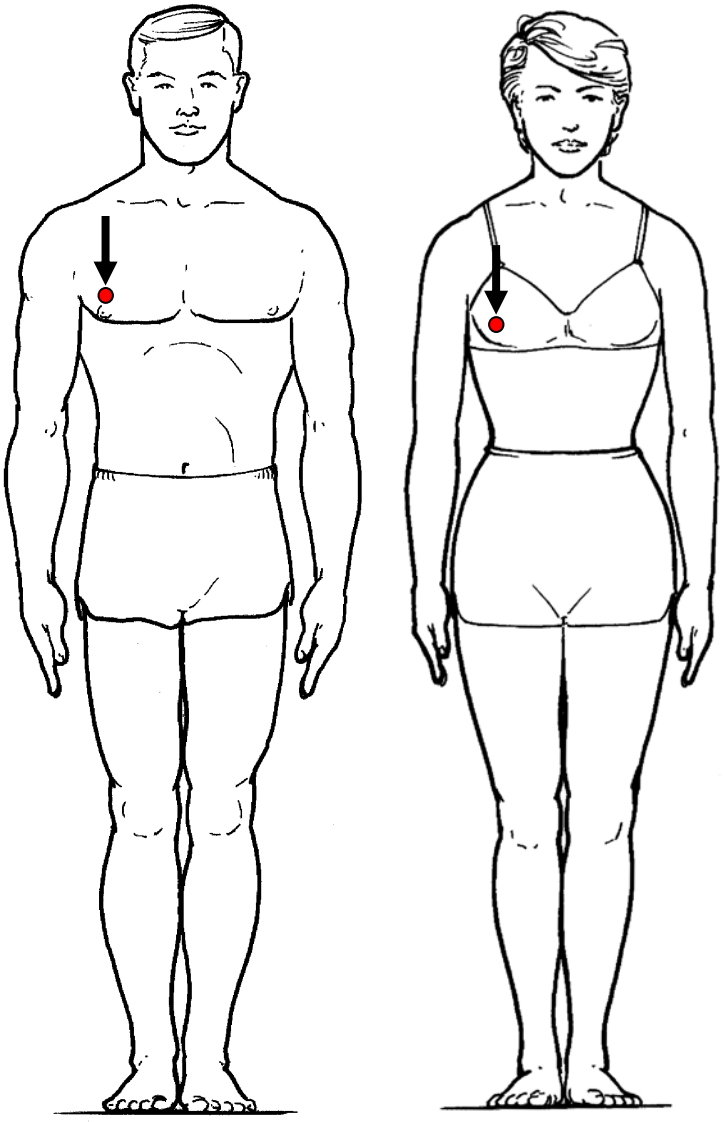
[1] The definition used in ANSUR refers to the “superior palpable point” rather than to the most prominent point. This change was made to bring the definition into compliance with standard anatomical usage (Martin, 1914) and international practice.

5.2.6 Chest point, anterior, right[2]

DESCRIPTION: The most anterior right point on the chest.

PROCEDURE: Participant is in the anthropometric standing position. Stand at the right of the participant and sight the most protruding right point of the chest. For women place an adhesive dot on the bra and for men draw a cross (+) on the chest. Draw a cross on the adhesive dot prior to placing it on the bra.

CAUTION: After placing the mark move to the front of the participant and verify that the landmark is properly placed.

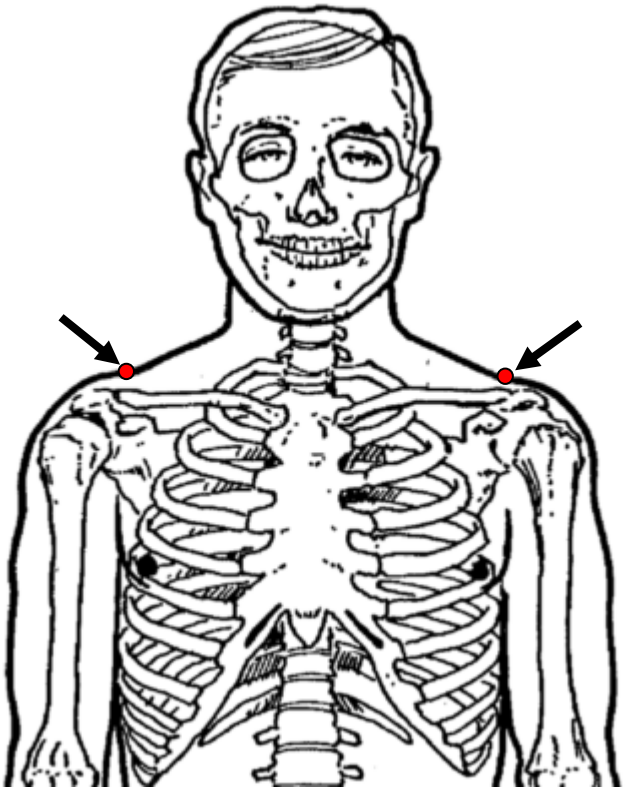


[2] This landmark is unchanged from ANSUR for female participants. For male participants, the ANSUR Thelion landmark, at the center of the nipple (unmarked) was used. Dimensions taken at that landmark often missed the largest portion of the chest, which is needed for determining clearance as well as clothing and protection. Now, the anterior point is used for both males and females.

5.2.7 Clavicle Point, Right and Left

DESCRIPTION: The superior points of the lateral ends of the clavicles (collar bones).

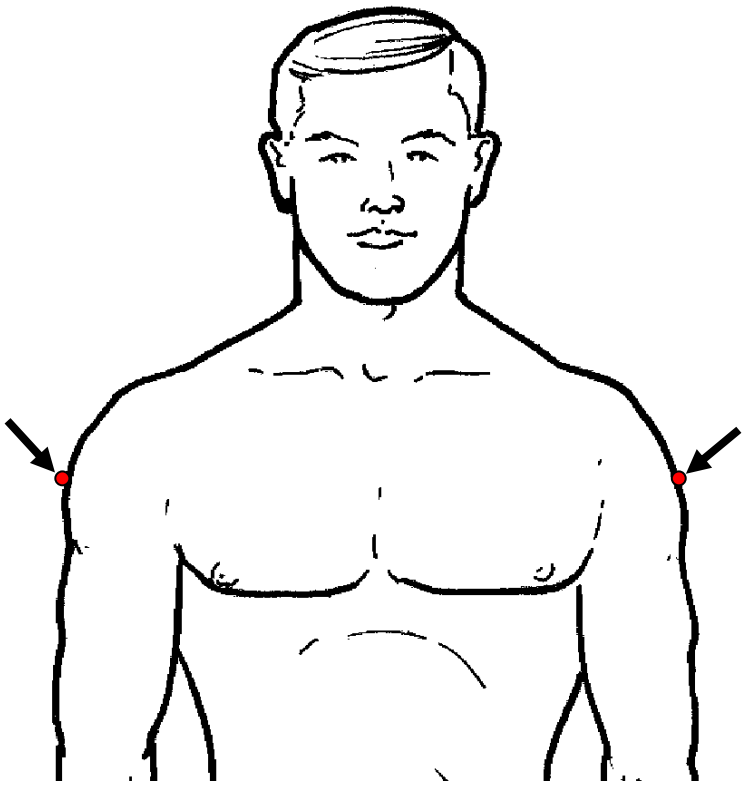
PROCEDURE: Participant is in the anthropometric standing position. Stand behind the participant and palpate the top of the lateral ends of the clavicles near the tips of the shoulders until you locate their most superior points. Place dots over the landmarks.



5.2.8 Deltoid Point, Right and Left

DESCRIPTION: The midpoint of the left and right deltoid muscles[3].

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant and locate, by inspection, the midpoint of the right upper arm overlying the deltoid muscle. Draw a short horizontal mark through the landmark. Repeat the process on the left side.

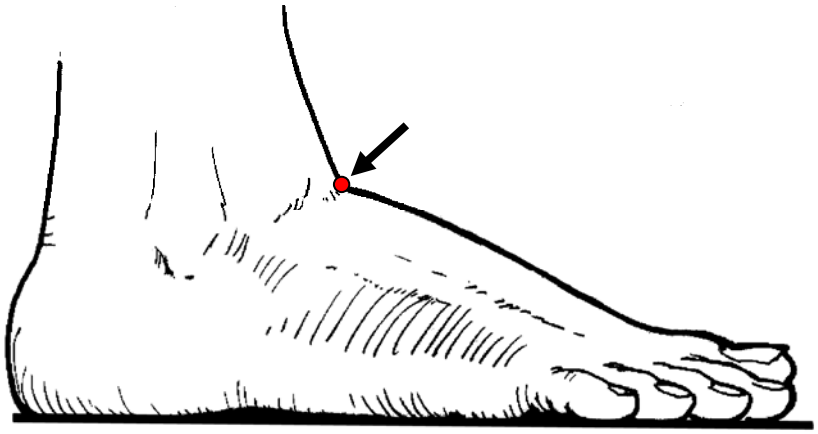


[3] These landmarks are used to place Shoulder Circumference. On heavier participants, the previous definition, at the "lateral point of the deltoid muscle" resulted in a Shoulder Circumference that was too low to be useful for clothing design. The midpoint location is correct for clothing design.

5.2.9 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°.

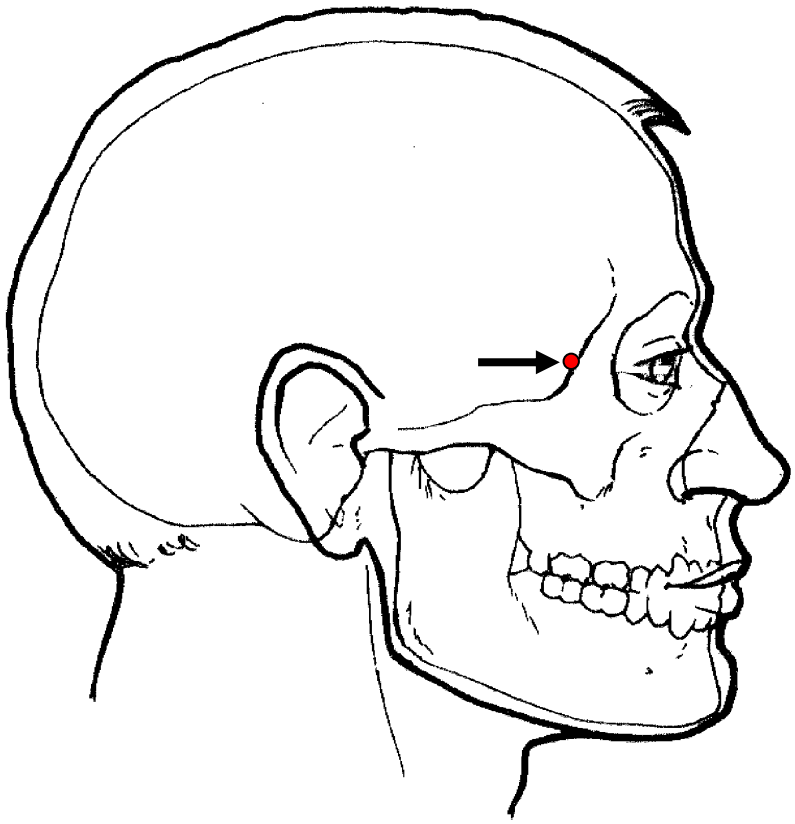
PROCEDURE: Participant stands on the table with the feet flat on the table and the knees bent so that distinct skin creases appear on the top of the foot at its juncture with the ankle. Stand in front of the participant and locate the top of the deepest and longest crease by inspection. Ask the participant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



5.2.10 Ectoorbitale, Right and Left

DESCRIPTION: The posterior point on the frontal process of the zygomatic bone at the level of the outer corner of the eye.

PROCEDURE: The participant stands, looking straight ahead, with facial muscles relaxed. Stand in front of the participant and locate the most posterior point on the frontal process of the zygomatic bone by palpation. Place a dot on each landmark.

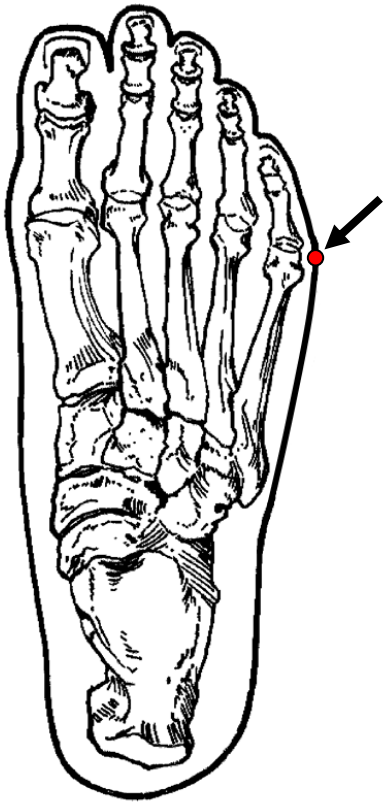


5.2.11 Fifth Metatarsophalangeal Protrusion

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

PROCEDURE: Participant stands on a table with the weight distributed equally on both feet. Stand in front of the participant 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.

REQUIRED INSTRUMENTS: Marking block.



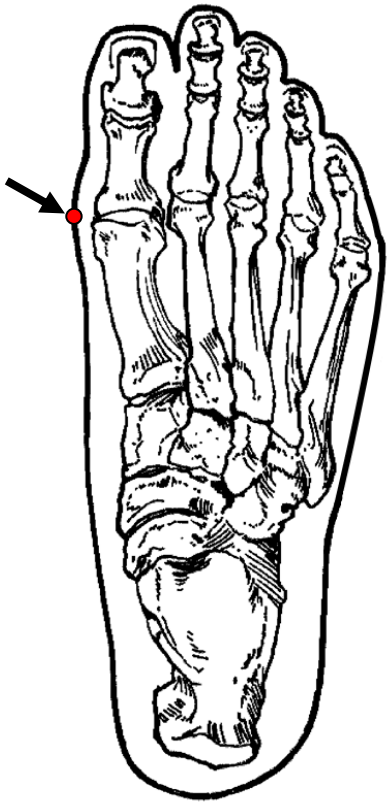
5.2.12 First Metatarsophalangeal Protrusion

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

PROCEDURE: Participant stands on a table with the weight distributed equally on both feet. Stand in front of the participant 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.

REQUIRED INSTRUMENTS: Marking block.

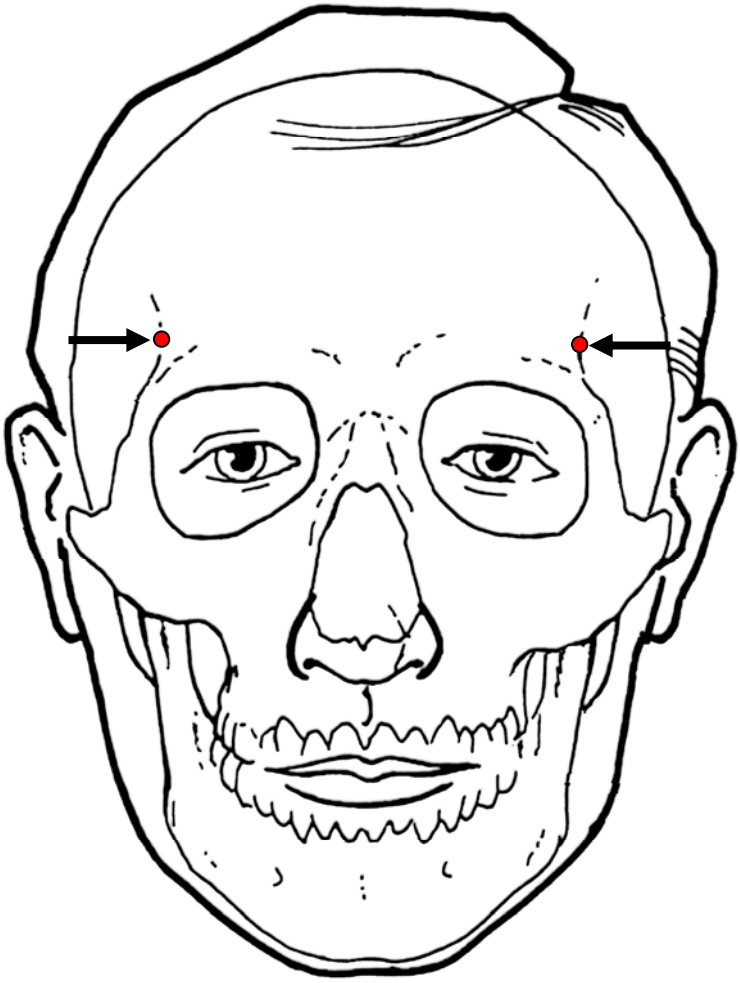
CAUTION: On some participants the big toe will splay out. This should be ignored. Be sure the mark is placed on or near the joint on the end of the foot and not on the toe.



5.2.13 Frontotemporale, Right and Left

DESCRIPTION: The point of deepest indentation of the temporal crest of the frontal bone above the browridges.

PROCEDURE: The participant stands, looking straight ahead, with brows relaxed. Stand in front of the participant and locate the landmarks by palpation along the temporal crest until the point of deepest indentation is found. Place a dot on each landmark.

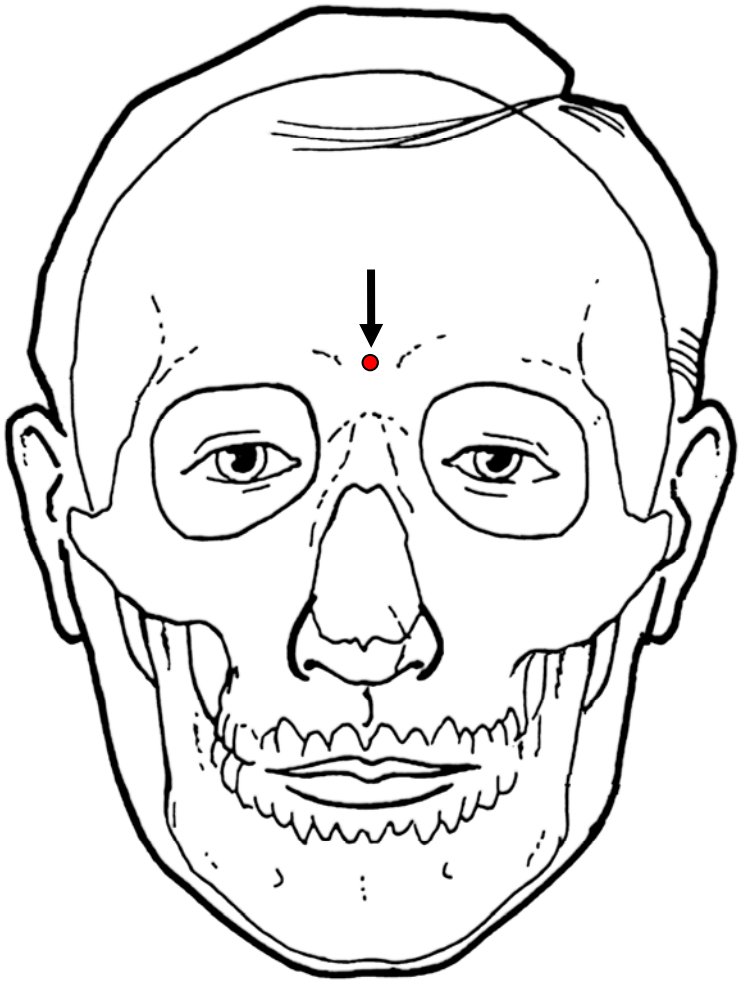


5.2.14 Glabella

DESCRIPTION: The most anterior point on the frontal bone midway between the bony browridges.

PROCEDURE: The participant stands, looking straight ahead, with brows relaxed. Stand at the right of the participant and locate the landmark by visual inspection. Then confirm the location by palpation. Draw a dot on the location in the midsagittal plane.

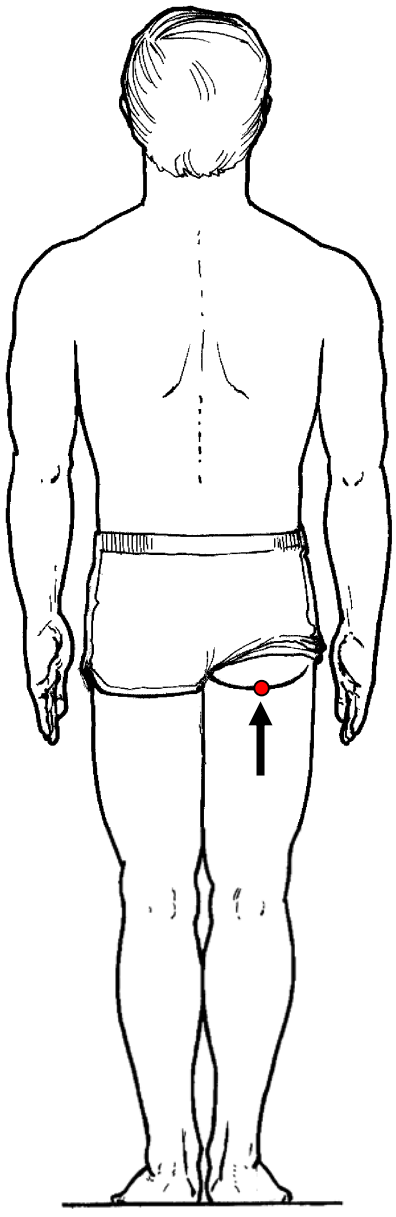
CAUTION: On some participants there is no distinctly anterior point and judgment will have to be used to establish its location.



5.2.15 Gluteal Furrow Point

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

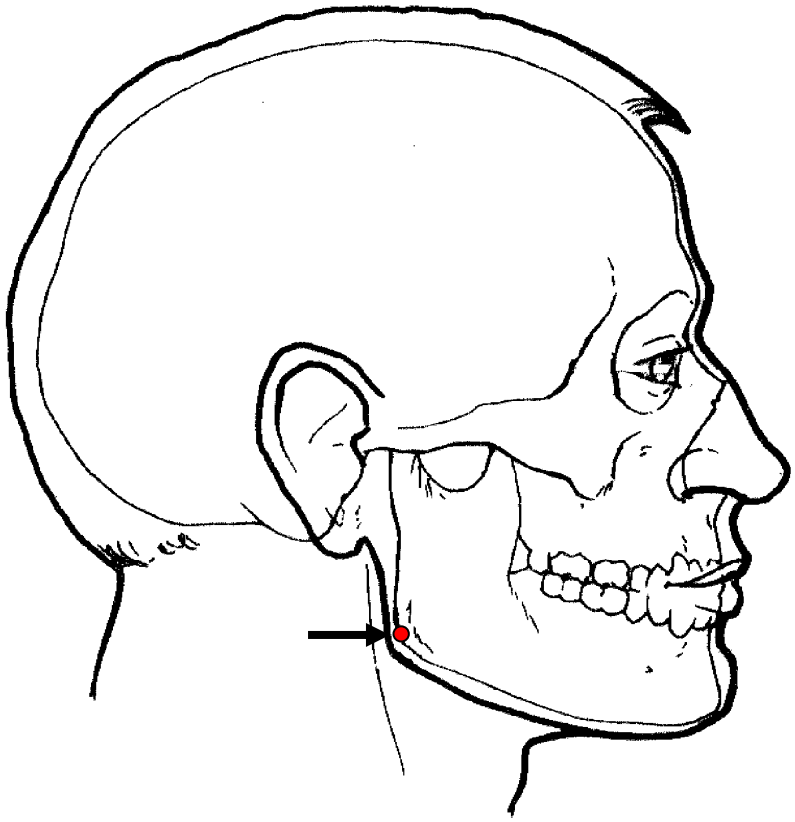
PROCEDURE: Participant is in the anthropometric standing position. Stand behind the participant and draw a short horizontal line at the top of the thigh at the lowest point of the lowest crease. Where there is a smooth continuous curve at the juncture of the thigh and buttock, view the buttock/thigh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



5.2.16 Gonion, Right and Left

DESCRIPTION: The most lateral point on the posterior angle of the mandible (lower jawbone).

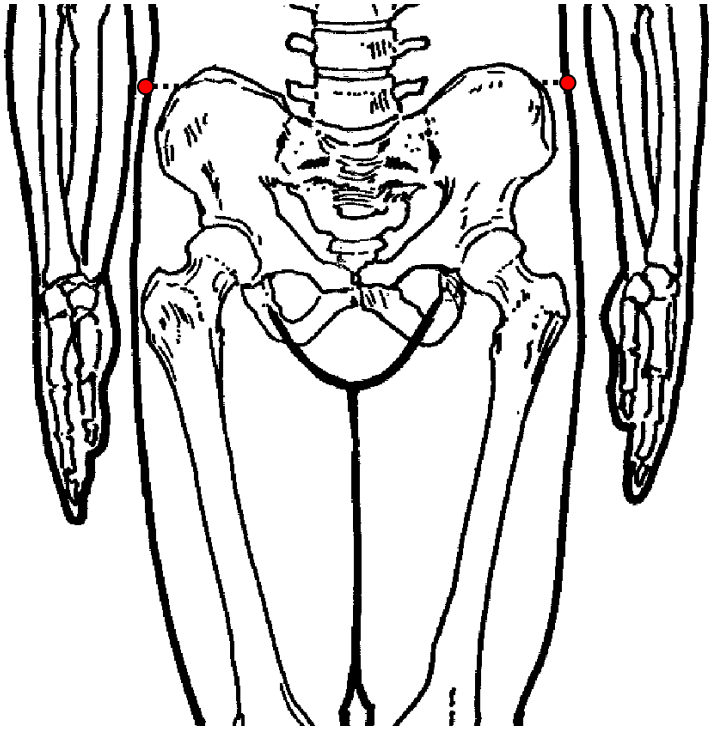
PROCEDURE: The participant stands with the head in the Frankfurt plane and the teeth together (lightly occluded). Stand in front of the participant and locate the posterior angles of the mandible by palpation. The landmarks are the most lateral points of these angles. Place a dot on each landmark.



5.2.17 Iliocristale, Right and Left

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

PROCEDURE: Participant stands in the anthropometric standing position. Stand in front of the participant. 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 two dots anterior to the line. Repeat the process on the left side.

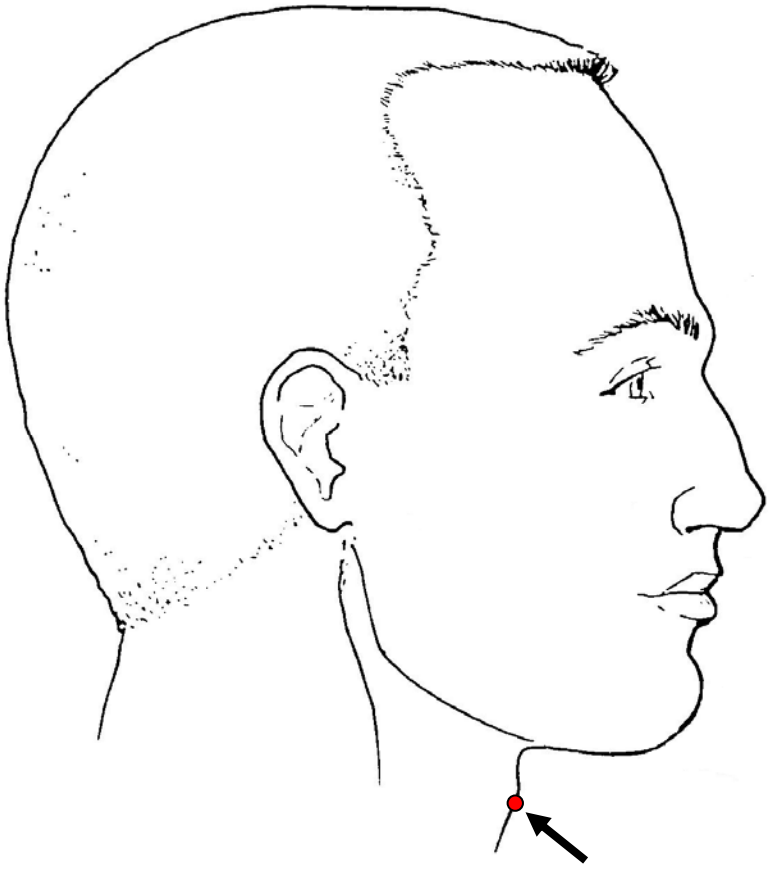


5.2.18 Infrathyroid

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

PROCEDURE: Participant stands with the head in the Frankfurt plane. Stand in front of the participant 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.

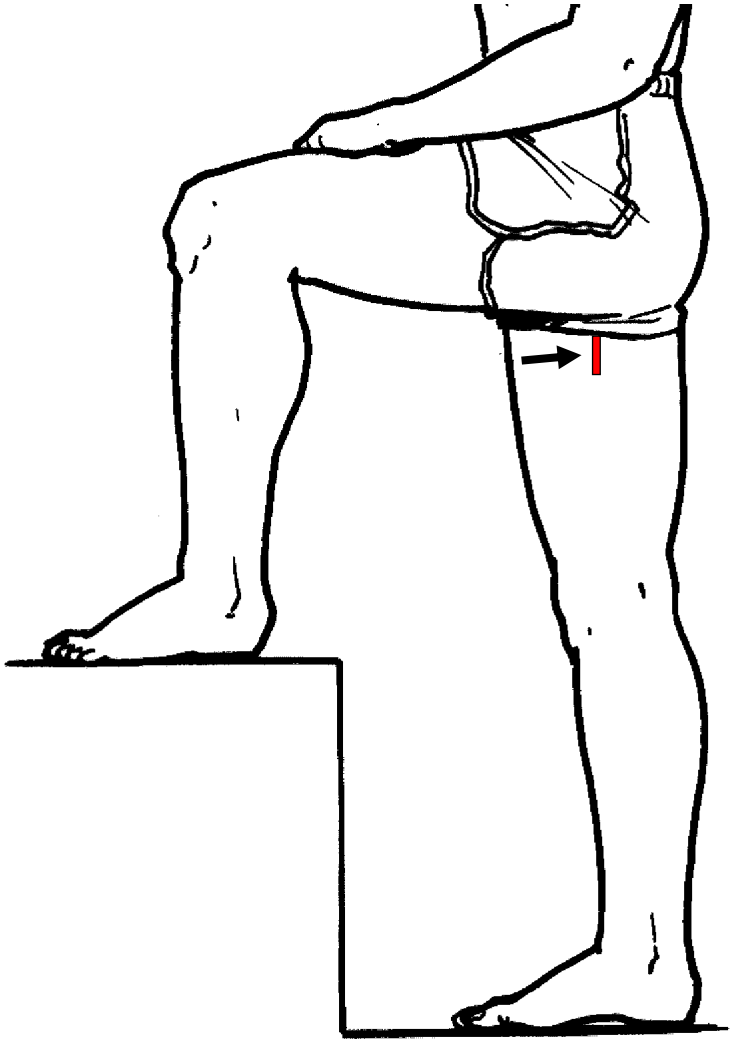
CAUTION: Be sure the participant's head is in the Frankfurt plane.



5.2.19 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: Participant stands erect, looking straight ahead with the left foot on a platform so that the left knee is flexed about 90°. Stand at the left of the participant 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).

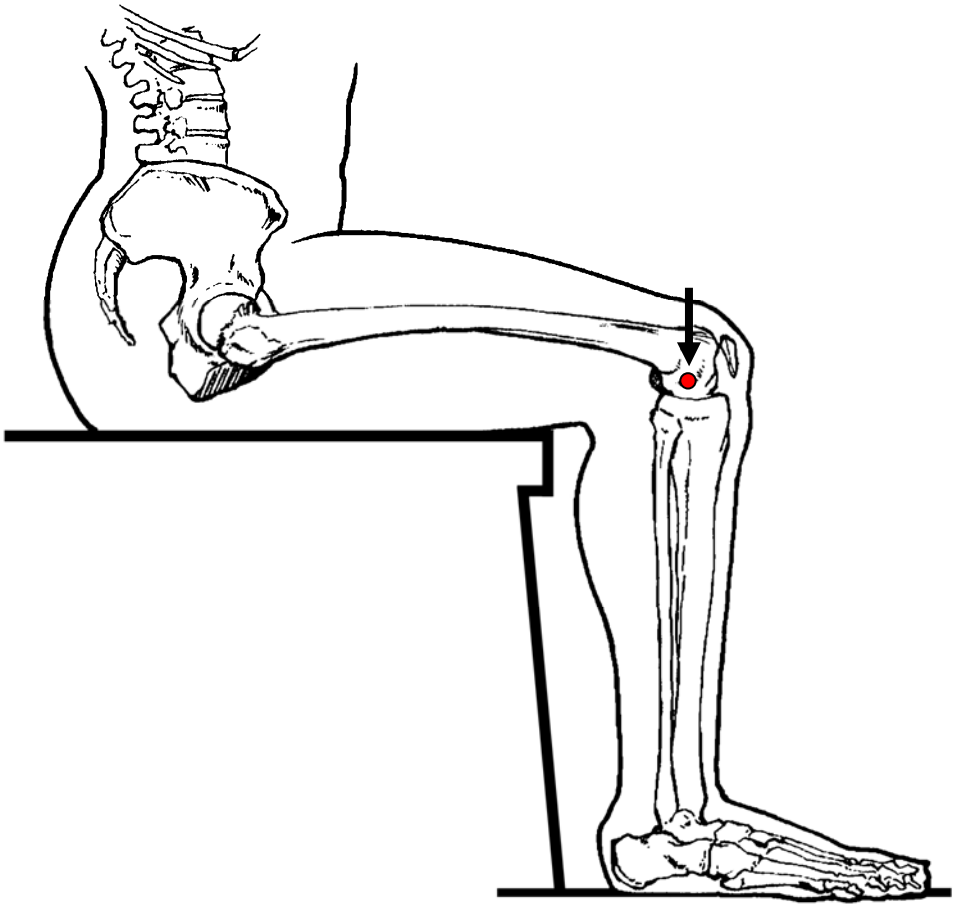


5.2.20 Lateral Femoral Epicondyle, Sitting

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

PROCEDURE: The participant sits with the legs bent approximately 90°. Stand in front of the participant and, with one hand, grasp the bony prominences of the bottom of the femur (femoral epicondyle) located to the left and right of 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 an "O" about 5 mm in diameter.

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

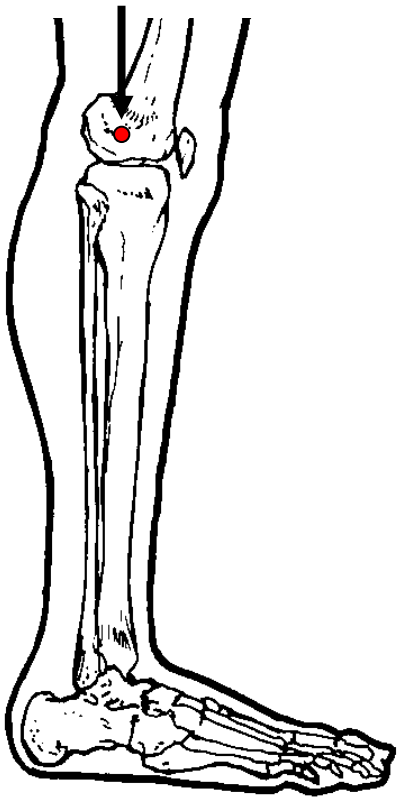


5.2.21 Lateral Femoral Epicondyle, Standing

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

PROCEDURE: Participant stands erect on a table with the weight distributed equally on both feet. Stand in front of the participant and, with one hand, grasp the bony prominences of the bottom of the femur (femoral epicondyle) located to the left and right of the knee. Have the participant flex the knee to help locate these structures. The participant 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.

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



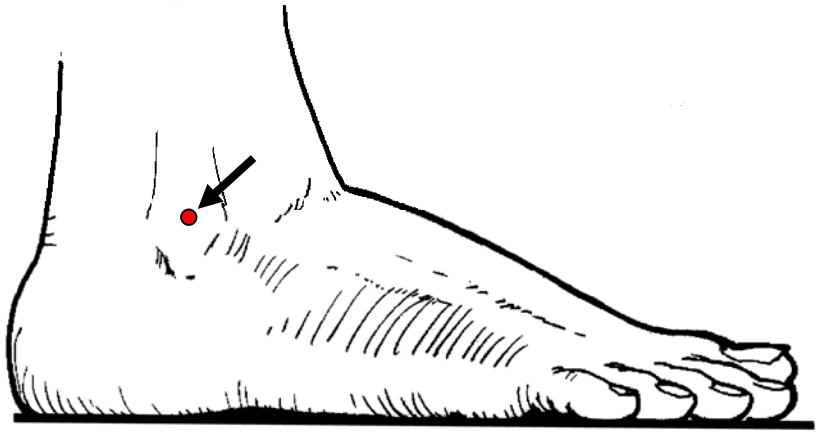
5.2.22 Lateral Malleolus

DESCRIPTION: The most lateral point of the right lateral malleolus (the ankle bone on the outside of the foot).

PROCEDURE: Participant stands on a table with the weight distributed equally on both feet. Stand at the participant's right and use a marking block to locate the protruding point on the lateral malleolus. Draw a cross (+) through the point.

REQUIRED INSTRUMENTS: Marking block.

CAUTION: This landmark can be on a vein.

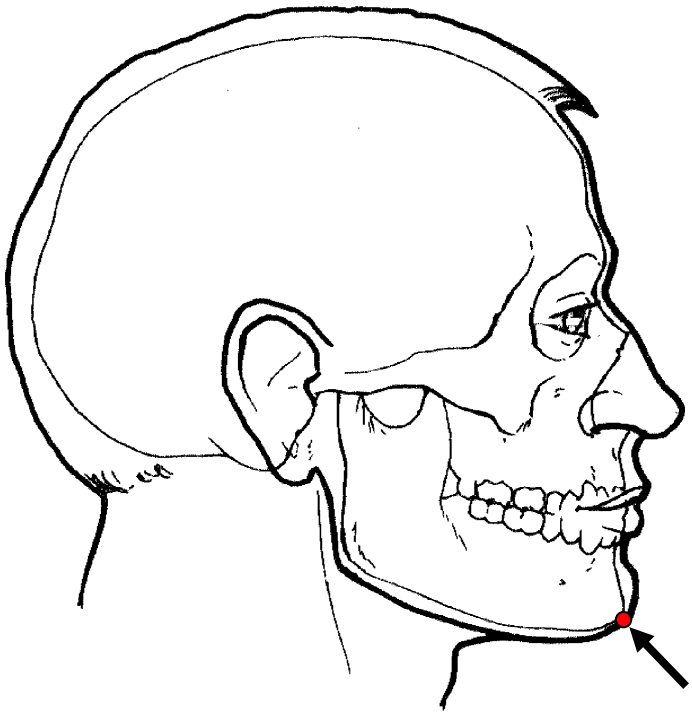


5.2.23 Menton

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

PROCEDURE: Participant stands with the head in the Frankfurt plane and the teeth together (lightly occluded). Stand in front of the participant. Locate the landmark by palpation of the lower jawbone just under the chin, and draw a dot on it.

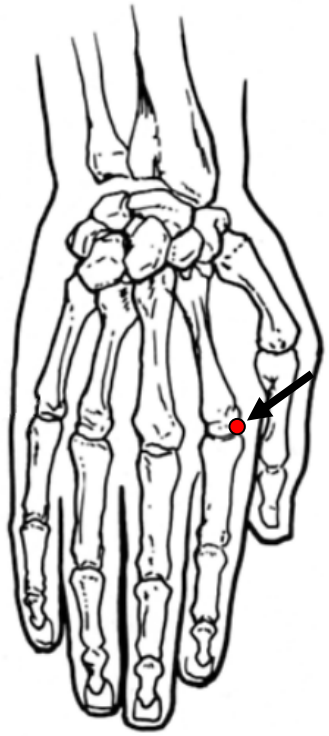
CAUTION: Be careful not to distort the sometimes soft tissue of the skin when drawing the landmark.



5.2.24 Metacarpale II

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

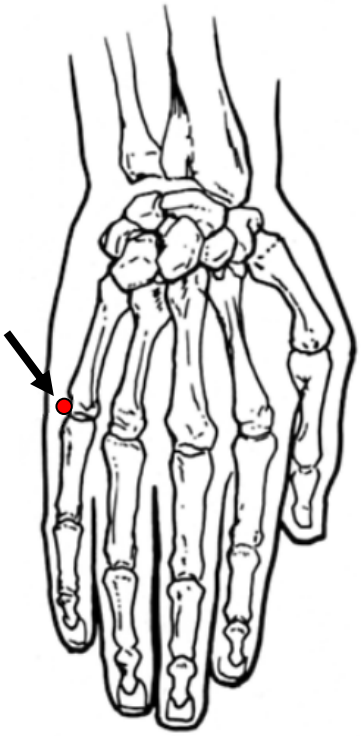
PROCEDURE: Participant stands. Stand in front of the participant. Grasp the participant's hand and palpate the metacarpophalangeal joint II to locate its most laterally protruding point. The landmark will be located on the side of the hand at the base of the index finger. Draw a short line perpendicular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



5.2.25 Metacarpale V

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

PROCEDURE: Participant stands. Stand in front of the participant. Grasp the participant'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.

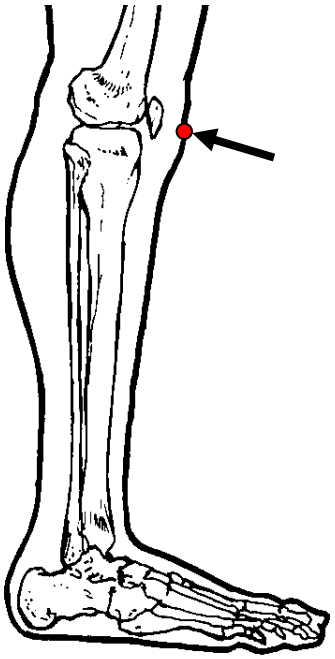


5.2.26 Midpatella

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

PROCEDURE: Participant stands erect on a table with the knee relaxed. Stand in front of the participant. Grasp the kneecap with the forefinger on the suprapatella 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: Participants commonly lock their knees when this landmark is being located. If the participant has difficulty relaxing the knee, firmly grasp the participant's thigh a few inches above the knee and then let go. This usually has the effect of relaxing the patella. If the participant is still unable to relax the knee, move on to other landmarks and then try the patella landmark again.



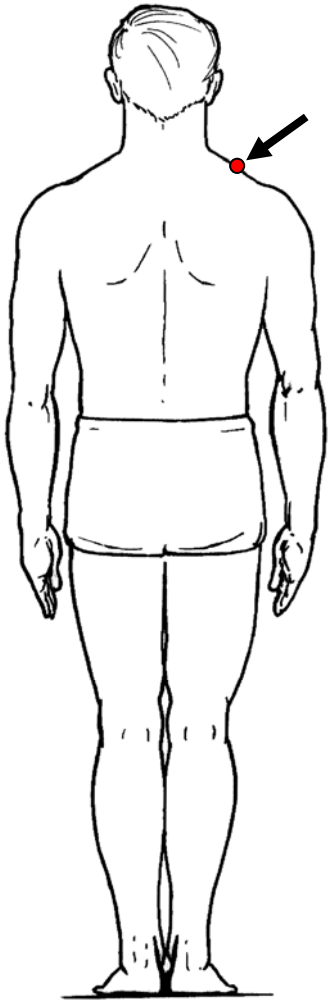
5.2.27 Midshoulder

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

REQUIRED LANDMARKS: Trapezius, right; acromion, right.

PROCEDURE: Participant stands in the anthropometric standing position. Stand behind the participant 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 of 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.

REQUIRED INSTRUMENTS: Steel tape.



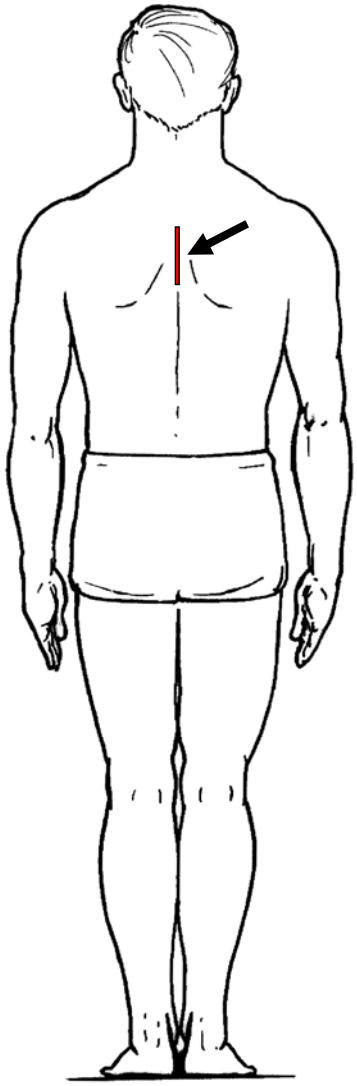
5.2.28 Midspine

DESCRIPTION: A line down the center of the back.

REQUIRED LANDMARKS: Cervicale.

PROCEDURE: Participant is in the anthropometric standing position. Stand behind the participant. 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). If the woman's bra covers the skin where this landmark is located, then place a strip of adhesive tape on the bra to mark this landmark.

REQUIRED INSTRUMENTS: Plastic rule.

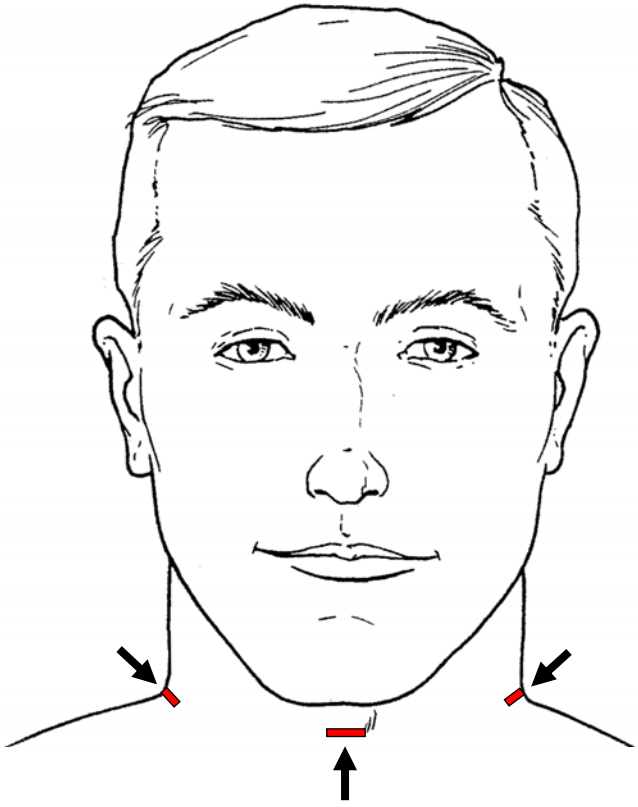


5.2.29 Neck, Anterior, Right Lateral, and Left Lateral

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

PROCEDURE: Participant stands looking straight ahead. Stand behind the participant. 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 participant 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 lateral 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.

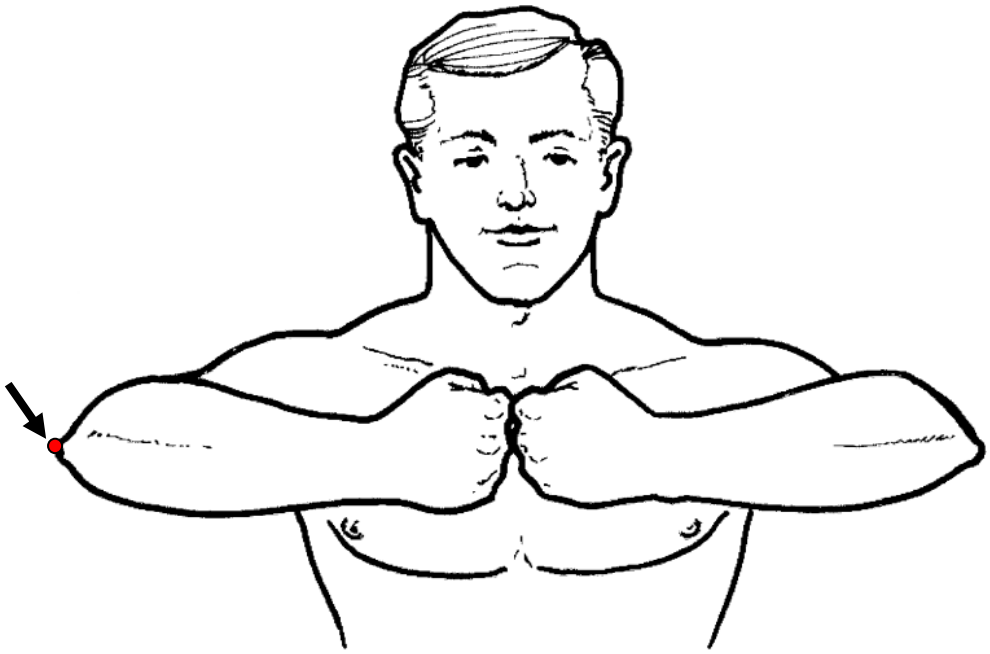
REQUIRED INSTRUMENTS: Steel tape.



5.2.30 Olecranon, Center

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

PROCEDURE: Participant stands. The participant 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 hands facing outwards and the palm sides facing inwards, the participant 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 participant. Locate the center of the curvature of the elbow by inspection and draw a short vertical line through the landmark.

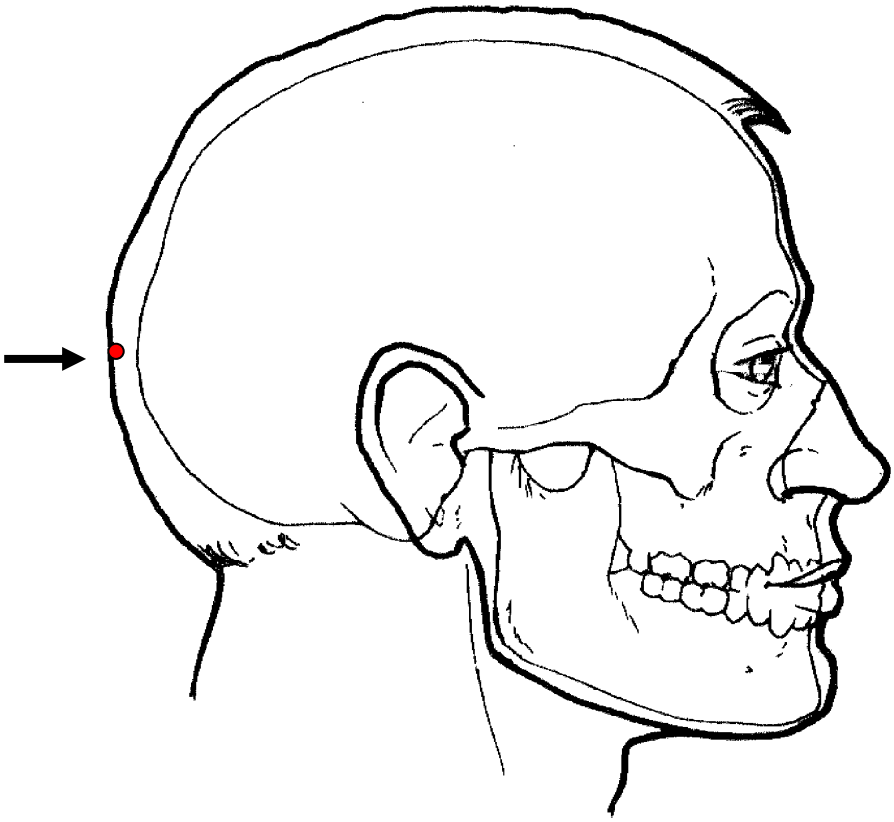


5.2.31 Opisthocranion

DESCRIPTION: The posterior point on the back of the head.

PROCEDURE: Participant stands, looking straight ahead and with wig cap in place. Stand to the right of the participant and locate the landmark by palpation along the back of the head in the midsagittal plane. Place a dot on it.

NOTE: This landmark is identified and marked in the scanning station.

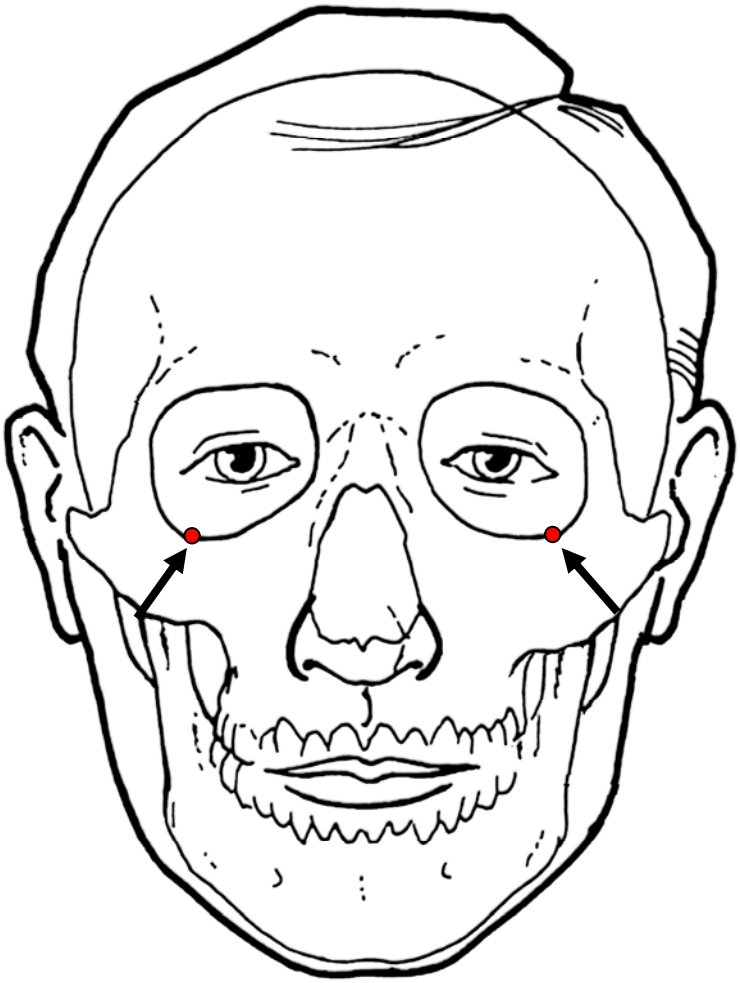


5.2.32 Orbitale[4], Right and Left

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

PROCEDURE: Participant stands, looking straight ahead. Stand in front of the participant and palpate the bony eye socket under the right eye to locate its lowest point. Draw a dot on the landmark. Repeat this procedure on the left side.

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

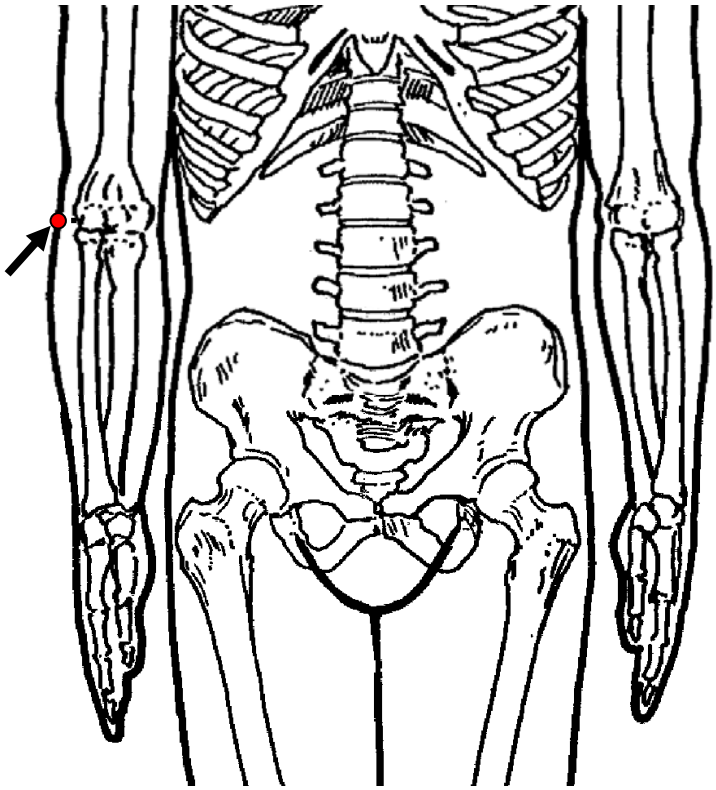


[4] This landmark was termed “Infraorbitale” in ANSUR. This change was made to bring the definition into compliance with standard anatomical usage (Martin, 1914) and international practice.

5.2.33 Radiale

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

PROCEDURE: Participant stands relaxed. Stand at the right of the participant 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 participant's wrist, and rotate the arm back and forth while palpating the bone in the area of the landmark.



5.2.34 Scye

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

Anterior scye on the torso (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 (IV)

REQUIRED LANDMARKS: acromion, right and left.

PROCEDURE: Participant is in the anthropometric standing position. The participant places both hands on his/her hips.

- Begin by standing in front of the participant and move around the participant 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 participant to carefully lower the arm to the side, thus clamping the rule in place. Make sure the rule is level, and then have the participant relax the shoulders.

- Draw a short horizontal line on the torso at the top of the rule on the anterior side (Anterior scye on the torso- I). This mark is made on the right side only.

- Draw a short horizontal line on the back at the top of the rule (Posterior horizontal scye, right- II). Repeat the process with the rule in the left armpit for the posterior horizontal scye, left.

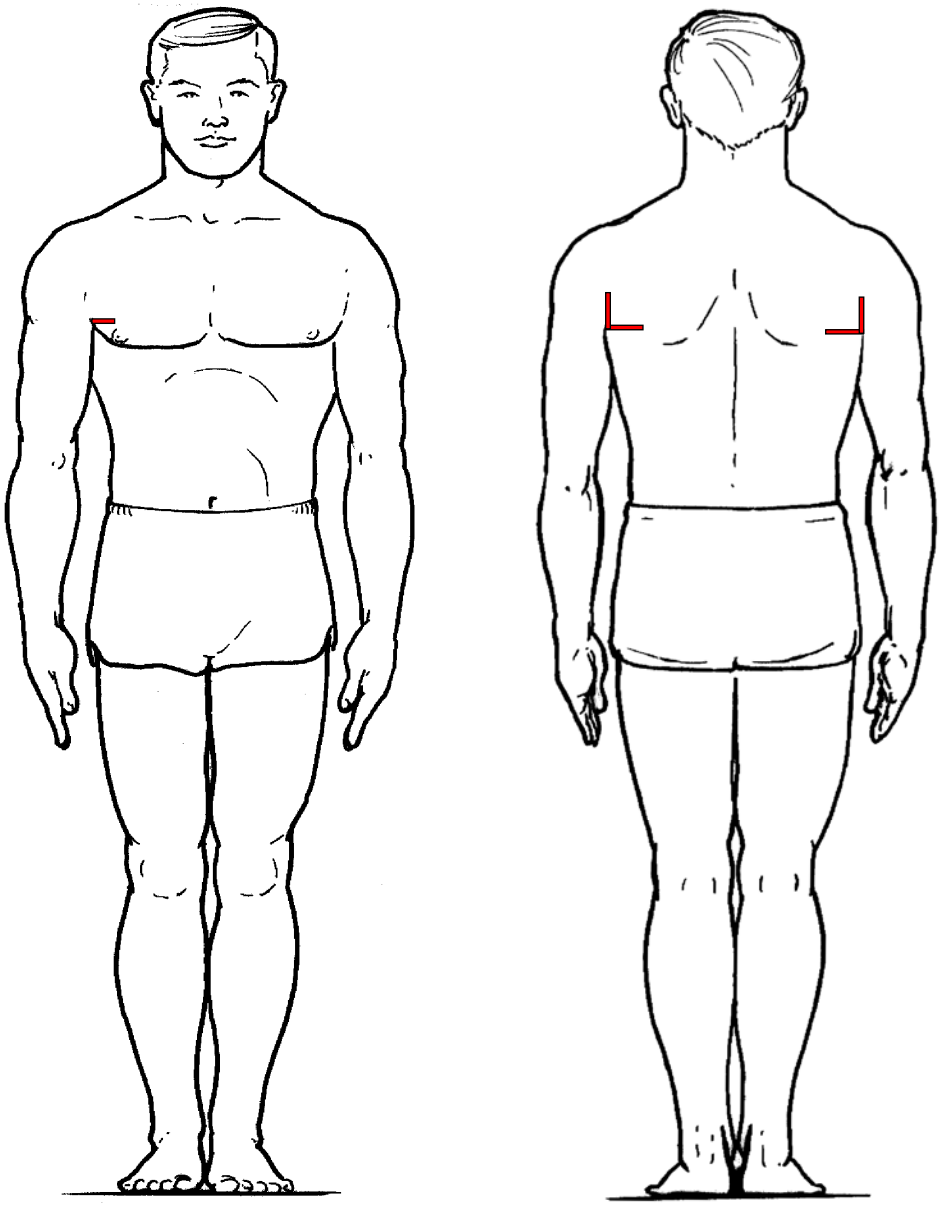
- Then remove the plastic rule and draw short vertical lines extending upwards along the arm creases from the posterior horizontal landmarks (Posterior vertical scye, right and left- II).

- Use a flexible rule to draw a line (Posterior diagonal scye- III) connecting the posterior vertical scye lines to the corresponding acromion landmarks. Hold the marked surface of the rule parallel to the coronal plane.

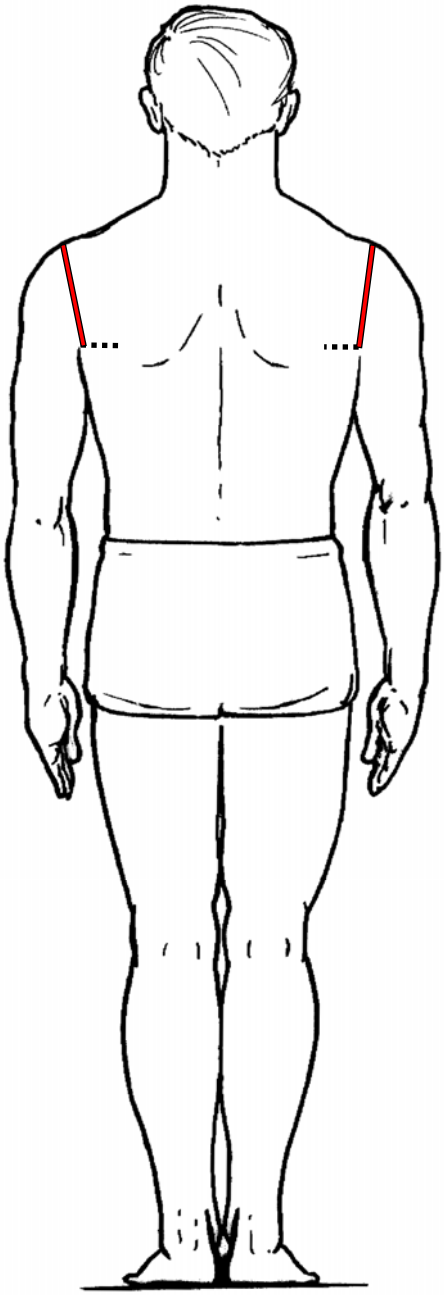
- Then place a tape in the same position, and note the distance between posterior horizontal scye and acromion points. Draw short horizontal lines intersecting the diagonal at one-half of the noted distance (Midscye- IV).

REQUIRED INSTRUMENTS: plastic rule with a level; flexible rule; tape.

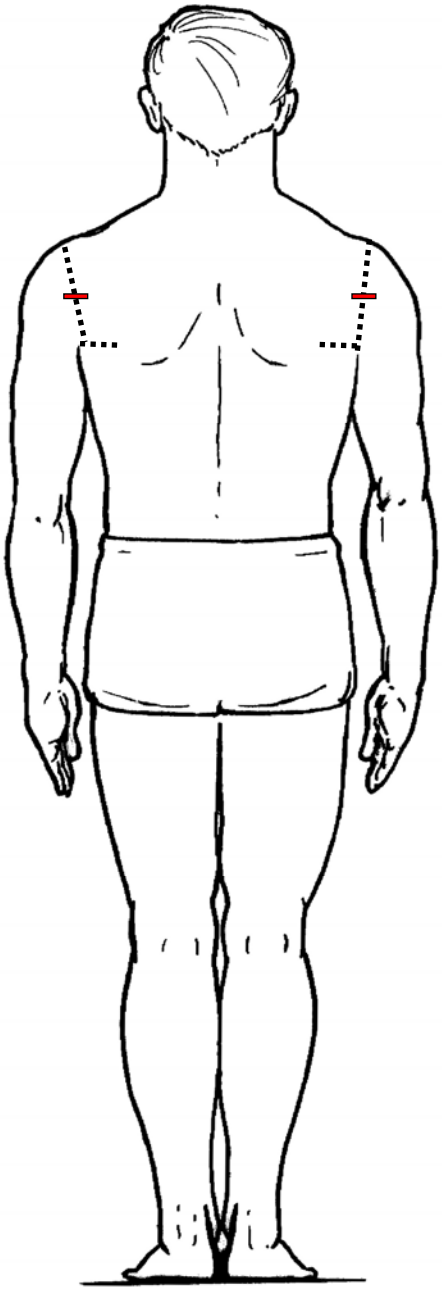
CAUTION: These are some of the more difficult landmarks to locate accurately and consistently. On some participants the arms will have to be held farther away from the body than the hands-on-hips position to place the ruler in its proper position. Be sure that the ruler is level when the arm is lowered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



I II



III

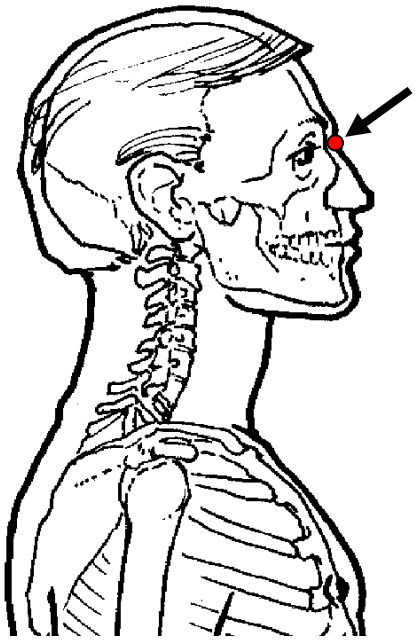


IV

5.2.35 Sellion

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

PROCEDURE: Participant stands, looking straight ahead. Stand at the right of the participant and palpate the point of deepest depression of the bridge of the nose in the midsagittal plane. On some participants, 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.

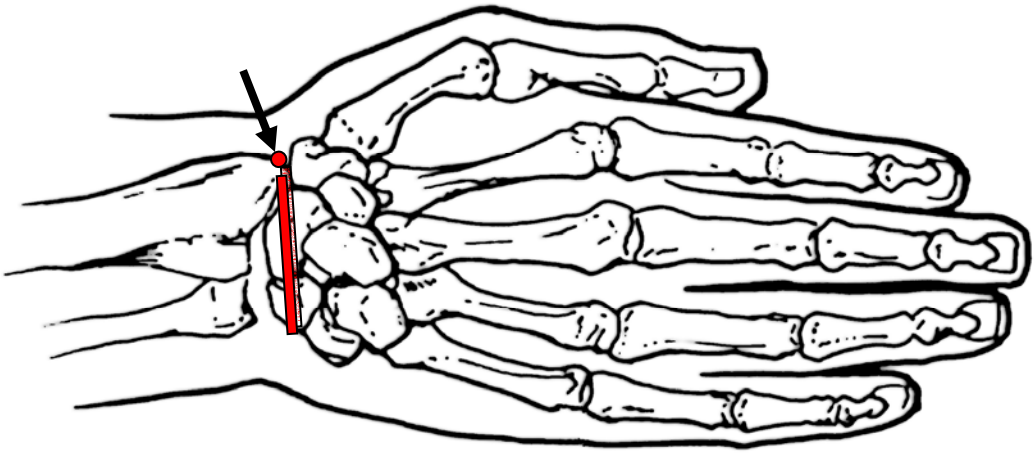


5.2.36 Stylion, Dorsal Stylion, and Ventral Stylion

DESCRIPTION: The inferior point of the bottom of the radius and the extension of this landmark on the dorsal and ventral sides of the wrist.

PROCEDURE: Participant stands with right elbow flexed 90°. Stand in front of the participant and grasp the participant's hand. Place your thumb on the thumb side of the participant's hand and palpate up toward the wrist until you locate the end of the radius. Draw a cross (+) over the landmark. Hold the participant's hand with the palm facing medially and look directly at the stylion landmark to eliminate errors in sighting. Draw a line across the dorsal (back) surface of the wrist, beginning below stylion. Next draw a line on the ventral (front) surface of the wrist, beginning below stylion.

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. When transferring, be sure the lines are straight and that their origin is at stylion.

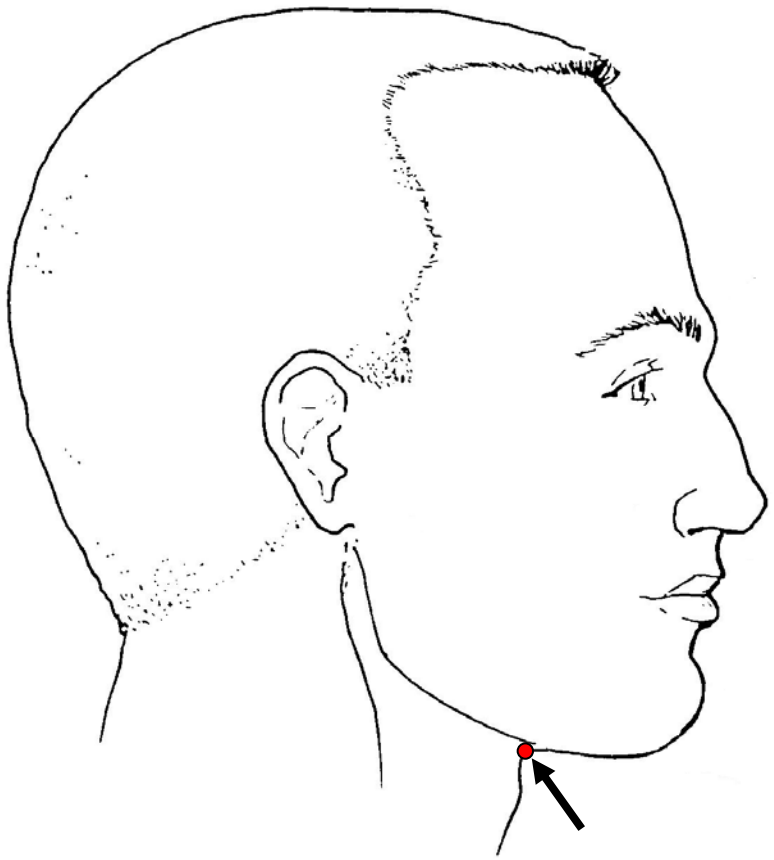


5.2.37 Submandibular

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

PROCEDURE: Participant stands with the head in the Frankfurt 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.

CAUTION: On participants with a sloping anterior neck, make a judgment about the position of a helmet strap. In no case should this mark be below infrathyroid.

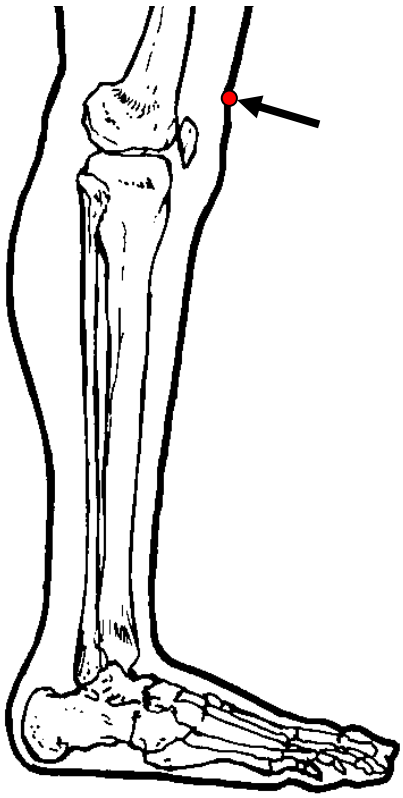


5.2.38 Suprapatella

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

PROCEDURE: Participant stands erect on a table with the patella *relaxed*. Stand in front of the participant 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.

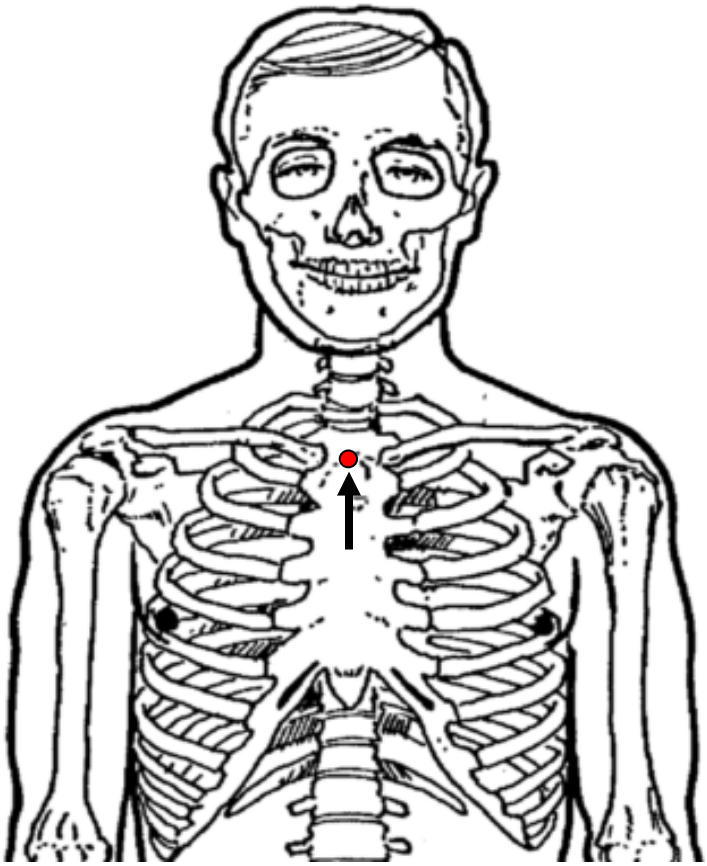
CAUTION: Participants will tend to lock their knees when this landmark is being located. If the participant has difficulty relaxing the knee, firmly grasp the participant's thigh a few inches above the knee and then let go. This usually has the effect of relaxing the patella. If the participant is still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



5.2.39 Suprasternale

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

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant, and locate the bottom of the notch of the sternum by palpation. Draw a cross (+) through the landmark.

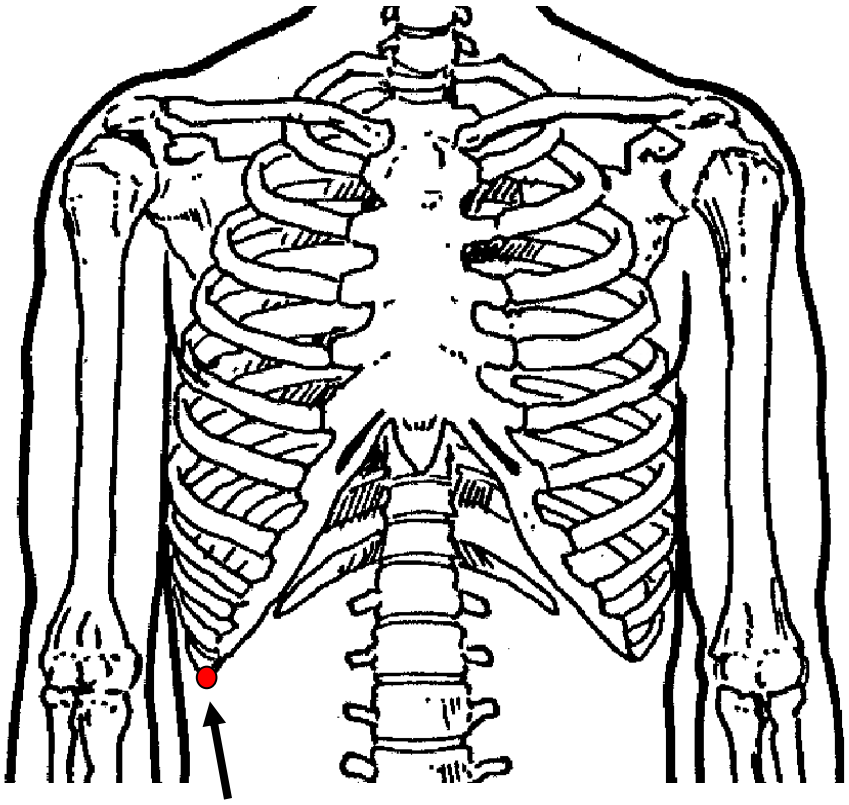


5.2.40 Tenth Rib

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

PROCEDURE: Participant stands erect. Stand in front of the participant, 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. On heavier participants, be sure to palpate the landmark horizontally from the lateral side, being careful not to move flesh from above or below the area.

CAUTION: Participants 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.

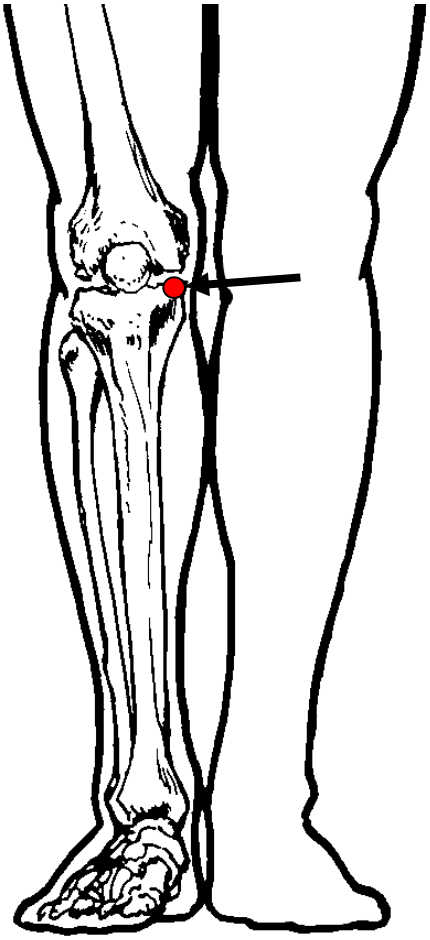


5.2.41 Tibiale

DESCRIPTION: The superior palpable point on the medial condyle of the right tibia.

PROCEDURE: Participant stands erect on a table with the weight distributed equally on both feet. Stand in front of the participant and, with one hand, grasp the bony prominences (condyles) located on the left and right side at the top of the tibia. Have the participant flex the knee to help locate these structures. The participant then straightens the knee. When you have located the superior palpable point on the medial condyle of the tibia, use the thumb or index finger of the other hand to mark its place, and draw a cross (+) through the landmark.

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

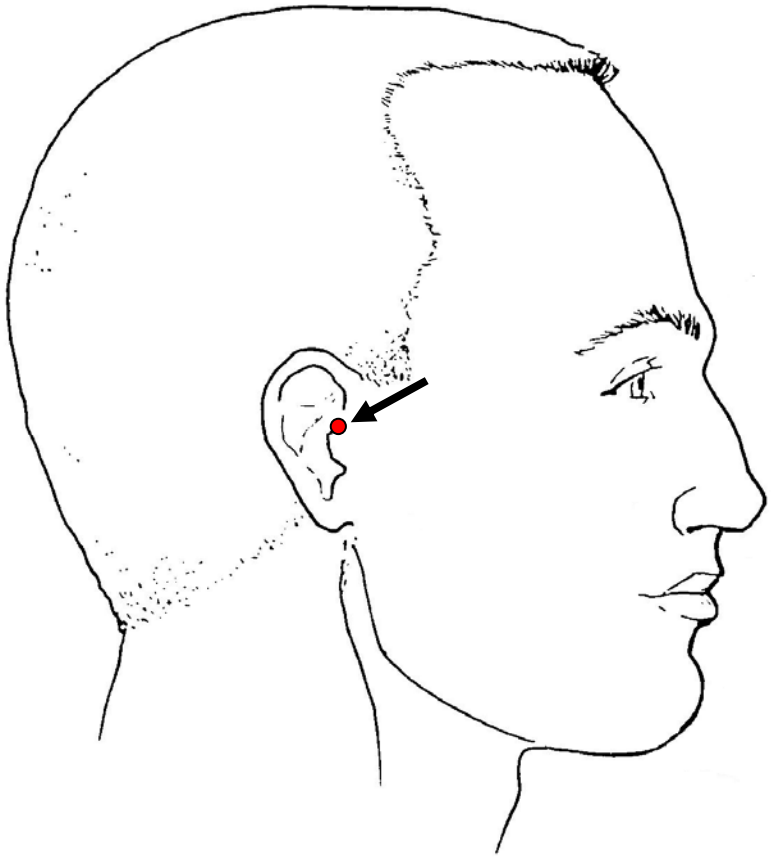


5.2.42 Tragion, Right and Left

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.

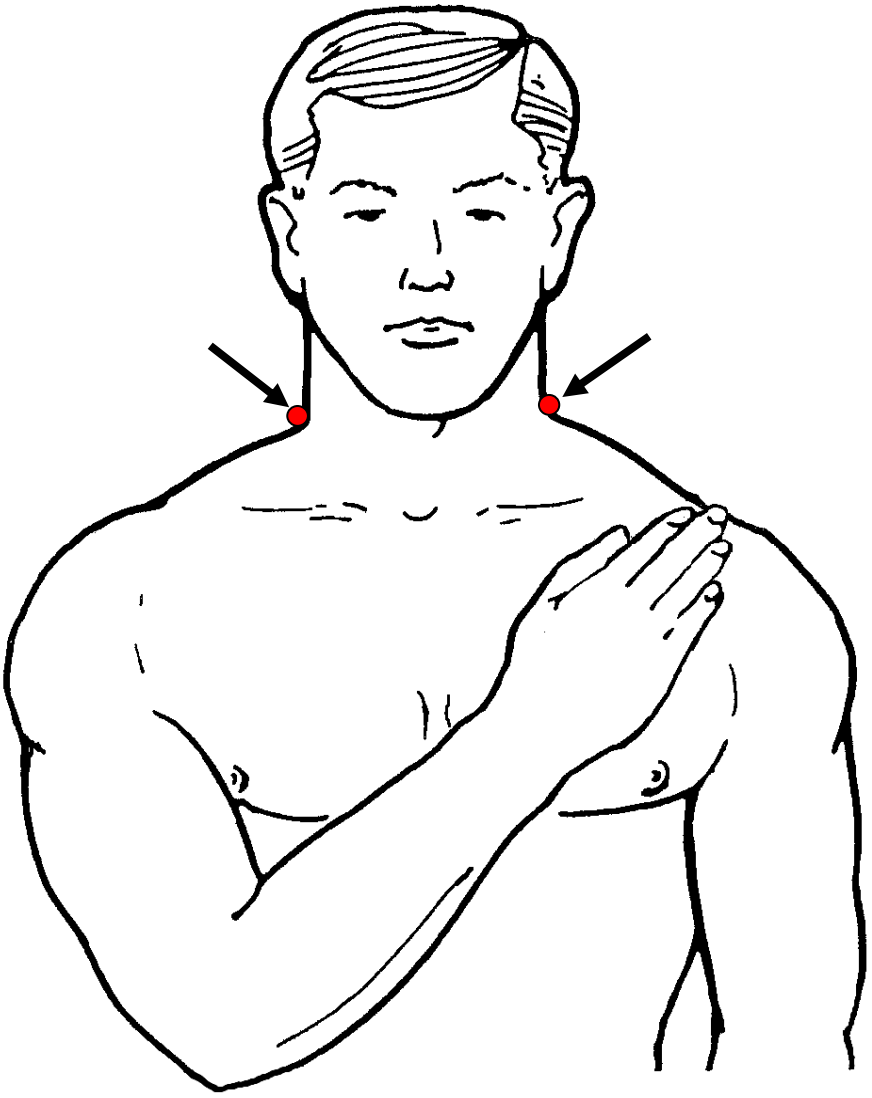


5.2.43 Trapezius Point, Right and Left

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

REQUIRED LANDMARKS: Neck, right lateral and left lateral.

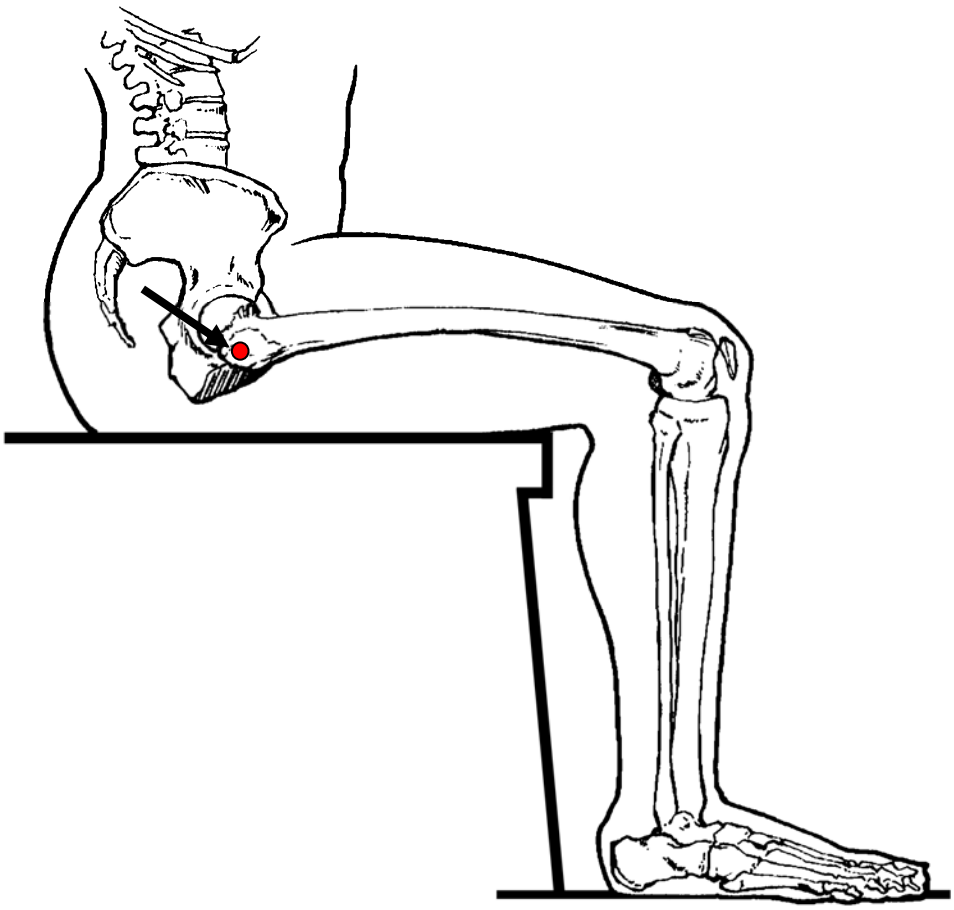
PROCEDURE: Participant stands looking straight ahead. Ask the participant to place the right hand on his/her left shoulder to help outline the trapezius muscle on the right shoulder. Stand at the side of the participant. Moving from the shoulder to the neck, palpate the mass of the trapezius muscle to 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.



5.2.44 Trochanter

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

PROCEDURE: Participant sits with the knees flexed about 90°. Stand at the right of the participant. 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. On heavier participants this landmark can be difficult to locate. Ask these participants to move the thigh back and forth laterally to feel for the movement of the joint. On heavier participants be careful to palpate only horizontally, avoiding moving flesh either above or below the trochanter.

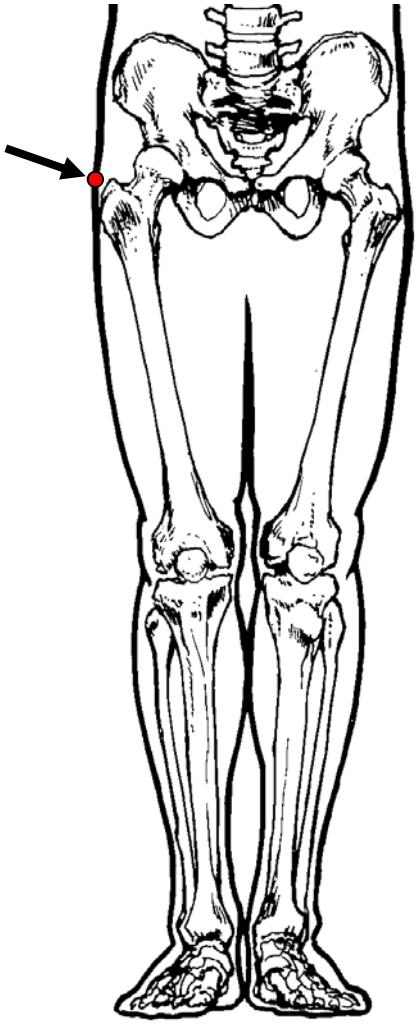


5.2.45 Trochanterion

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

PROCEDURE: Participant stands erect with weight distributed equally on both feet. Stand in front of the participant. 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 participants it will help to have the participant move the thigh back and forth. Draw a cross (+) at the level of the landmark. On heavier participants be sure to palpate directly horizontally, and avoid moving flesh either above or below the landmark.

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



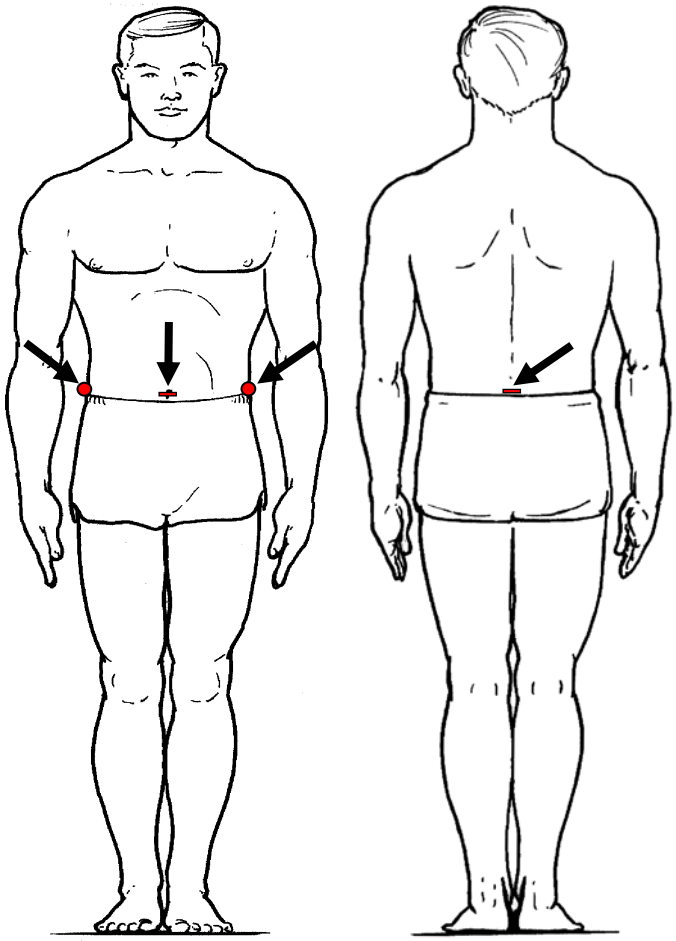
5.2.46 Waist (Omphalion), Right, Left, Anterior, and Posterior

DESCRIPTION: Center of the navel and its posterior and lateral extensions.

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant and locate the landmark by inspection. Draw a 4-cm horizontal line to the right side of 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 participant. The landmarks are drawn at the maximum point of quiet respiration. On heavy participants, the navel may point downward, instead of anteriorly. On such participants, continue to follow the procedures outlined above.

REQUIRED INSTRUMENTS: Landmark transfer rod.

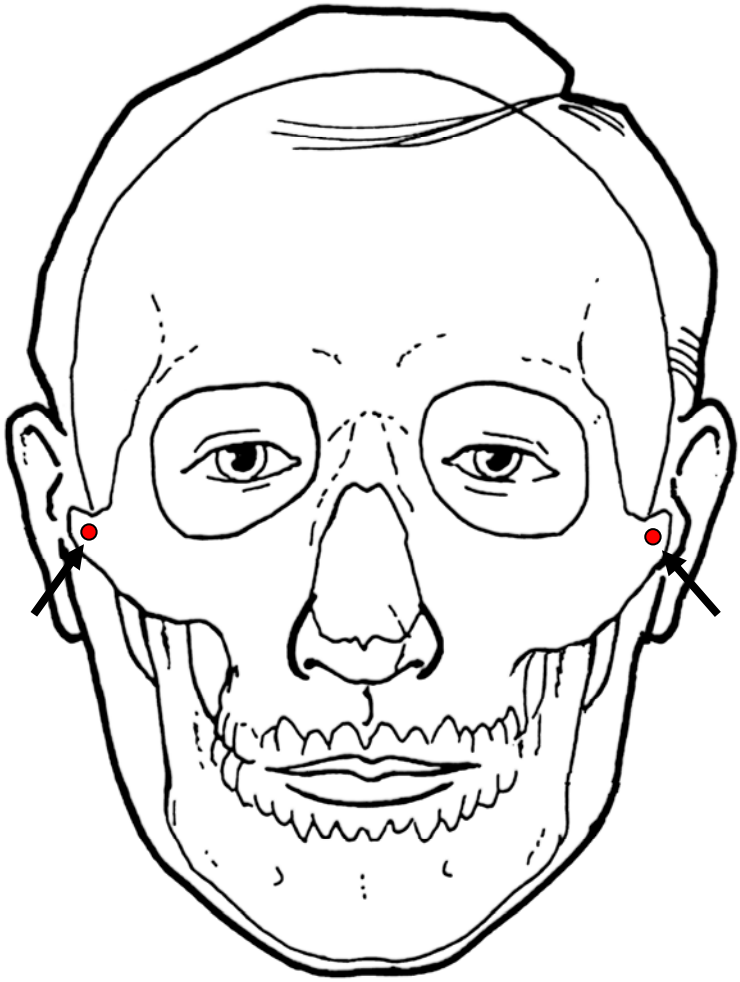
CAUTION: The participant must not tense the abdominal muscles or change body position while these marks are drawn.



5.2.47 Zygion, Right and Left

DESCRIPTION: The most lateral point on the zygomatic arch.

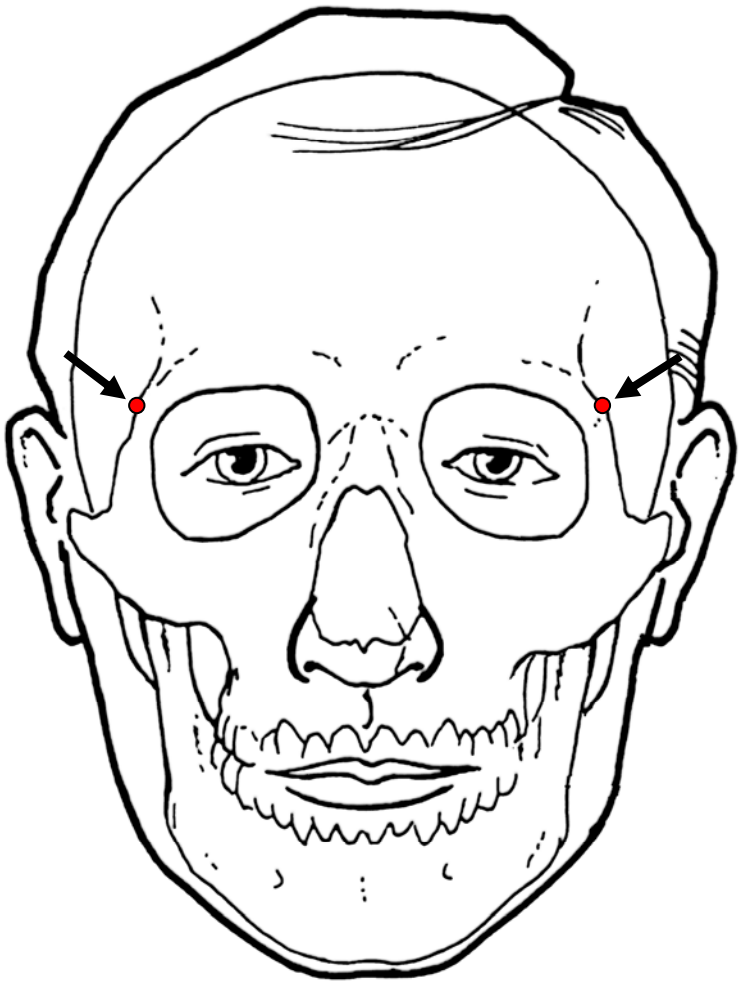
PROCEDURE: The participant stands, looking straight ahead, with facial muscles relaxed. Stand in front of the participant and locate the most lateral point on each zygomatic arch by palpation. Draw a dot on these landmarks. (When unmarked, this is located by movement of the tips of the spreading caliper during measurement.)



5.2.48 Zygofrontale, Right and Left

DESCRIPTION: The most lateral point of the frontal bone on its zygomatic process.

PROCEDURE: The participant stands, looking straight ahead, with brows relaxed. Stand in front of the participant, and locate by palpation the most lateral point of each frontal bone on its zygomatic process in the area of the browridges. Place a dot on these landmarks.



6. THE MEASUREMENTS

The techniques of measuring each body dimension are described in this chapter. Included in each description is a definition of the measurement, required posture for the participant, 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 rare cases where an anatomical abnormality makes it necessary to measure on the left side. All measurements are made to the nearest millimeter. Weight is taken to the nearest 0.1 kg.

6.1 PARTICIPANT POSTURE

The purpose of a standardized participant posture is to ensure that measurement differences between individuals are due to body size differences, 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.

6.1.1 Anthropometric Standing

For anthropometric standing (Figure 19), participants 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. On individuals with muscular upper arms, the elbows may not touch the sides. This posture is similar to that of the position of military attention, but without the stiffness and bracing with which it is often associated.

FIGURE 19
Anthropometric Standing Position

6.1.2 Anthropometric Sitting

In the position of anthropometric sitting (Figure 20), the participant sits on a cushionless flat surface with the long axes of the thighs parallel. There is approximately an 8 cm gap (hand width) between the surface edge and the back of the knee at thigh level. The feet are in line with the thighs (apart) and are on an adjustable foot rest, and the knees are flexed 90°. This position is established using a scored plastic right angle and the two seated landmarks on the thigh (trochanter and lateral femoral epicondyle, sitting). 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 Styrofoam pieces of various thicknesses, move the feet up and down until the two landmarks are in line with each other. The lateral femoral epicondyle, sitting and lateral malleolus landmarks are set in line with each other using the other arm of the angle. The trunk is erect without stiffness; the head is also erect, and the participant looks straight ahead. The shoulders are relaxed, and the upper arms are hanging loosely at the sides. The hands rest on the thighs. Before measuring, have the participant flex the elbows 90° with the hands straight, palms facing inward. Deviations from these standardized positions are indicated where appropriate.

FIGURE 20
Anthropometric Sitting Position

A number of dimensions require that the participant's head be in the Frankfurt plane (also known as the Frankfurt horizontal). This head position is quite similar to "head is erect" and "participant looks straight ahead." However, when the Frankfurt plane is called for, the anthropometrist will position the participant's head so that an imaginary line connecting the drawn landmarks at right tragion and right orbitale is horizontal (Figure 21)

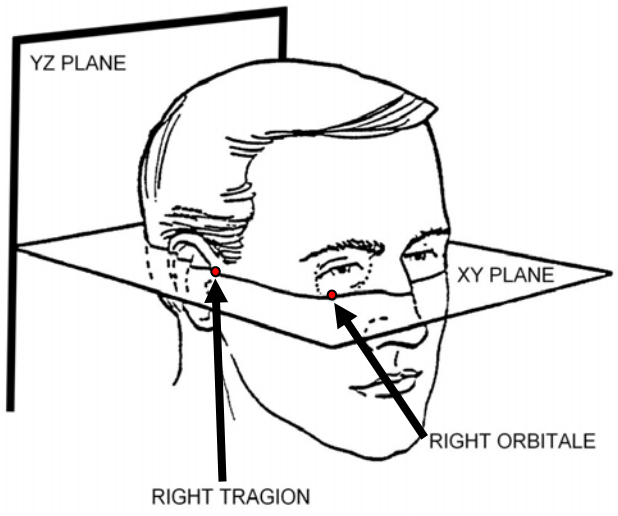


FIGURE 21
Frankfurt Plane

6.2 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 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, participants 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.

6.3 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 participant 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. The majority of these measurements should be taken at the maximum point of quiet respiration, i.e., just before the individual exhales.

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 participant is slightly tilted when the measurement is made. If someone is visibly swaying take the measurement when he or she is most vertical.

For a number of dimensions there is a caution not to let the participant tense the abdominal muscles. WAIST CIRCUMFERENCE (OMPHALION) 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 participant to achieve the required body position. One example is BICEPS CIRCUMFERENCE, FLEXED in which the participant is asked to "make a muscle" as hard as possible. Variability in the motivation of the participant can be a problem here, and participants should be urged to make a maximum effort.

The same amount of tension is used on the tape when measuring body circumferences and arcs. However, it is more difficult to achieve consistency when measuring dimensions where tissue may often be relatively soft or compressed by an adjacent body segment than when measuring dimensions where tissue is usually firm.

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

A table listing allowable interobserver error for the measurements in the surveys, and a description of how the values were determined, appears in Appendix G.

6.4 DIMENSION DESCRIPTIONS

Illustrated measurement descriptions for one of the 94 dimensions appear in each of the following sections. Each section includes the following categories, when applicable: description, undrawn landmark, drawn landmark, procedure, instrument, and caution. 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 H. Many of these descriptions are from Clauser et al. (1988) and Gordon et al. (1989).

6.4.1 Abdominal Extension Depth, Sitting

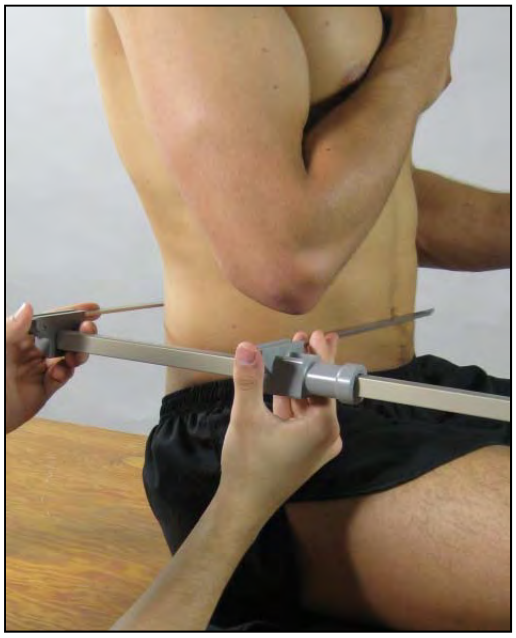
DESCRIPTION: The maximum depth of the abdomen when participant is sitting.

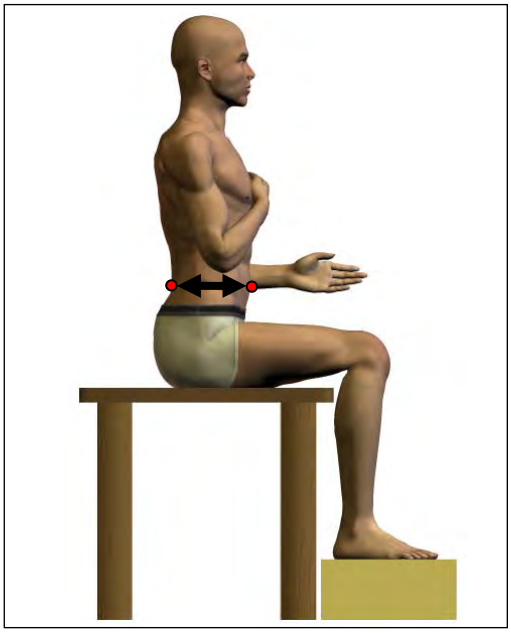
UNDRAWN LANDMARK: Abdominal point, anterior.

PROCEDURE: Participant is in the anthropometric sitting position, but the right hand is placed on the chest. Stand at the participant'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.

INSTRUMENT: Beam caliper.

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





6.4.2 Acromial Height

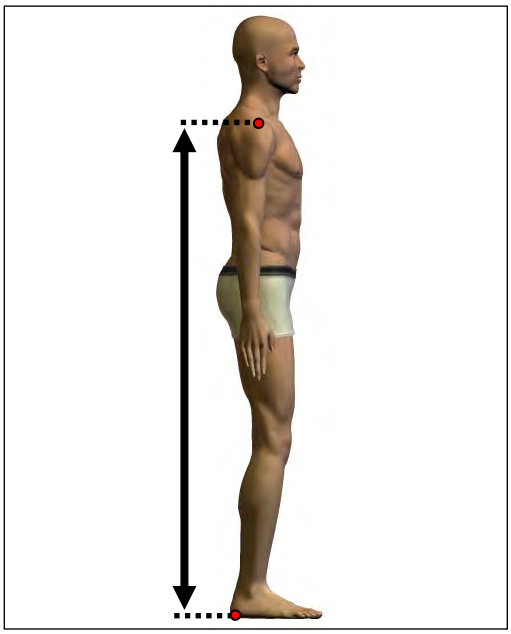
DESCRIPTION: Vertical distance from the floor to the right acromion landmark.

DRAWN LANDMARK: Acromion, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand to the right of the participant, 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.

INSTRUMENT: Anthropometer.

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



6.4.3 Acromion-Radiale Length

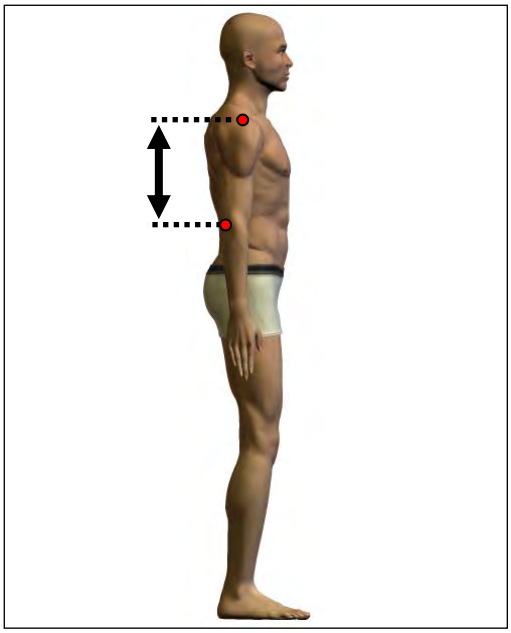
DESCRIPTION: The distance between the acromion landmark on the right shoulder and the radiale landmark on the right elbow.

DRAWN LANDMARKS: Acromion, right; Radiale, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand to the right of the participant, 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 acromion landmark during this measurement. Both blades of the instrument just touch the body.

INSTRUMENT: Beam caliper.

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



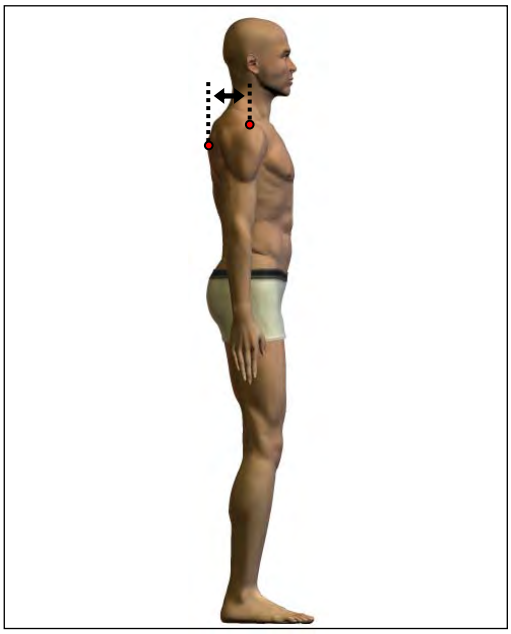
6.4.4 Acromion–Wall Depth

DESCRIPTION: The horizontal distance from a vertical surface to the acromion.

DRAWN LANDMARK: Acromion, right.

PROCEDURE: Participant stands fully erect with shoulder blades and buttocks firmly against a vertical surface with equal pressure exerted by the shoulders against the vertical surface. The feet are together and the heels are on a marked line 20 cm from the wall. The arms are relaxed at the sides. Stand to the right of the participant, and measure the horizontal distance from the vertical surface to the acromion landmark with a height gauge. The base of the height gauge is placed firmly against the vertical surface, and the blade is on the acromion landmark.

INSTRUMENT: Height gauge.



6.4.5 Ankle Circumference

DESCRIPTION: Minimum horizontal circumference of the ankle.

PROCEDURE: Participant 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 participant 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.

INSTRUMENT: Steel tape.

6.4.6 Axilla Height

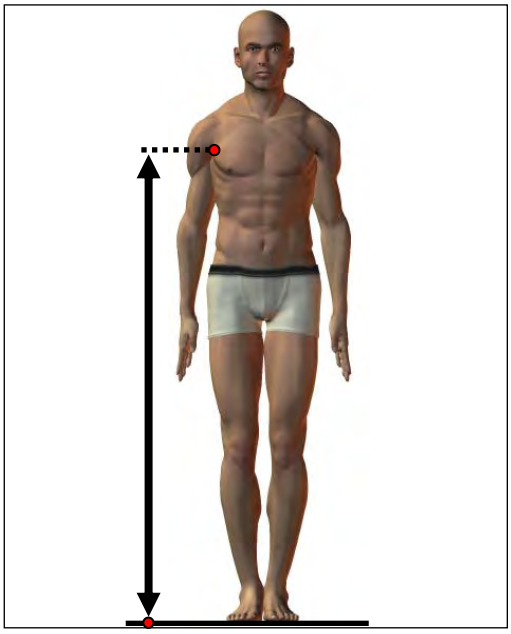
DESCRIPTION: The vertical distance between a standing surface and the right axillary fold, as designated by the anterior scye on the torso landmark.

DRAWN LANDMARK: Anterior scye on the torso, right**.**

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant, 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.

INSTRUMENT: Anthropometer.

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



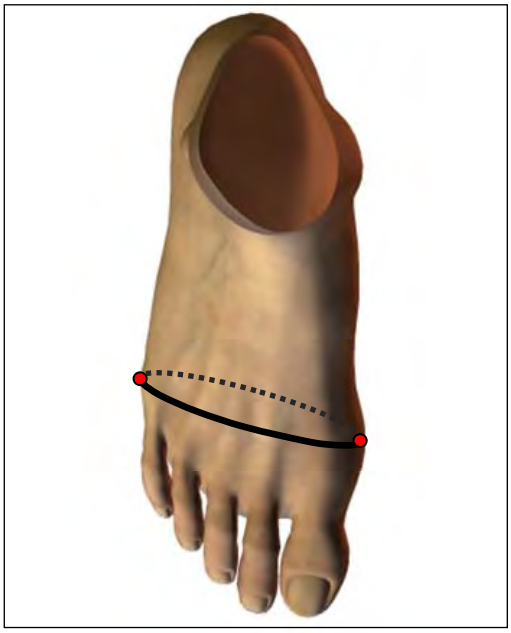
6.4.7 Ball of Foot Circumference

DESCRIPTION: The circumference of the ball of the right foot encompassing the first and fifth metatarsophalangeal landmarks.

DRAWN LANDMARKS: First metatarsophalangeal protrusion, right; fifth metatarsophalangeal protrusion, right.

PROCEDURE: Participant stands on a table with the feet about 10 cm apart and the weight distributed equally on both feet. Stand in front of the participant, 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.

INSTRUMENT: Steel tape.



6.4.8 Ball of Foot Length

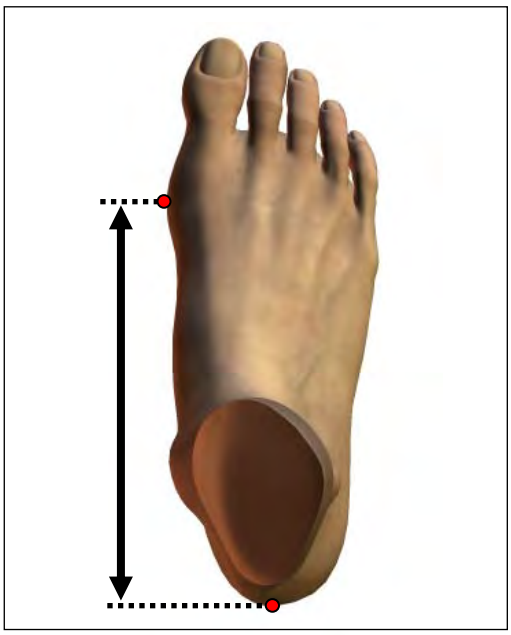
DESCRIPTION: The distance from the back of the heel (pternion) to the landmark at the first metatarsophalangeal protrusion on the ball of the right foot.

DRAWN LANDMARK: First metatarsophalangeal protrusion, right.

UNDRAWN LANDMARK: Pternion.

PROCEDURE: Participant stands erect on a table with the right foot on the Brannock device and the left foot on a board of equal height. The weight is distributed equally on both feet. Stand to the right side of the participant, and make sure the back of the heel (pternion) is lightly touching the back of the device and that the long axis of the foot is in line with the long axis of the device. When the foot is correctly positioned, move to the front of the participant. Measure the distance between the back of the heel and the ball of the foot by moving the pointer of the “vertical” slide to the level of the drawn landmark at the first metatarsophalangeal protrusion. Read the measurement at that point from the device scale.

INSTRUMENTS: Brannock device.



6.4.9 Biacromial Breadth

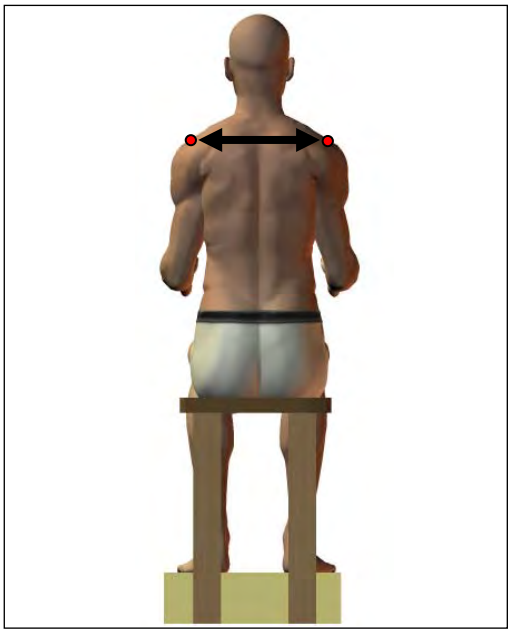
DESCRIPTION: The distance between the right and left acromion landmarks on the tips of the shoulder.

DRAWN LANDMARKS: Acromion, right and left.

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

INSTRUMENT: Beam caliper.

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



6.4.10 Biceps Circumference, Flexed

DESCRIPTION: The circumference of the right upper arm at the biceps point landmark

DRAWN LANDMARK: Biceps point, right.

PROCEDURE: Participant stands. The right upper arm is extended forward horizontally and the elbow is flexed about 90°. 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 participant is urged to exert maximum effort in “making a muscle.” Stand at the right of the participant, 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.

INSTRUMENT: Steel tape.

6.4.11 Bicristal Breadth

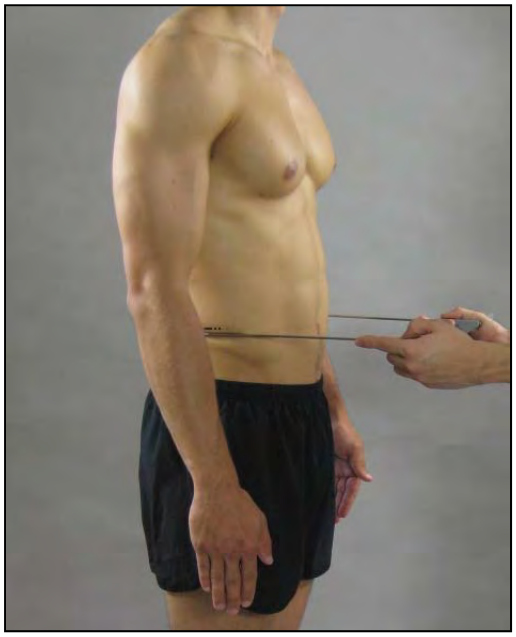
DESCRIPTION: The straight-line distance between the right and left iliocristale landmarks on the iliac crests.

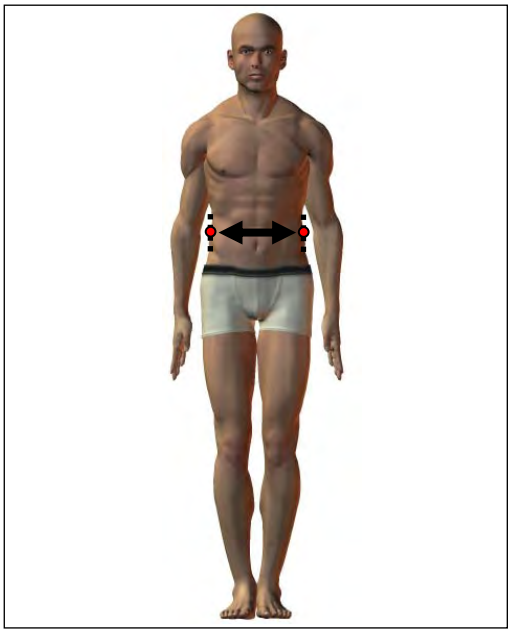
DRAWN LANDMARKS: Iliocristale, right and left.

PROCEDURE: Participant stands on a table in the anthropometric standing position. Stand in front of the participant, and use a beam caliper to measure the distance between the drawn right and left iliocristale landmarks. Compress the tissue firmly to ensure you are on the bony landmarks. Due to rolling on top of the pelvis, it may be necessary to position the blades slightly inferior to the iliocristale landmarks.

INSTRUMENT: Beam caliper.

NOTE: The beam will not necessarily be parallel to the floor, since the two iliac crests are not always located directly across from each other, but it must be parallel to the coronal plane.





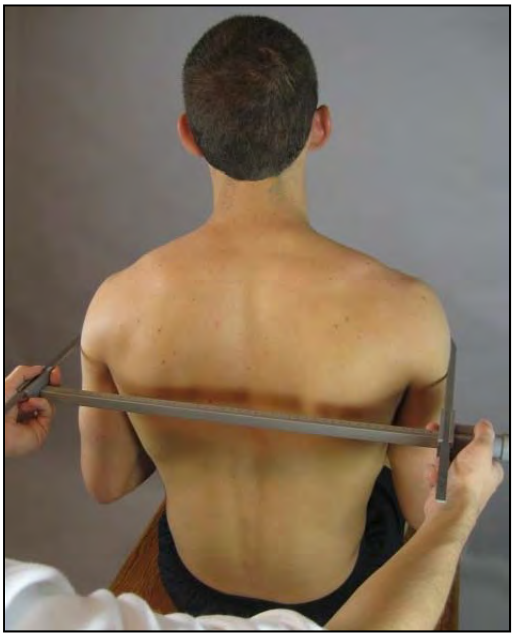
6.4.12 Bideltoid Breadth

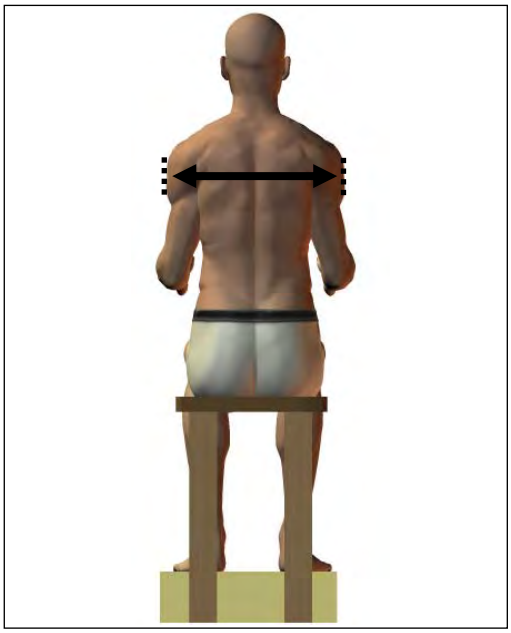
DESCRIPTION: The maximum horizontal distance between the lateral margins of the upper arms on the deltoid muscles.

PROCEDURE: Participant is in the anthropometric sitting position. Stand behind the participant, 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.

INSTRUMENT: Beam caliper.

CAUTION: The participant must not be allowed to change the position of the shoulders. This measurement should never be taken lower than the bottom of the deltoid muscles.





6.4.13 Bimalleolar Breadth

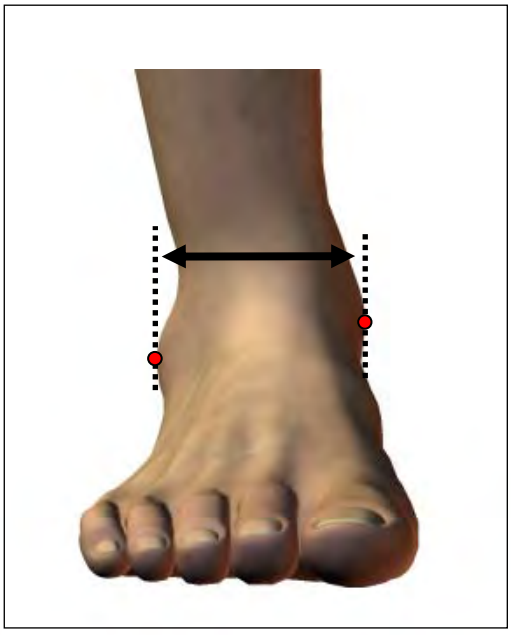
DESCRIPTION: The horizontal distance between the maximum protrusions of the ankle bones (lateral and medial malleoli) on the right foot.

DRAWN LANDMARK: Lateral malleolus, right.

UNDRAWN LANDMARK: Medial malleolus.

PROCEDURE: Participant 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 participant, 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.

INSTRUMENT: Holtain caliper.



6.4.14 Bitragion Chin Arc

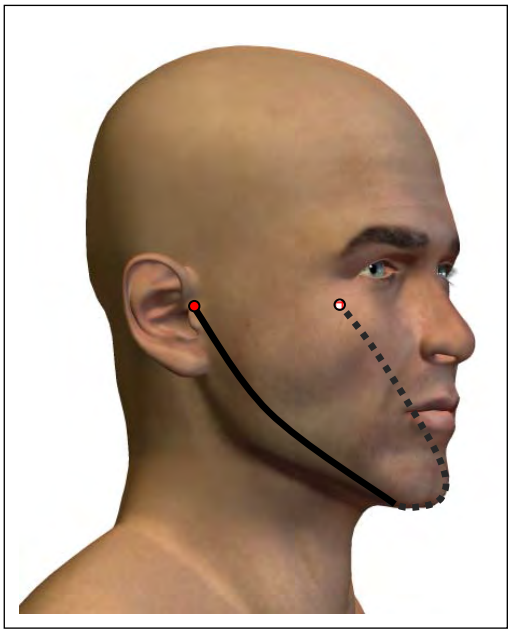
DESCRIPTION: The surface distance between the right and left tragion across the anterior point of the chin.

DRAWN LANDMARKS: Tragion, right and left.

UNDRAWN LANDMARK: Chin.

PROCEDURE: Participant sits with the teeth together (lightly occluded). Stand in front of the participant, 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 the tragion landmark. The chin will be slightly compressed.

INSTRUMENT: Steel tape.



6.4.15 Bitragion Submandibular Arc

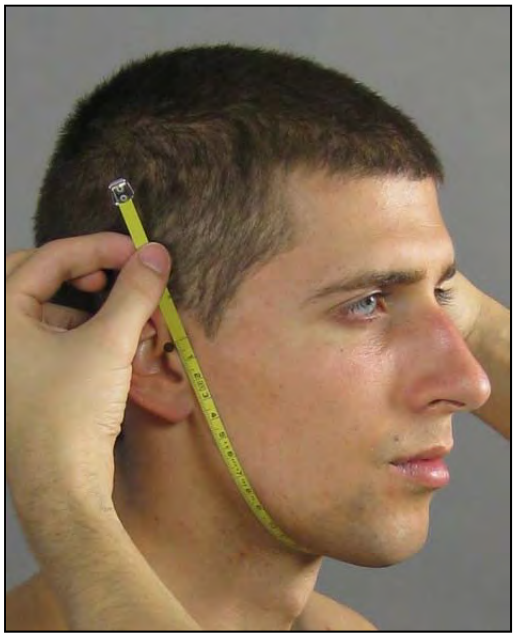
DESCRIPTION: The surface distance between the right and left tragion across the submandibular landmark at the juncture of the jaw and the neck.

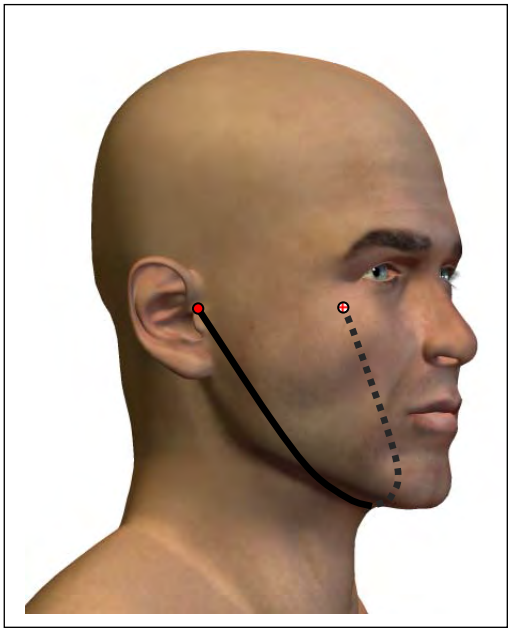
DRAWN LANDMARKS: Tragion, right and left; Submandibular.

PROCEDURE: Participant sits with the head in the Frankfurt plane. Stand in front of the participant, 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 the tragion landmark, and exert only enough tension on the tape to maintain light contact between the tape and the skin.

INSTRUMENT: Steel tape.

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





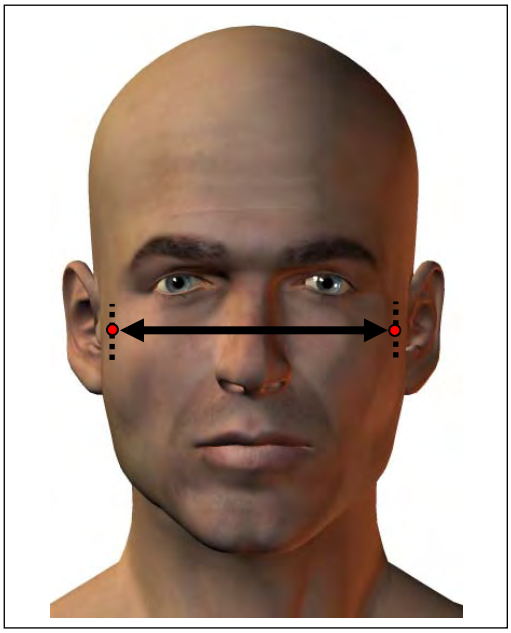
6.4.16 Bizygomatic Breadth

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

DRAWN LANDMARKS: Zygion, right and left.

PROCEDURE: Participant sits. Stand in front of the participant, 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.

INSTRUMENT: Spreading caliper.



6.4.17 Buttock Circumference

DESCRIPTION: The horizontal circumference of the trunk at the level of the maximum protrusion of the right buttock.

DRAWN LANDMARKS: Buttock point, right lateral and left lateral.

UNDRAWN LANDMARK: Buttock point, posterior.

PROCEDURE: Participant stands erect on a table with heels together. Ask the participant to hold up the right leg of the shorts to expose the landmark. Stand at the participant'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. If necessary, ask male participants 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.

INSTRUMENT: Steel tape.

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

6.4.18 Buttock Depth

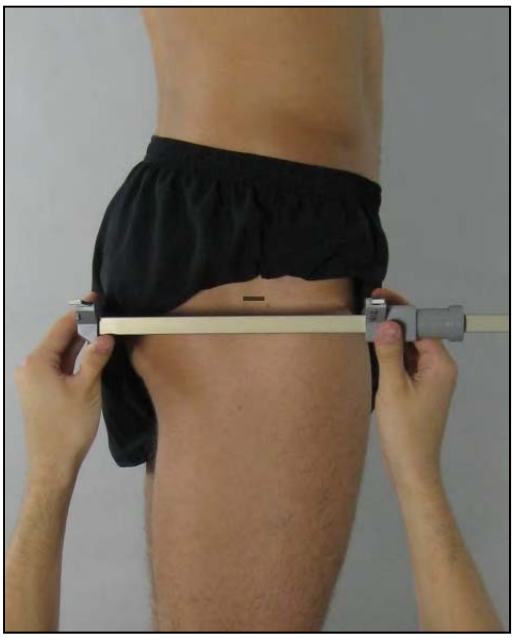
DESCRIPTION: The horizontal depth of the torso at the level of the maximum protrusion of the right buttock.

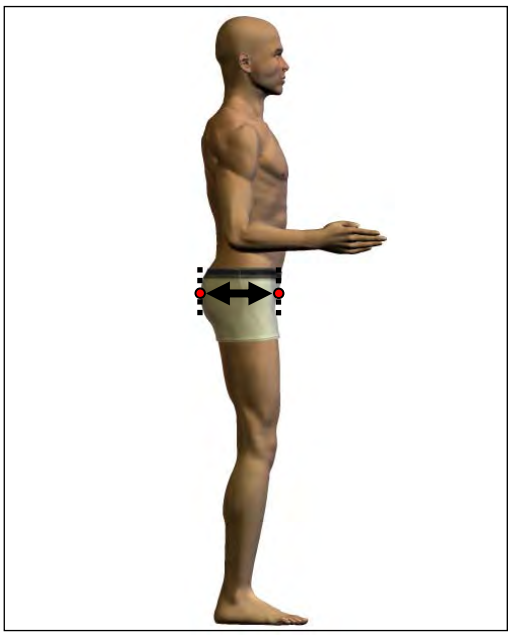
DRAWN LANDMARK: Buttock point, right lateral.

UNDRAWN LANDMARK: Buttock point, posterior.

PROCEDURE: Participant stands on a table with heels together. Ask the participant to hold up the right side of the measuring shorts so the measurer can see the right lateral buttock point. Stand at the participant's right, and use a beam caliper to measure the horizontal depth of the torso at the level of the maximum protrusion of the right buttock. The fixed 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. The blades should be at the level of the right lateral buttock point. If necessary, ask male participants 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.

INSTRUMENT: Beam caliper.





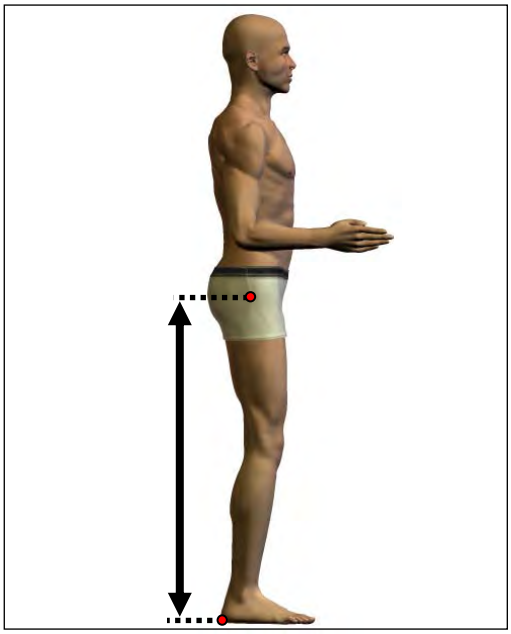
6.4.19 Buttock Height

DESCRIPTION: The vertical distance between a standing surface and the level of the maximum protrusion of the right buttock.

DRAWN LANDMARK: Buttock point, right lateral.

PROCEDURE: Participant stands on a table in the anthropometric standing position, but with the right elbow flexed. In some cases the participant will have to hold up the right leg of the shorts to expose the landmark. Stand at the right of the participant, 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.

INSTRUMENT: Anthropometer.



6.4.20 Buttock-Knee Length

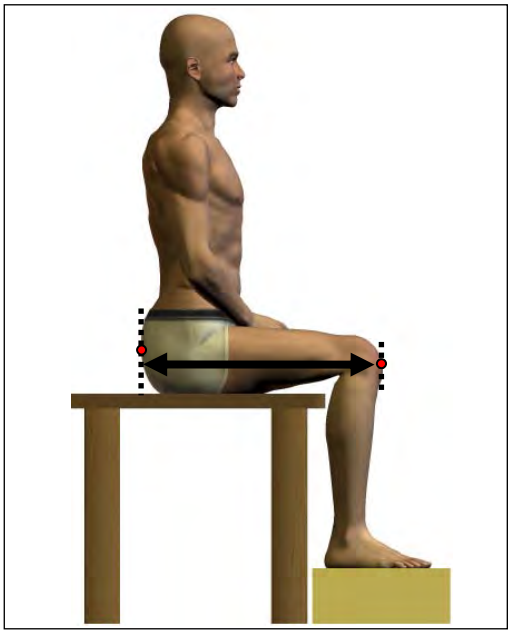
DESCRIPTION: The horizontal distance between a buttock plate placed at the most posterior point of either buttock and the anterior point of the right knee.

UNDRAWN LANDMARK: Knee point, anterior.

PROCEDURE: Participant is in the anthropometric sitting position, but with arms relaxed on the lap. Stand at the right of the participant, and slide the buttock plate toward the participant 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.

INSTRUMENTS: Anthropometer, Buttock plate.

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



6.4.21 Buttock-Popliteal Length

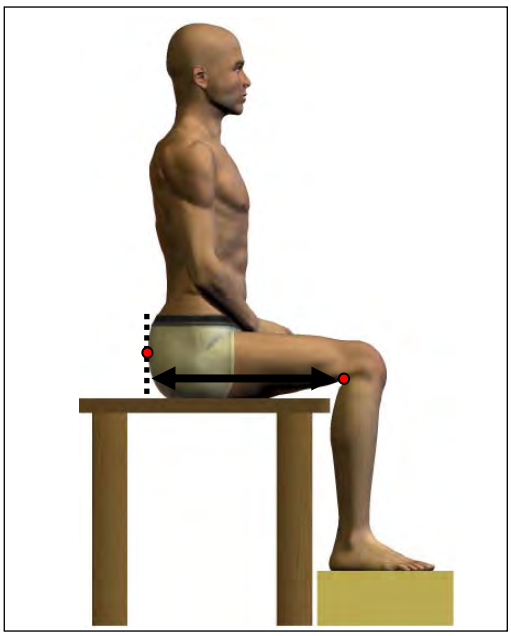
DESCRIPTION: The horizontal distance between a buttock plate placed at the most posterior point of either buttock and the back of the right knee (the popliteal fossa at the dorsal juncture of the calf and thigh).

UNDRAWN LANDMARK: Popliteal fossa at the dorsal juncture of the calf and thigh.

PROCEDURE: Participant is in the anthropometric sitting position with the arms relaxed on the lap. Stand at the right of the participant, and slide the buttock plate toward the participant 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.

INSTRUMENTS: Anthropometer, Buttock plate.

CAUTION: To ensure that the anthropometer is horizontal, be sure that the base of the anthropometer 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.

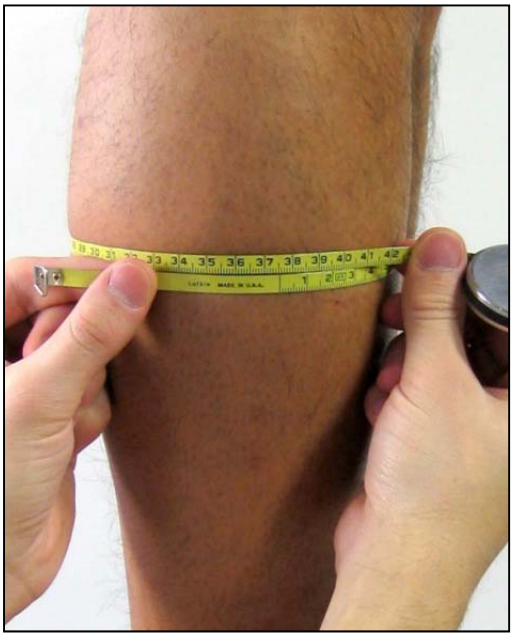


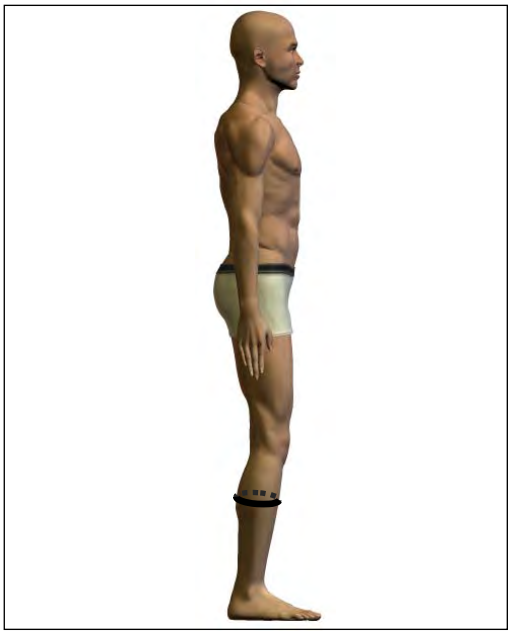
6.4.22 Calf Circumference

DESCRIPTION: The maximum horizontal circumference of the right calf.

PROCEDURE[5]: Participant 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 participant. With a tape held in the horizontal plane measure the circumference of the calf at three locations in the area of observed maximum circumference. Record all three values. Exert only enough tension on the tape to maintain contact between the tape and the skin.

INSTRUMENT: Steel tape.





[5] In ANSUR, the level of the circumference was found by sliding the horizontal tape up and down the thigh until the maximum was achieved. The current procedure is faster and produces equivalent results (Hotzman et al., 2010).

6.4.23 Cervicale Height

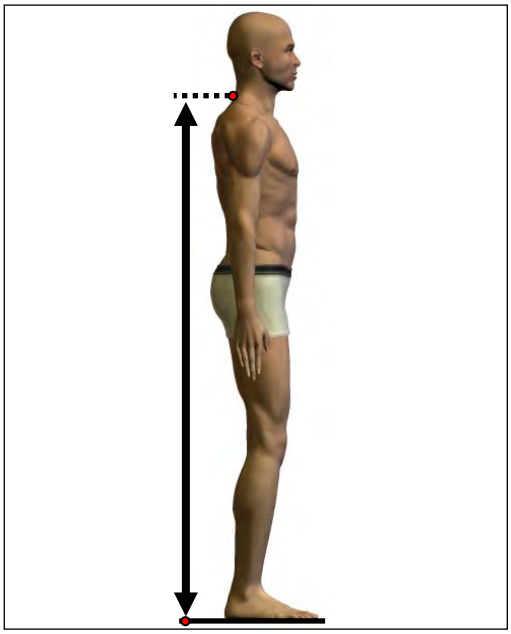
DESCRIPTION: The vertical distance between a standing surface and the cervicale landmark at the base of the neck.

DRAWN LANDMARK: Cervicale.

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

INSTRUMENT: Anthropometer.

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



6.4.24 Chest Breadth

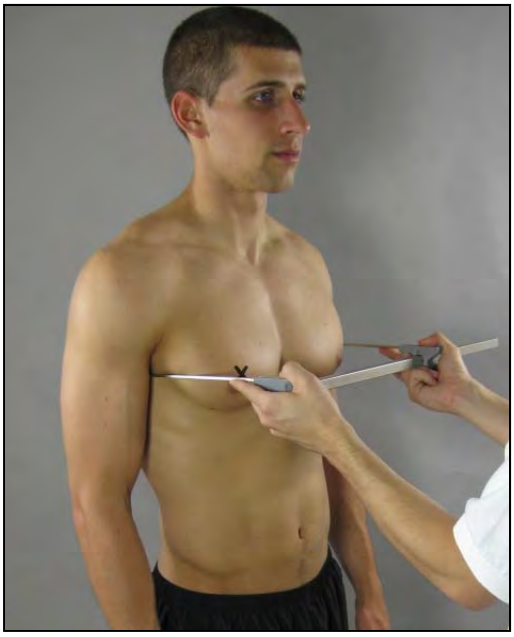
DESCRIPTION: The maximum horizontal breadth of the chest at the level of the chest point anterior landmark[6].

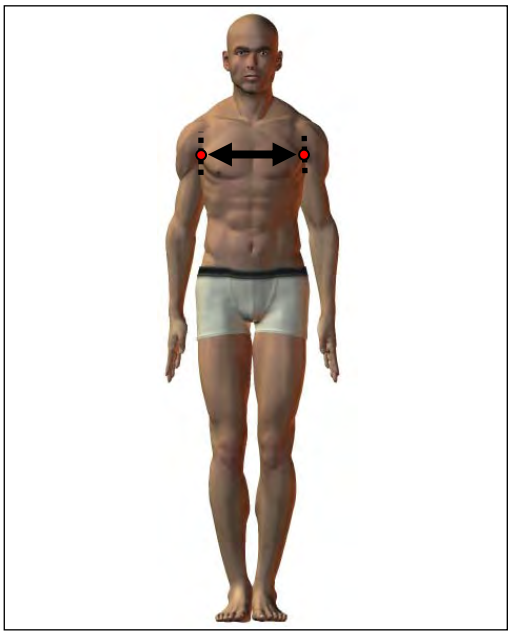
DRAWN LANDMARK: Chest point, anterior, right.

PROCEDURE: Participant stands erect looking straight ahead with the heels together and the weight distributed evenly on both feet. The participant places both hands on the hips. Stand in front of the participant, and ready the beam caliper by lining up the blades at the level of chest point anterior. Ask the participant to take a deep breath and hold it. Compress the tissue firmly to ensure contact with the rib cage, ask the participant to lower the arms, and take the measurement. The measurement is taken at maximum inspiration of the chest at the level of the chest point anterior landmark. On women, the landmark will be an adhesive dot on the bra. Before taking the measurement verify that this landmark has not shifted.

INSTRUMENT: Beam caliper.

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. Additionally, unlike most other dimensions, which are measured at the maximum point of quiet respiration, this dimension is measured at full inspiration.





[6] In ANSUR this measurement was taken (in males) at the level of Thelion (nipple). This change was made in order to capture the breadth of the chest at its maximum. It is unchanged for females.

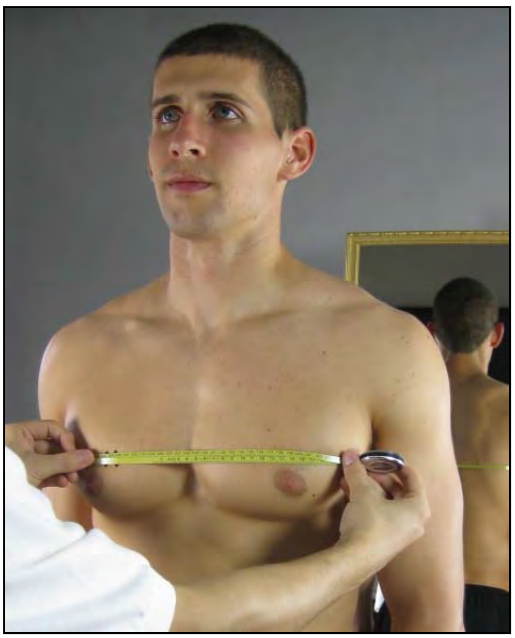
6.4.25 Chest Circumference

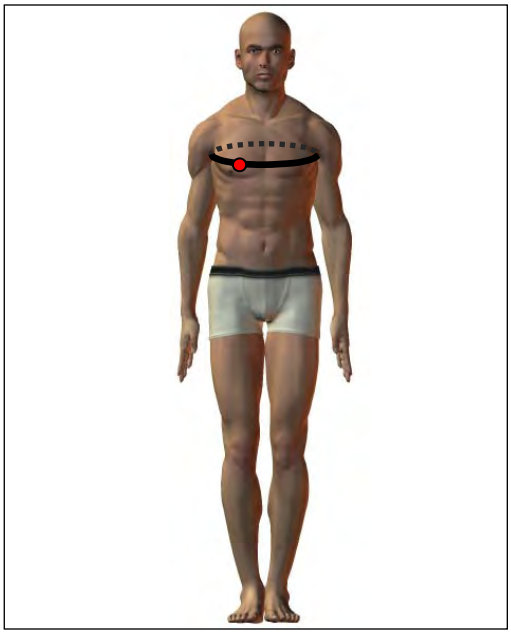
DESCRIPTION: The maximum circumference of the chest at the fullest part of the breast[7].

DRAWN LANDMARK: Chest point, anterior, right.

PROCEDURE: Participant is in the anthropometric standing position in front of a mirror. Stand in front of the participant, and use a tape to measure the horizontal circumference of the chest at the level of the right chest point anterior landmark. On women, the landmark will be an adhesive dot on the bra. Before taking the measurement verify that this landmark has not shifted. Use the mirror to check the position of the tape as it crosses the participant'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.

INSTRUMENT: Steel tape.





[7] In ANSUR this measurement was taken (in males) at the level of Thelion (nipple). This change was made in order to capture the circumference of the chest at its maximum. It is unchanged for females.

6.4.26 Chest Depth

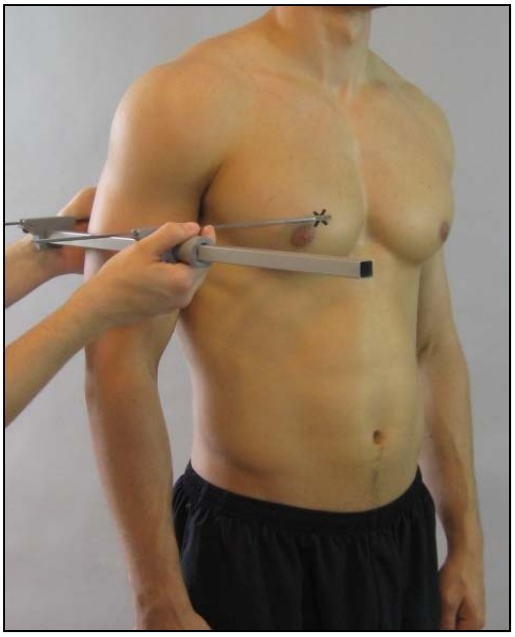
DESCRIPTION: The horizontal distance between the right chest point anterior landmark and the back at the same level[8].

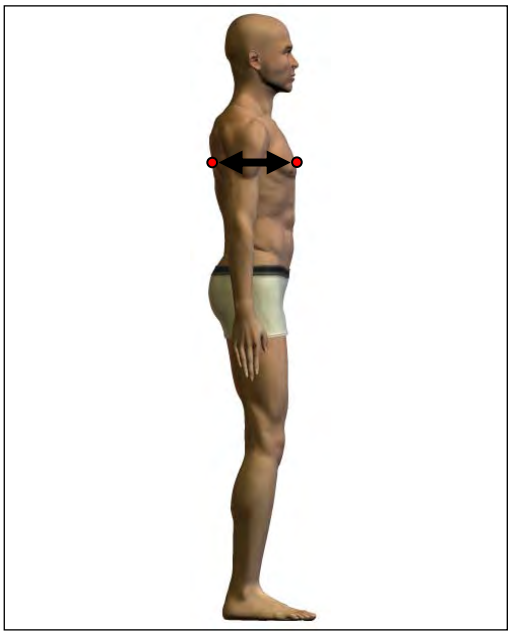
DRAWN LANDMARK: Chest point, anterior, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand at the right of the participant, and use a beam caliper to measure the horizontal distance between the chest at the level of the right chest point anterior landmark and the back at the same level. Place the fixed blade of the caliper on the back. On women, the landmark will be an adhesive dot on the bra. Before taking the measurement verify that this landmark has not shifted. 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).

INSTRUMENT: Beam caliper.

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





[8] In ANSUR this measurement was taken (in males) at the level of Thelion (nipple). This change was made in order to capture the depth of the chest at its maximum. It is unchanged for females.

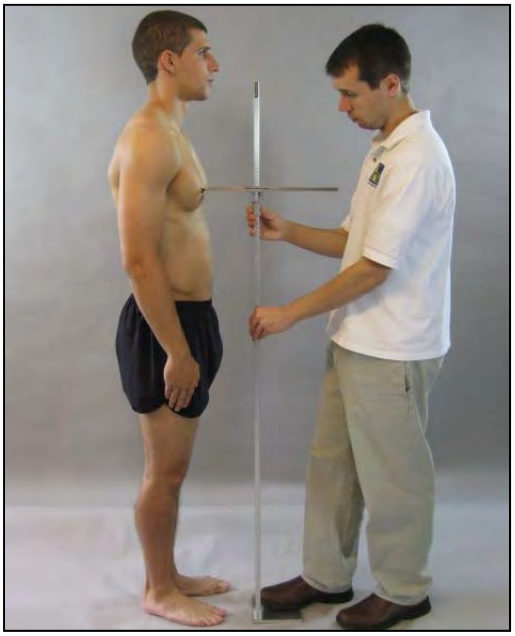
6.4.27 Chest Height

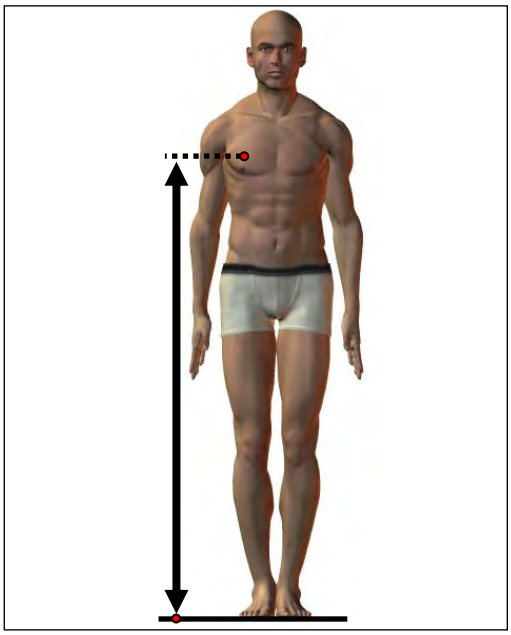
DESCRIPTION: The vertical distance between a standing surface and the right chest point anterior landmark[9].

DRAWN LANDMARK: Chest point, anterior, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant, and use an anthropometer to measure the vertical distance between the standing surface and the right chest point anterior landmark. On women, the landmark will be an adhesive dot on the bra. Before taking the measurement verify that this landmark has not shifted. The measurement is taken at the maximum point of quiet respiration.

INSTRUMENT: Anthropometer.





[9] In ANSUR this measurement was taken (in males) at the level of Thelion (nipple). This change was made in order to capture the height of the chest at its maximum fullness. It is unchanged for females.

6.4.28 Crotch Height

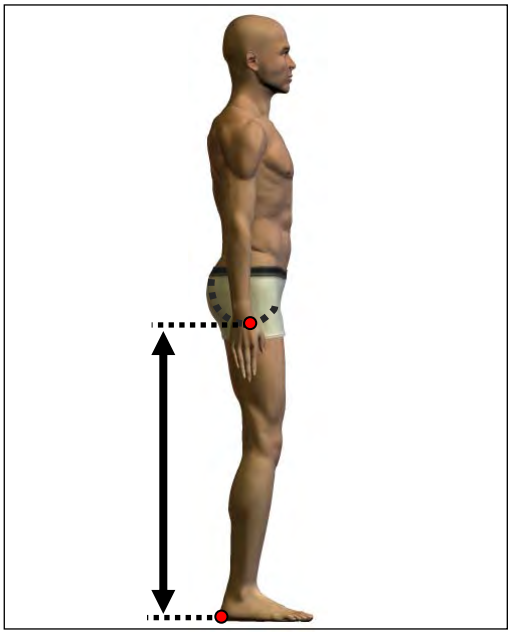
DESCRIPTION: The vertical distance between the standing surface and the crotch.

UNDRAWN LANDMARK: Crotch.

PROCEDURE: Participant stands on a table in the anthropometric standing position. Stand in front of the participant. Ask the participant to spread the legs apart enough to allow placement of the blade of an anthropometer near the crotch. The participant 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.

INSTRUMENT: Anthropometer.

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



6.4.29 Crotch Length (Omphalion)

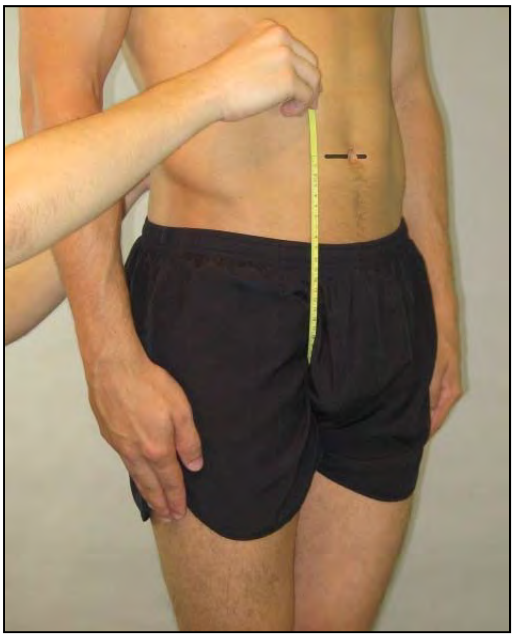
DESCRIPTION: The distance between the abdomen at the level of the center of the navel (omphalion) to the same level on the back.

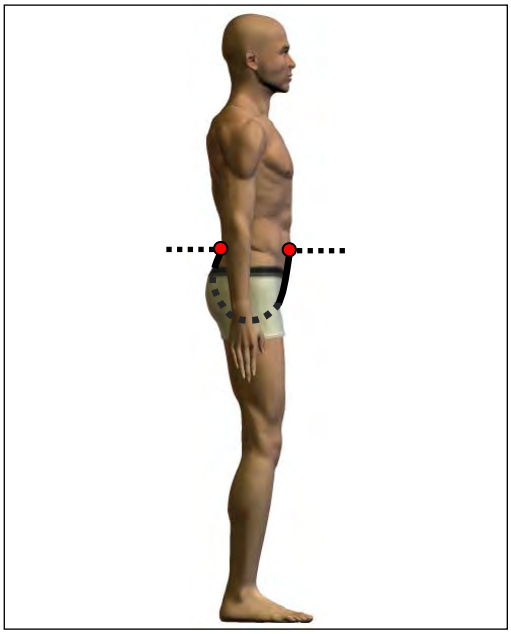
DRAWN LANDMARKS: Waist (omphalion), anterior and posterior.

PROCEDURE: Participant 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 participant brings the heels together for the measurement. Stand at the right of the participant ,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.

INSTRUMENT: Steel tape.

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





6.4.30 Crotch Length, Posterior (Omphalion)

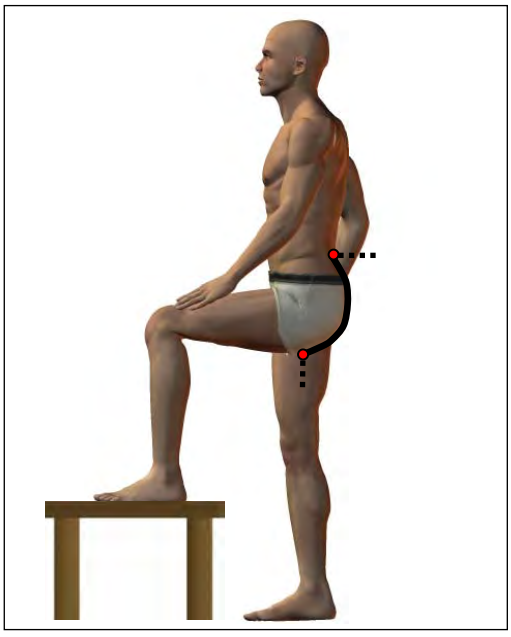
DESCRIPTION: The surface distance from the crotch at the inner thigh landmark to the back of the waist at the level of the center of the navel (omphalion).

DRAWN LANDMARKS: Inner thigh, right; Waist (omphalion), posterior.

PROCEDURE: Participant stands erect with the left foot on a platform so that the knee is flexed. Stand to the left rear of the participant, 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 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.

INSTRUMENT: Modified tape.

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



6.4.31 Ear Breadth

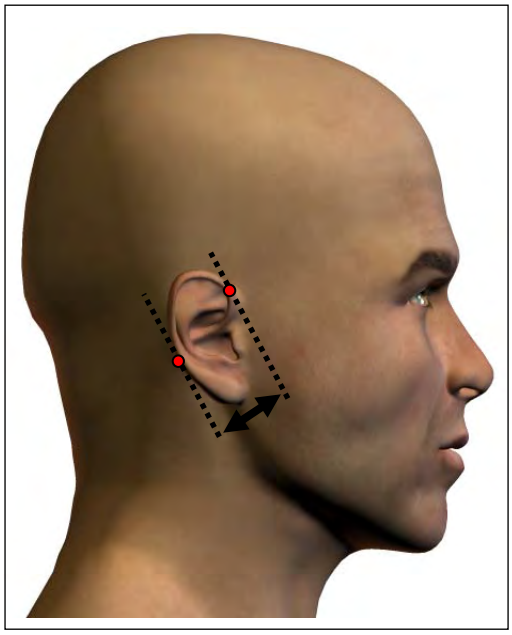
DESCRIPTION: The maximum breadth of the ear between otobasion, superior, and a point on the outside edge of the ear in a line perpendicular to the long axis of the ear.

UNDRAWN LANDMARK: Otobasion, superior.

PROCEDURE: Participant sits looking straight ahead. Stand at the participant'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.

INSTRUMENT: Sliding caliper.

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



6.4.32 Ear Length

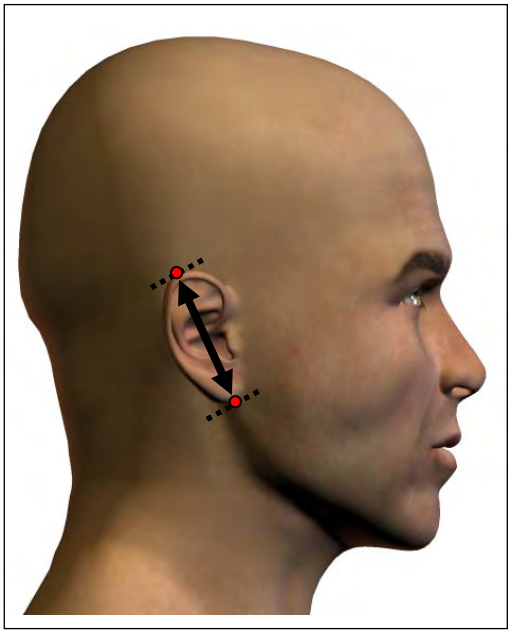
DESCRIPTION: The length of the right ear from its highest to lowest points on a line parallel to the long axis of the ear.

UNDRAWN LANDMARKS: Ear, top and bottom.

PROCEDURE: Participant sits looking straight ahead. Stand at the right of the participant, 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.

INSTRUMENT: Sliding caliper.

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



6.4.33 Ear Protrusion

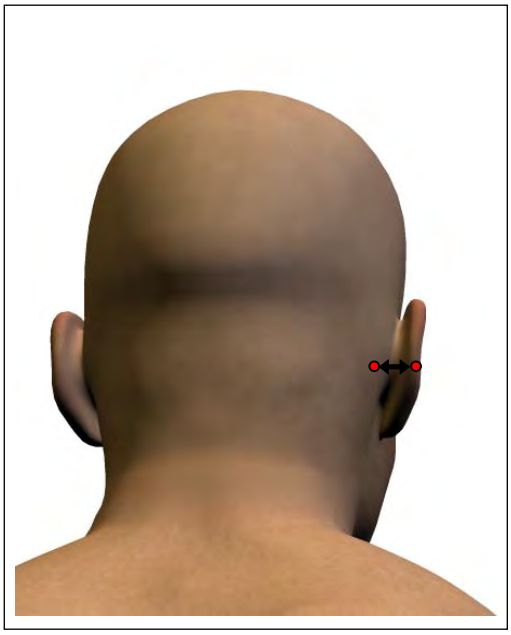
DESCRIPTION: The horizontal distance between the mastoid process and the outside edge of the right ear at its most lateral point (ear point).

UNDRAWN LANDMARK: Ear point.

PROCEDURE: Participant sits looking straight ahead. Stand at the right of the participant, 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 (ear 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.

INSTRUMENT: Sliding caliper.

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



6.4.34 Elbow Rest Height

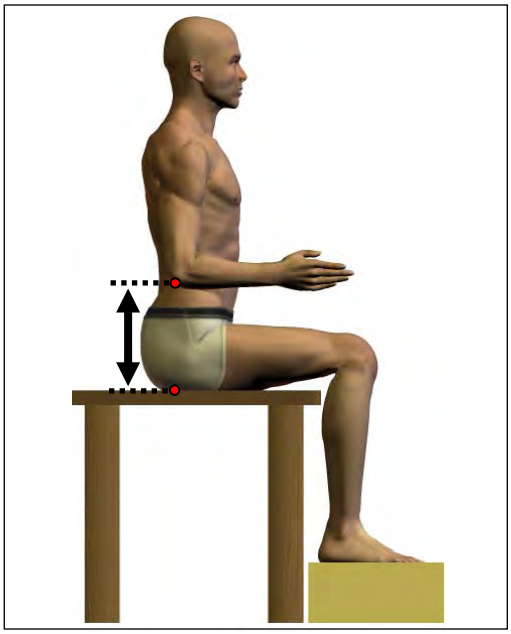
DESCRIPTION: The vertical distance between a sitting surface and the olecranon landmark on the bottom of the flexed right elbow.

UNDRAWN LANDMARK: Olecranon, bottom.

PROCEDURE: Participant is in the anthropometric sitting position. Stand behind the participant, 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.

INSTRUMENT: Anthropometer.

CAUTION: This dimension is difficult to measure with a high degree of reliability. Check the participant'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.



6.4.35 Eye Height, Sitting

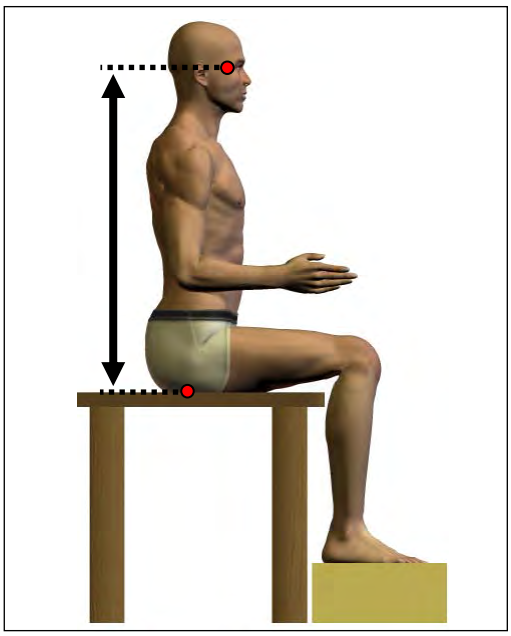
DESCRIPTION: The vertical distance between a sitting surface and the ectocanthus landmark on the outer corner of the right eye.

UNDRAWN LANDMARK: Ectocanthus.

PROCEDURE: Participant is in the anthropometric sitting position with the head in the Frankfurt 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 participant with the blade directed away from the participant. Move the blade to a position approximately level with the participant's eyes. Then swivel it around toward the participant bringing it close to the corner of the eye without actually touching it. On some larger and heavier participants, the anthropometer may have to be brought around to the side or even to the front of the participant in order for the blade to reach the area close to the corner of the eye. Align along the *bottom* of the blade at the level of ectocanthus. The measurement is taken at the maximum point of quiet respiration.

INSTRUMENT: Anthropometer.

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



6.4.36 Foot Breadth, Horizontal

DESCRIPTION: The maximum breadth of the right foot.

DRAWN LANDMARKS: First metatarsophalangeal protrusion, right; fifth metatarsophalangeal protrusion, right.

PROCEDURE: Participant stands erect on a table with the right foot on the Brannock device and the left foot on a board of equal height. The weight is distributed equally on both feet. Stand to the right side of the participant and make sure the back of the heel (pternion) is lightly touching the back of the device and that the long axis of the foot is in line with the long axis of the device. Move the point of the “vertical” slide to the level of the drawn landmark on the first metatarsophalangeal protrusion. When the foot is correctly positioned, measure the maximum breadth of the foot by moving the ‘horizontal’ slide until it is just touching the side of the foot. Read the measurement at that point from the device scale.

INSTRUMENTS: Brannock device.

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

6.4.37 Foot Length

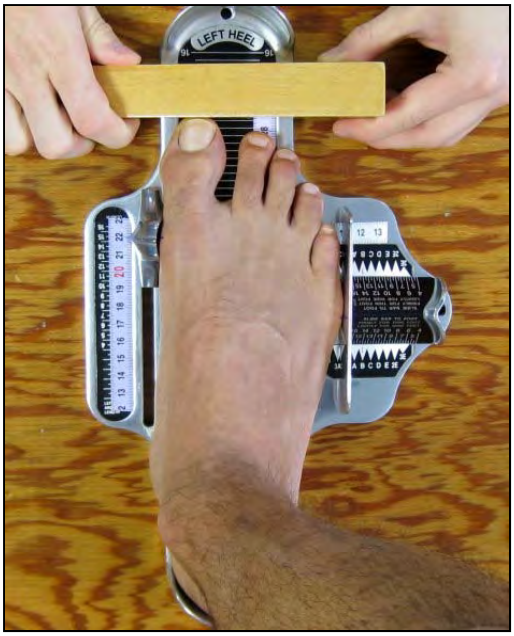
DESCRIPTION: The maximum length of the right foot.

UNDRAWN LANDMARKS: Acropodion; Pternion.

PROCEDURE: Participant stands erect on a table with the right foot on the Brannock device and the left foot on a board of equal height. The weight is distributed equally on both feet. Stand to the right side of the participant, and make sure the back of the heel (pternion) is lightly touching the back of the device and that the long axis of the foot is in line with the long axis of the device. When the foot is correctly positioned, measure the length of the foot by placing a block against the tip of the longest toe (acropodion) to establish the length of the foot. Use only enough pressure to ensure that the block touches the toe. Read the measurement at that point from the device scale.

INSTRUMENTS: Brannock device; block.

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



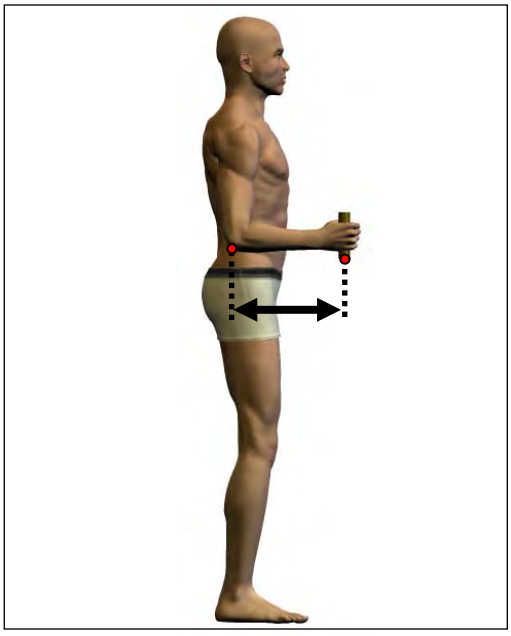
6.4.38 Forearm-Center of Grip Length

DESCRIPTION: The horizontal distance between the back of the tip of the right elbow (olecranon, rear) to the center of a 1-1/4” diameter dowel gripped in the right hand.

UNDRAWN LANDMARK: Olecranon, rear.

PROCEDURE: Participant stands erect with the upper arms hanging at the side and the right elbow flexed 90°. The hand grips a 1-1/4” diameter dowel placed on the fixed blade of a beam caliper. The hand gripping the dowel should be in line with the long axis of the arm; typically this requires gripping the dowel at the bottom. Stand to the right of the participant and use the beam caliper to measure the horizontal distance between the back of the tip of the elbow (olecranon, rear) to center of the dowel. Place the movable blade on olecranon, rear. Exert only enough pressure to attain contact between the caliper and the skin. Be sure that the dowel remains vertical.

INSTRUMENT: Beam caliper; 1-1/4” diameter dowel.



6.4.39 Forearm Circumference, Flexed

DESCRIPTION: The circumference at the elbow crease of the flexed right forearm.

UNDRAWN LANDMARK: Elbow crease.

PROCEDURE: Participant stands with the upper arm extended forward horizontally, the elbow flexed 90°, and the fist tightly clenched. Stand at the right of the participant, 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.

INSTRUMENT: Steel tape.

CAUTION: Urge the participant to clench the fist tightly.

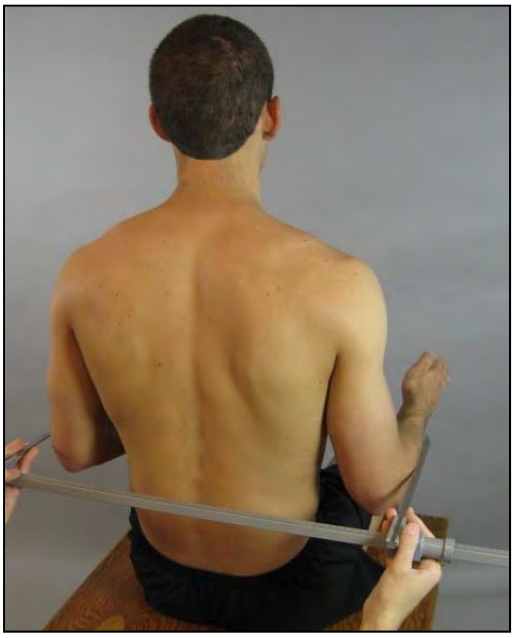
6.4.40 Forearm-Forearm Breadth

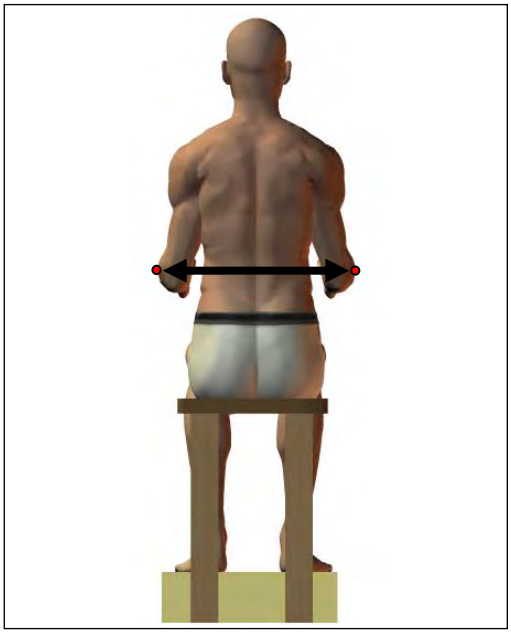
DESCRIPTION: The maximum horizontal distance between the outer sides of the forearms.

PROCEDURE: Participant is in the anthropometric sitting position. Stand behind the participant, 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.

INSTRUMENT: Beam caliper.

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





6.4.41 Forearm-Hand Length

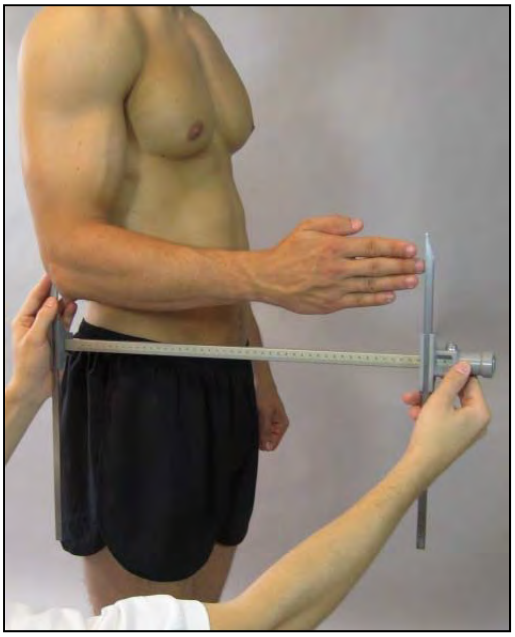
DESCRIPTION: The horizontal distance between the back of the tip of the right elbow to the tip of the right middle finger.

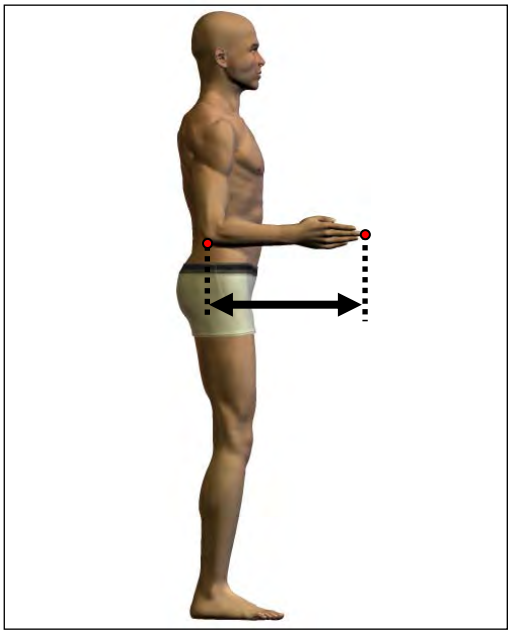
UNDRAWN LANDMARKS: Olecranon, rear; Dactylion III, right.

PROCEDURE: Participant stands erect with the upper arms hanging at the side and the right elbow flexed 90°. The hand is held out straight with the palm facing inward. Stand to the right of the participant, 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.

INSTRUMENT: Beam caliper.

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





6.4.42 Functional Leg Length

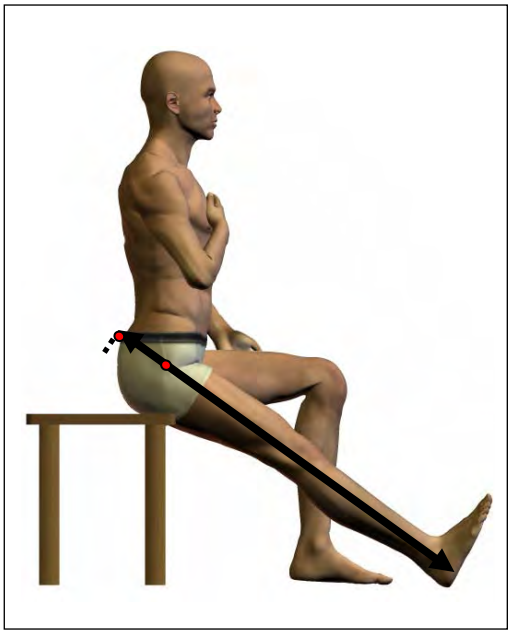
DESCRIPTION: The straight-line distance between the plane of the bottom of the right foot with the leg extended and the back of the body of a seated participant.

DRAWN LANDMARK: Trochanter.

PROCEDURE: Participant sits erect on the edge of a seat that is approximately 45.8 cm tall with the trochanter 10 cm from the front of the seat, the right leg extended, and the foot on the base plate of an anthropometer, which rests on the floor. The participant bends the left leg approximately 90° to enhance stability. Stand at the right of the participant 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.

INSTRUMENT: Anthropometer.

CAUTION: Urge the participant to fully extend the knee. Be sure that the anthropometer is properly aligned with the trochanter landmark. Be sure the participant has his or her hips parallel to the edge of the bench. The computer will subtract 10 mm to eliminate the thickness of the anthropometer base.



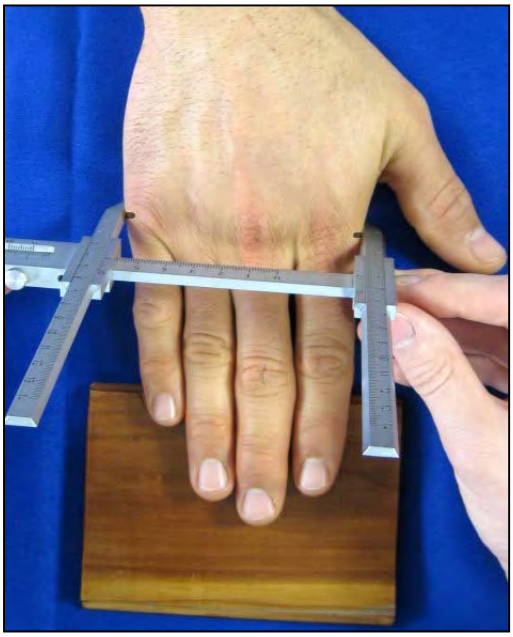
6.4.43 Hand Breadth

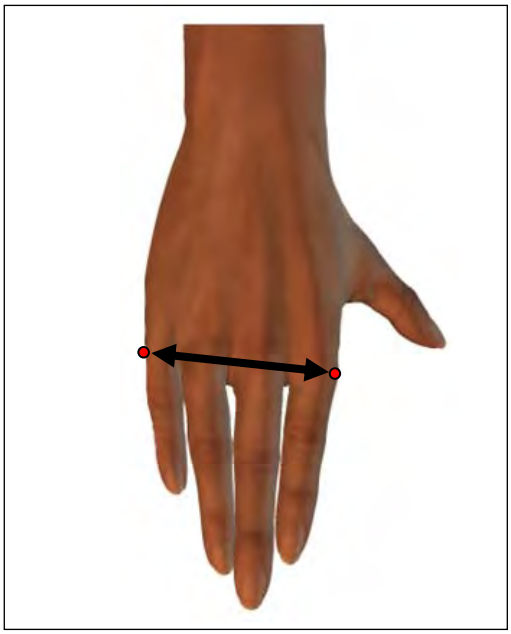
DESCRIPTION: The breadth of the right hand between the landmarks at metacarpale II and metacarpale V.

DRAWN LANDMARKS: Metacarpale II, right; Metacarpale V, right.

PROCEDURE: Participant sits with the palm on a table and the distal 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° angle. The measurer presses the hand into firm contact with the table and instructs the participant to hold this position. The middle finger is parallel to the long axis of the forearm. Stand in front of the participant, 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.

INSTRUMENT: Sliding caliper.





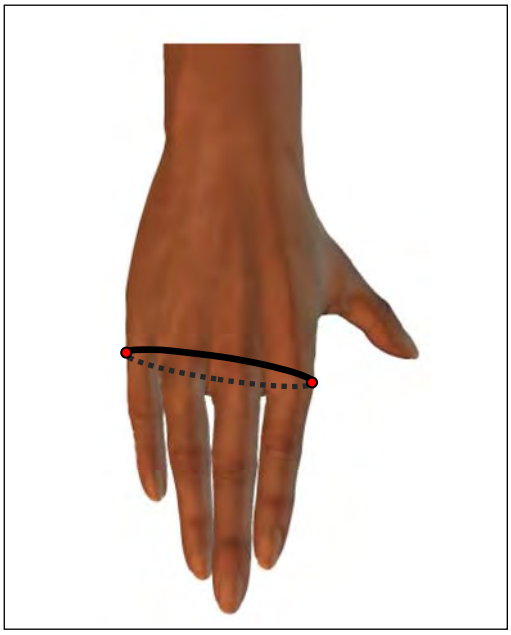
6.4.44 Hand Circumference

DESCRIPTION: The circumference of the right hand encompassing the landmarks metacarpale II and metacarpale V.

DRAWN LANDMARKS: Metacarpale II, right; Metacarpale V, right.

PROCEDURE: Participant sits with the palm on a table and the distal 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° angle. The measurer presses the hand into firm contact with the table and instructs the participant 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 participant. Stand in front of the participant, 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.

INSTRUMENT: Steel tape.



6.4.45 Hand Length

DESCRIPTION: The length of the right hand between the stylion landmark on the wrist and the tip of the middle finger (dactylion III).

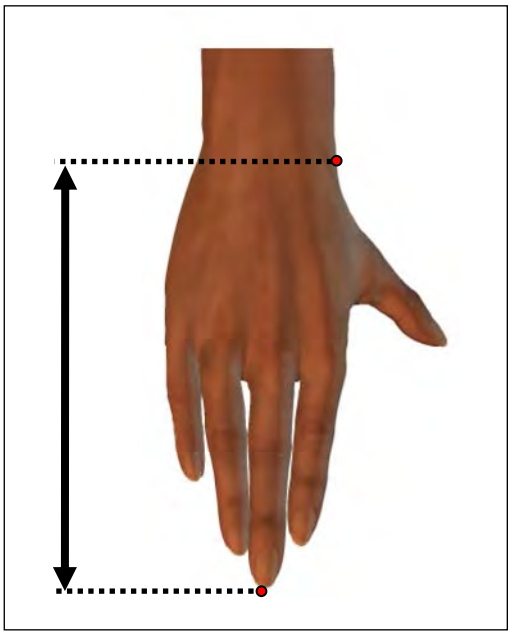
DRAWN LANDMARK: Stylion.

UNDRAWN LANDMARK: Dactylion III, right.

PROCEDURE: Participant sits with the palm on a table and the distal 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° angle. The measurer presses the hand into firm contact with the table and instructs the participant to hold this position. The middle finger is parallel to the long axis of the forearm. Stand at the left of the participant, 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.

INSTRUMENT: Poech sliding caliper.

CAUTION: Participant must not be allowed to flex or hyperextend. Be sure the measurement is taken at the tip of the finger and not the nail.



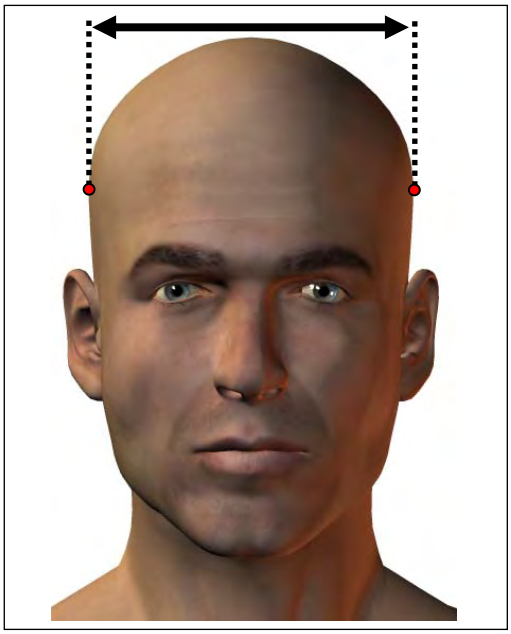
6.4.46 Head Breadth

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

UNDRAWN LANDMARKS: Euryon, right and left.

PROCEDURE: Participant sits. Stand behind the participant, and use a spreading caliper to measure the maximum horizontal breadth of the head above the ears (euryon, right and left). Exert sufficient pressure to obtain contact between the caliper and the skin.

INSTRUMENT: Spreading caliper.



6.4.47 Head Circumference

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

PROCEDURE: Participant sits. Stand to the right of the participant, 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.

INSTRUMENT: Steel tape.

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.

6.4.48 Head Length

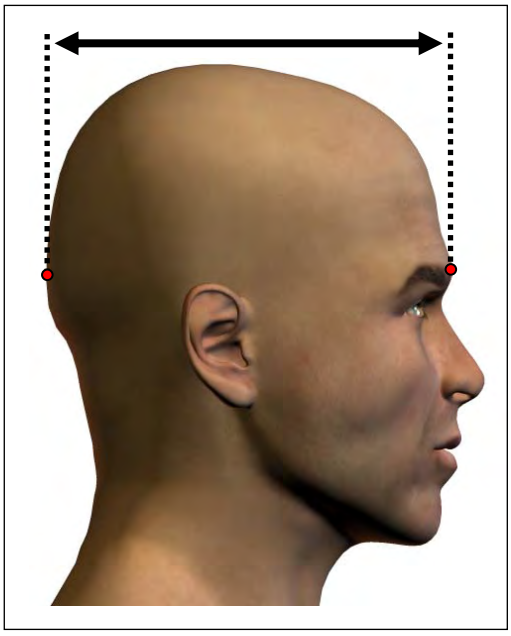
DESCRIPTION: The distance from the glabella landmark between the brow ridges to opisthocranion.

DRAWN LANDMARK: Glabella.

UNDRAWN LANDMARK: Opisthocranion.

PROCEDURE: Participant sits. Stand at the right of the participant. Use a spreading caliper to measure in the midsagittal plane, the distance between the glabella landmark and opisthocranion. 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 on opisthocranion to compress the hair.

INSTRUMENT: Spreading caliper.



6.4.49 Heel-Ankle Circumference

DESCRIPTION: The circumference of the right foot encompassing the right ankle and base of the heel.

DRAWN LANDMARK: Dorsal juncture of the foot and leg, right.

PROCEDURE: Participant stands on a table with the feet about 10 cm apart and the weight distributed equally on both feet. Stand in front of the participant, 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.

INSTRUMENT: Steel tape.

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

6.4.50 Heel Breadth

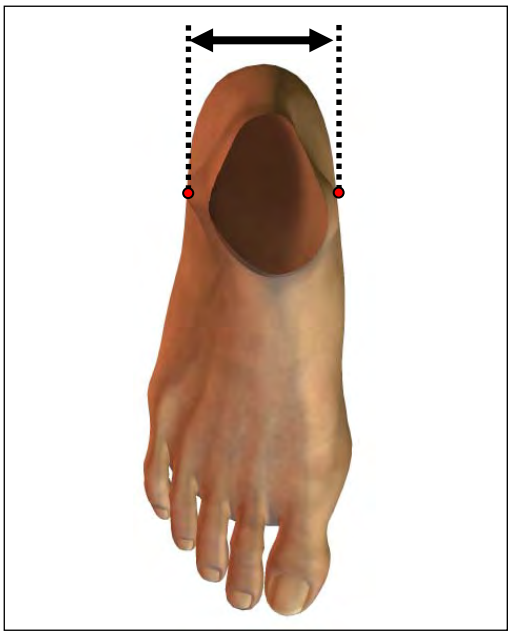
DESCRIPTION: The maximum horizontal distance between the medial and lateral points on the inside and outside of the right heel, at or posterior to the lateral malleolus landmark.

UNDRAWN LANDMARKS: Heel point, lateral and medial.

PROCEDURE: Participant 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 participant, 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.

INSTRUMENT: Holtain caliper.

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



6.4.51 Hip Breadth

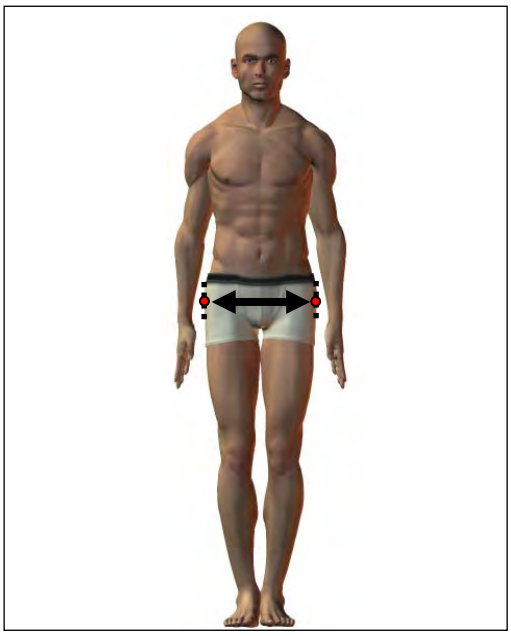
DESCRIPTION: The horizontal distance between the lateral buttock landmarks on the sides of the hips.

DRAWN LANDMARKS: Buttock point, right lateral and left lateral.

PROCEDURE: Participant is in the anthropometric standing position with the arms held slightly away from the body. Stand in front of the participant, and use a beam caliper to measure the horizontal distance between the drawn lateral buttock landmarks. If necessary, have the participant hold the sides of the shorts above the landmarks. Exert only enough pressure to ensure that the caliper blades are on the hips.

INSTRUMENT: Beam caliper.

CAUTION: Make sure participants do not pull soft tissue when they hold up their shorts.



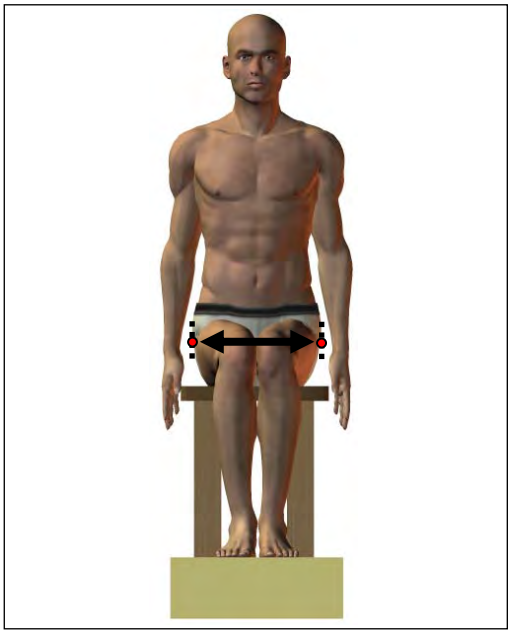
6.4.52 Hip Breadth, Sitting

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

PROCEDURE: Participant sits erect with the feet and knees together and the arms relaxed at the sides. Stand in front of the participant, 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° 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.

INSTRUMENT: Beam caliper.

CAUTION: The recorder should help the participant hold the knees together. Make sure the participant's torso is still erect immediately prior to taking the measurement.



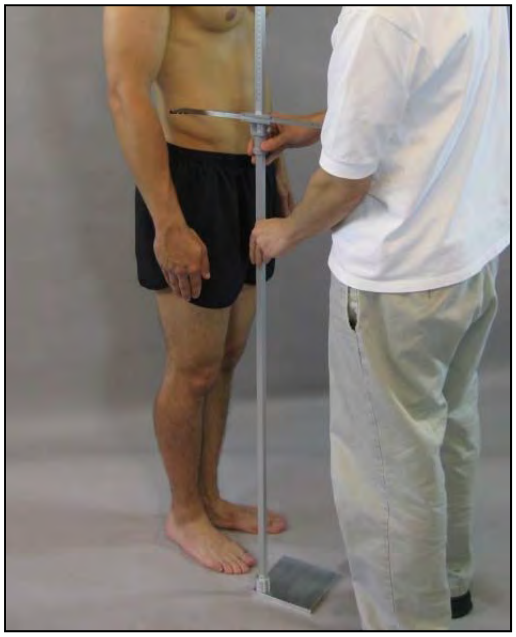
6.4.53 Iliocristale Height

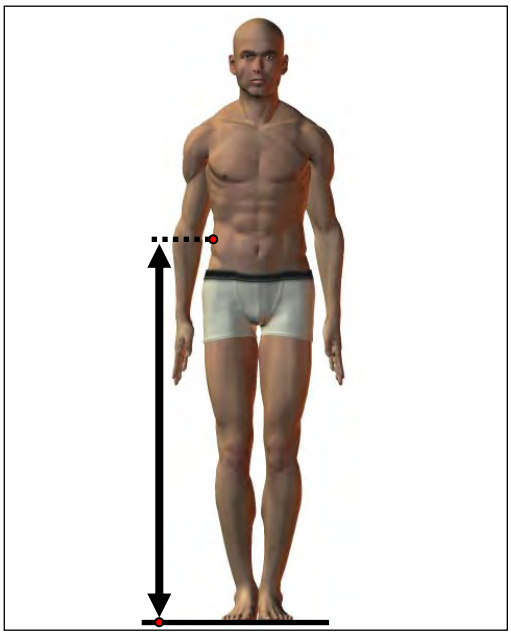
DESCRIPTION: The vertical distance between a standing surface and the iliocristale landmark on the right side of the pelvis.

DRAWN LANDMARK: Iliocristale, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant, and use an anthropometer to measure the vertical distance between the standing surface and the drawn iliocristale landmark on the right side of the pelvis.

INSTRUMENT: Anthropometer.





6.4.54 Interpupillary Breadth

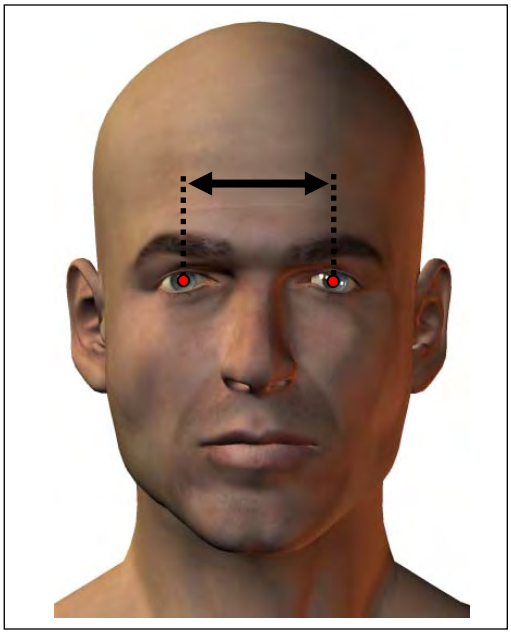
DESCRIPTION: The distance between the centers of the right and left pupils.

UNDRAWN LANDMARKS: Center of pupil, right and left.

PROCEDURE: Participant sits. Stand in front of the participant, and use a pupillometer to measure the distance between the two pupils. Move the lever on the top of the device all the way to the right. Ask the participant 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. Remove the device from the participant's face, and read the measurement from the middle of the three scales on the bottom of the pupillometer.

INSTRUMENT: Pupillometer.

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



6.4.55 Interscye l

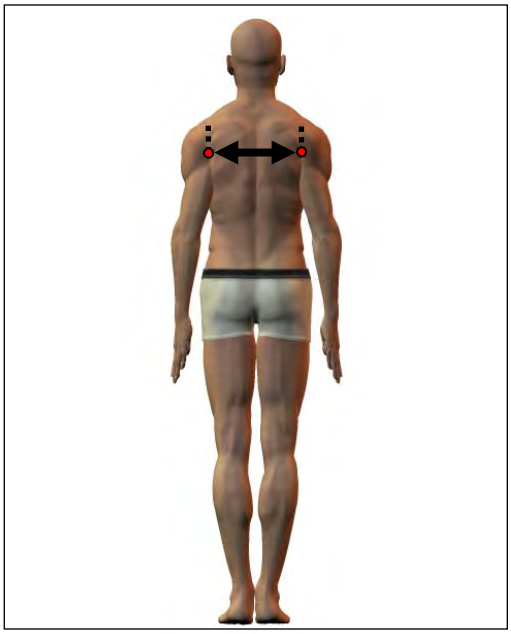
DESCRIPTION: The distance across the back between the right and left posterior axillary fold landmarks.

DRAWN LANDMARKS: Axillary fold, right posterior and left posterior.

PROCEDURE: Participant is in the anthropometric standing position. Stand behind the participant, 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.

INSTRUMENT: Steel tape.

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



6.4.56 Interscye II

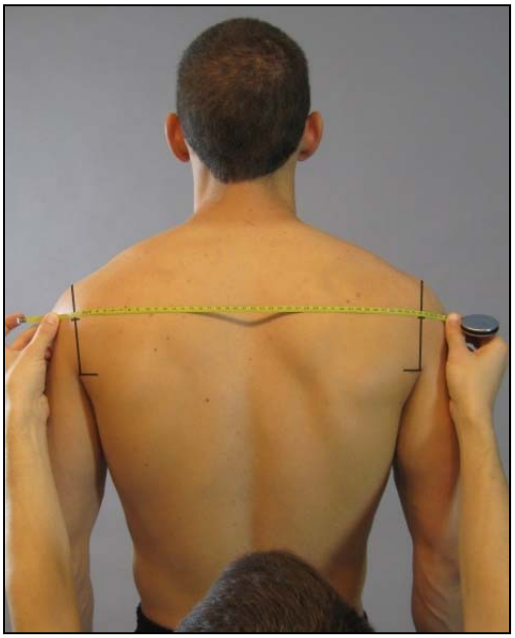
DESCRIPTION: The distance across the back between the right and left midscye landmarks.

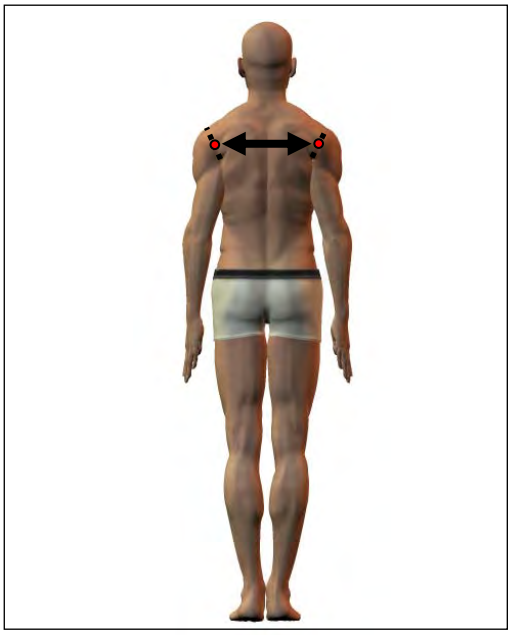
DRAWN LANDMARKS: Midscye, right and left.

PROCEDURE: Participant is in the anthropometric standing position. Stand behind the participant, 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.

INSTRUMENT: Steel tape.

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





6.4.57 Knee Height, Midpatella

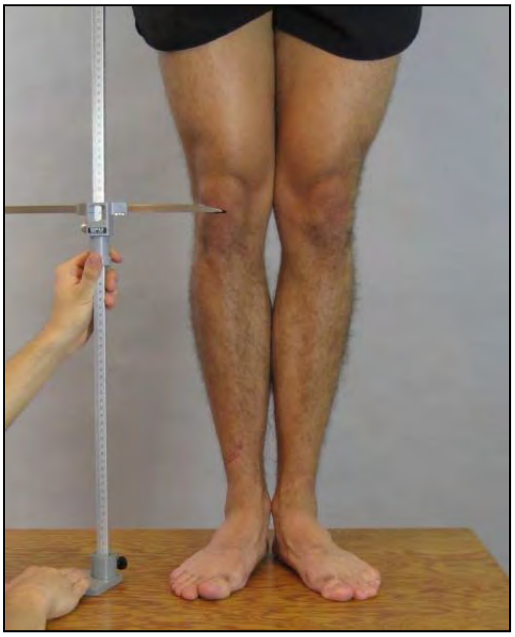
DESCRIPTION: The vertical distance between a standing surface and the midpatella landmark.

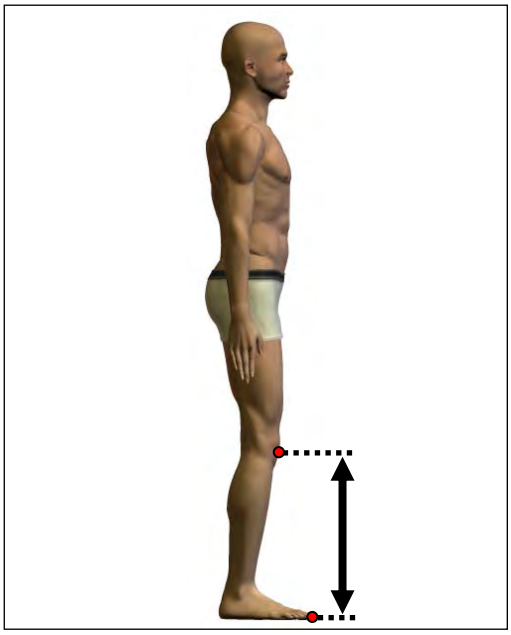
DRAWN LANDMARK: Midpatella, right.

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

INSTRUMENT: Anthropometer.

CAUTION: Participants will tend to lock their knees. If participants 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.





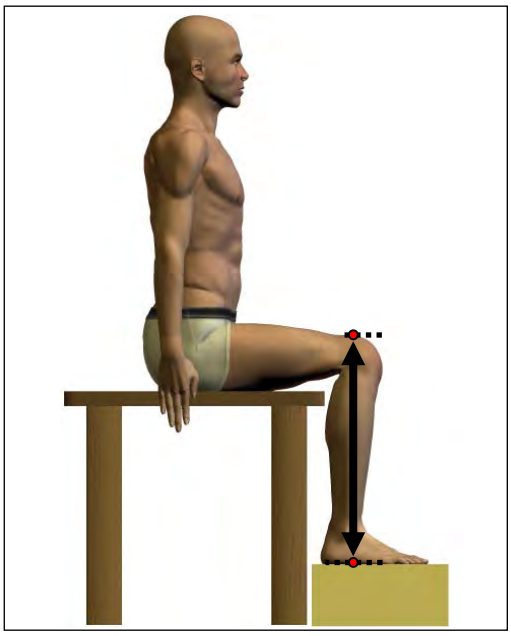
6.4.58 Knee Height, Sitting

DESCRIPTION: The vertical distance between a footrest surface and the suprapatella landmark.

DRAWN LANDMARK: Suprapatella, right.

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

INSTRUMENT: Anthropometer.



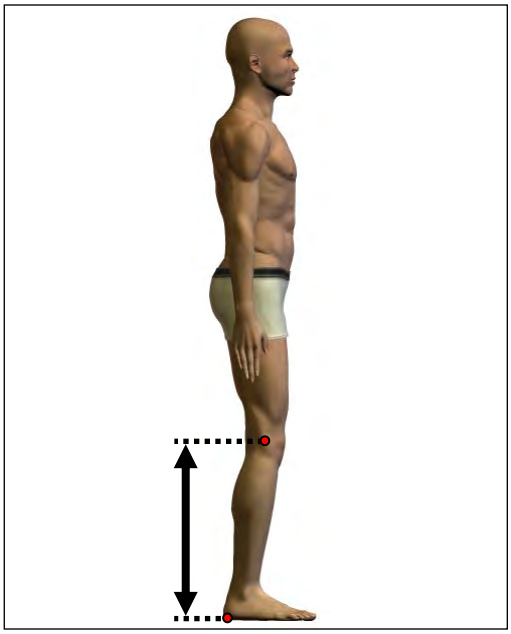
6.4.59 Lateral Femoral Epicondyle Height

DESCRIPTION: The vertical distance between a standing surface and the standing lateral femoral epicondyle landmark.

DRAWN LANDMARK: Lateral femoral epicondyle, standing, right.

PROCEDURE: Participant stands erect on a table with the heels together and the weight distributed equally on both feet. Stand at the right side of the participant, 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.

INSTRUMENT: Anthropometer.



6.4.60 Lateral Malleolus Height

DESCRIPTION: The vertical distance between a standing surface and the lateral malleolus landmark.

DRAWN LANDMARK: Lateral malleolus, right.

PROCEDURE: Participant stands erect on a table with the heels together and the weight distributed equally on both feet. Stand at the right of the participant, and use a height gauge to measure the vertical distance between the standing surface and the drawn lateral malleolus landmark on the outside of the right ankle.

INSTRUMENT: Modified height gauge.

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

6.4.61 Lower Thigh Circumference

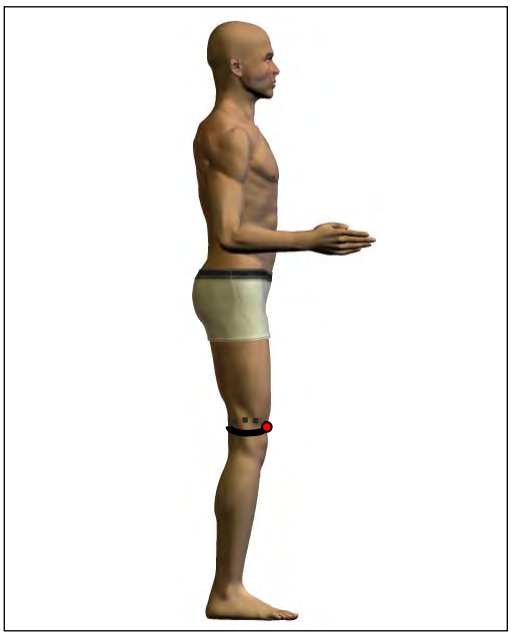
DESCRIPTION: The horizontal circumference of the right thigh at the level of the suprapatella landmark.

DRAWN LANDMARK: Suprapatella, right.

PROCEDURE: Participant 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 participant, 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.

INSTRUMENT: Steel tape.

CAUTION: Participants will tend to lock their knees. If participants 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.



6.4.62 Menton-Sellion Length

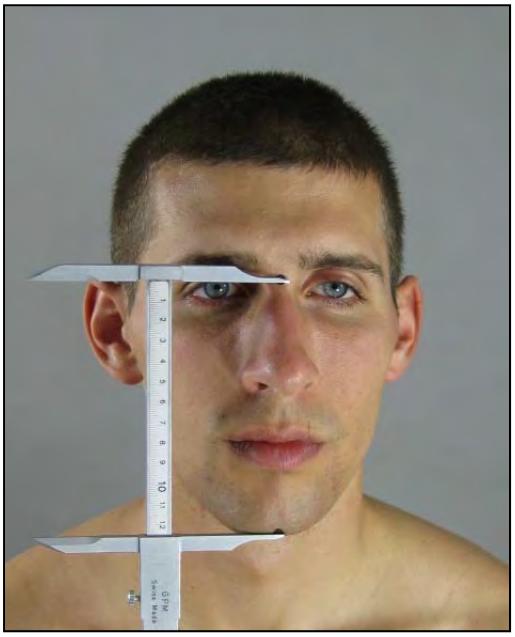
DESCRIPTION: The distance between the menton landmark and the sellion landmark in the midsagittal plane.

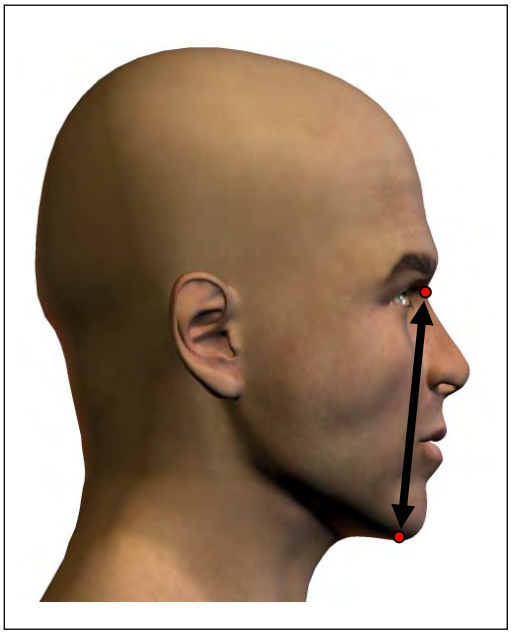
DRAWN LANDMARKS: Menton; Sellion.

PROCEDURE: Participant sits. The teeth are together, but not clenched. Stand toward the right of the participant, 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.

INSTRUMENT: Sliding caliper.

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





6.4.63 Neck Circumference

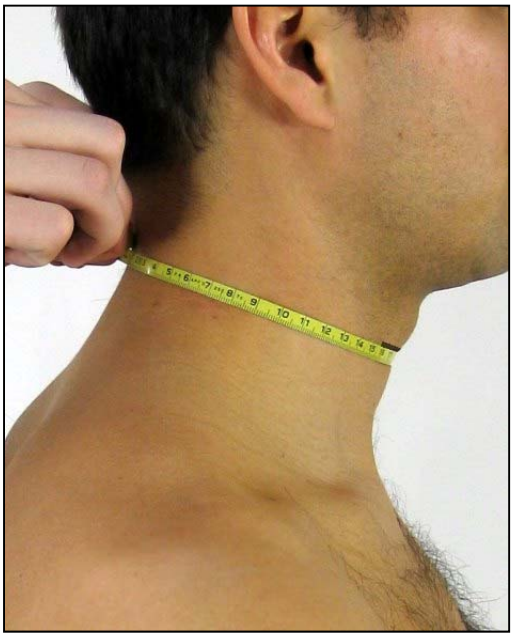
DESCRIPTION: The circumference of the neck at the level of the infrathyroid landmark (Adam's apple).

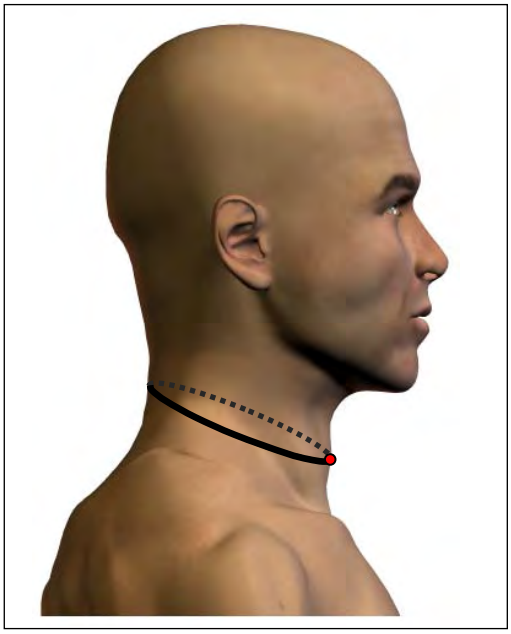
DRAWN LANDMARK: Infrathyroid.

PROCEDURE: Participant is in the anthropometric standing position with the head in the Frankfurt plane. Stand at the right of the participant, and use a tape to measure the circumference of the neck at the level of the drawn infrathyroid landmark. 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.

INSTRUMENT: Steel tape.

CAUTION: Be sure that the participant's head is in the Frankfurt plane.





6.4.64 Neck Circumference, Base

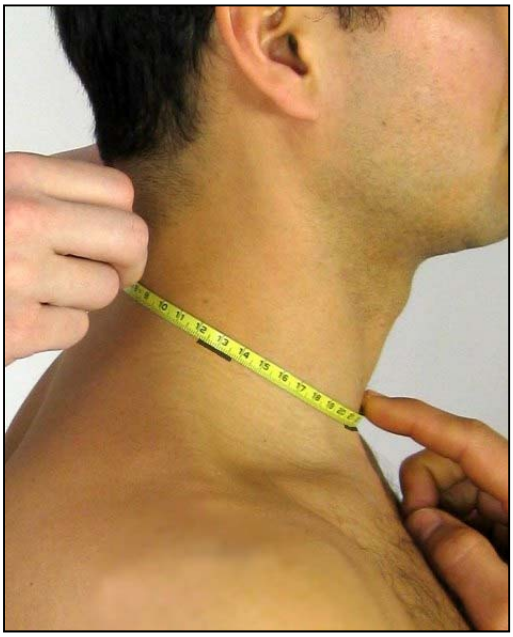
DESCRIPTION: The circumference of the base of the neck encompassing the lateral neck and anterior neck landmarks.

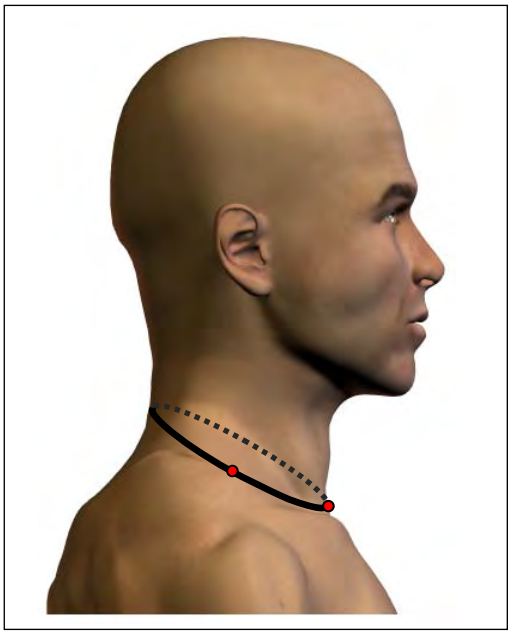
DRAWN LANDMARKS: Neck, anterior, right lateral, and left lateral.

PROCEDURE: Participant is in the anthropometric standing position with the head in the Frankfurt plane. Stand behind the participant, 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 participant will hold the tape on the anterior neck landmark.

INSTRUMENT: Steel tape.

CAUTION: Be sure that the participant's head is in the Frankfurt plane.





6.4.65 Overhead Fingertip Reach, Sitting

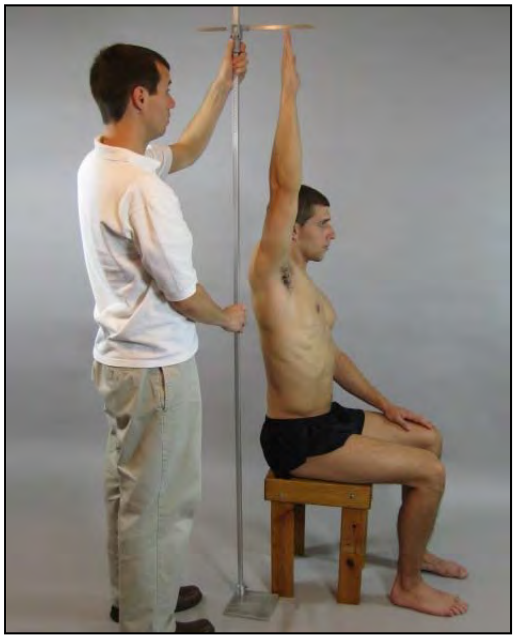
DESCRIPTION: The vertical distance between a sitting surface and the tip of the right middle finger of a seated participant whose arm is extended overhead.

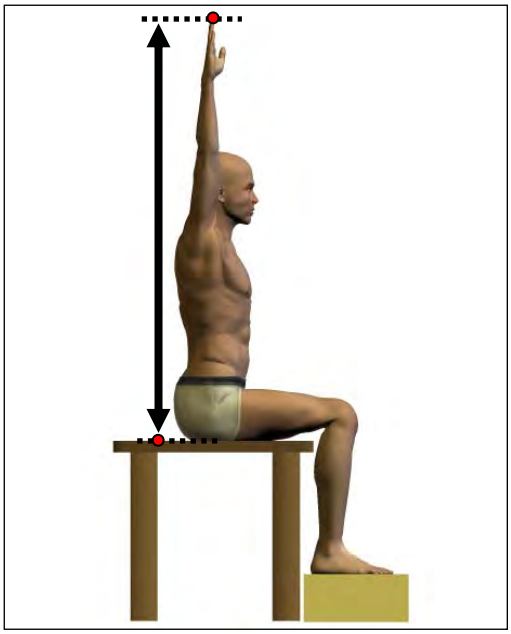
UNDRAWN LANDMARK: Dactylion III, right.

PROCEDURE: Participant sits erect on a flat surface with the right arm, hand extended vertically overhead as far as possible, and the palm of the hand facing forward. Grasp the participant's wrist to guide the arm into a vertical position. Some participants 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. Stand at the right of the participant, and use an anthropometer to measure the 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.

INSTRUMENT: Anthropometer.

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





6.4.66 Palm Length

DESCRIPTION: The distance between the center of the crease at the base of the middle finger (digit III, base) and the ventral stylion landmark on the right wrist.

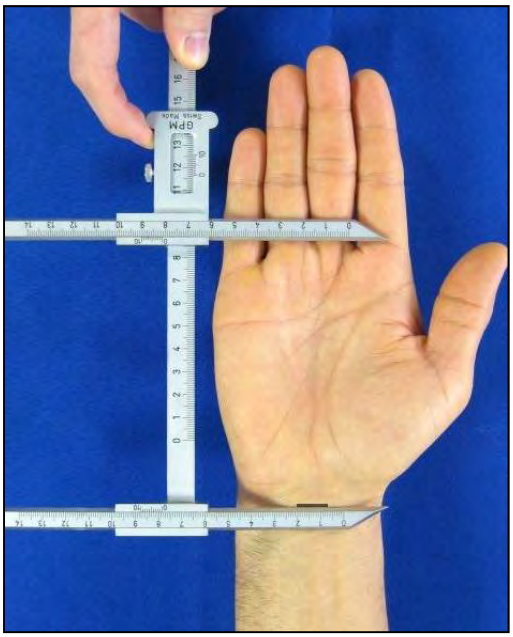
DRAWN LANDMARK: Ventral stylion.

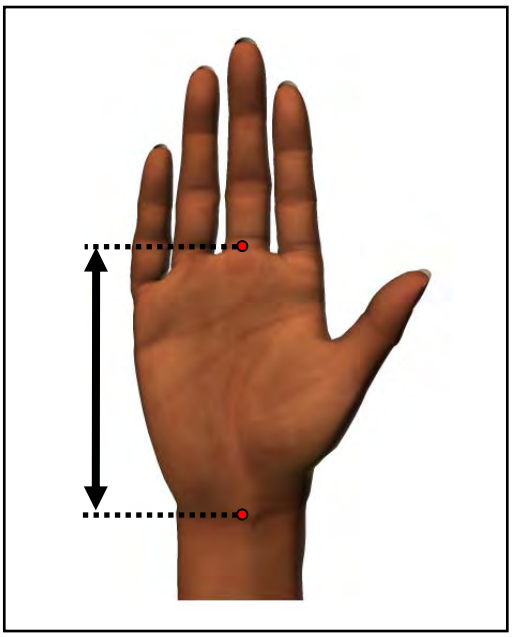
UNDRAWN LANDMARK: Digit III, base.

PROCEDURE: The participant holds the right forearm horizontal with the hand straight, palm up. The fingers are together, and the thumb is abducted approximately 45°. The middle finger is parallel to the long axis of the forearm. Stand at the left of the participant, and use a Poech sliding caliper to measure the perpendicular distance between the center of the crease at the base of the finger (digit III, base) and the ventral stylion landmark on the wrist. Place the fixed blade of the caliper at the base of the finger. The beam of the caliper is parallel to the long axis of the arm.

INSTRUMENT: Poech sliding caliper.

CAUTION: Participant must not be allowed to flex or hyperextend the fingers or the hand. If there are multiple creases at the base of digit III, choose the most proximal crease.





6.4.67 Popliteal Height

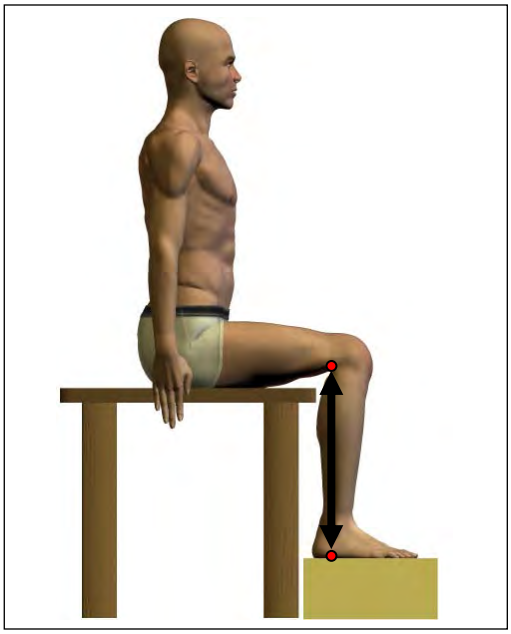
DESCRIPTION: The vertical distance from a footrest to the back of the right knee (the popliteal fossa at the dorsal juncture of the calf and thigh).

UNDRAWN LANDMARK: Popliteal fossa at the dorsal juncture of the calf and thigh.

PROCEDURE: Participant sits with the thighs parallel, the knees flexed 90°. The feet are in line with the thighs, and the arms are relaxed at the sides. Stand to the right of the participant, 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).

INSTRUMENT: Anthropometer.

CAUTION: Take care that the blade of the anthropometer does not compress the thigh tissue (compressing the calf is OK). 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.



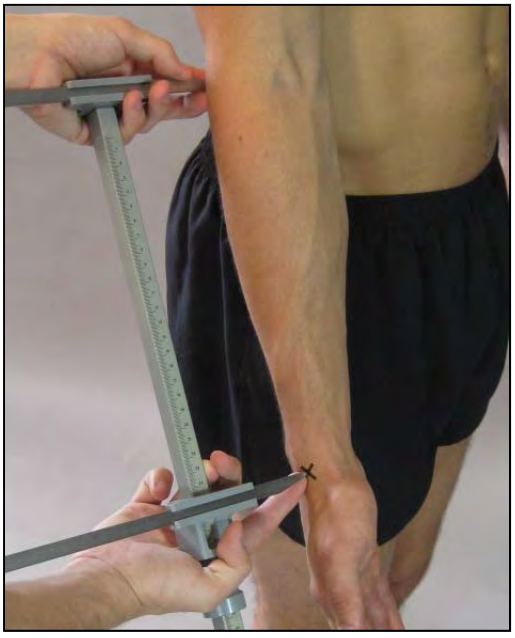
6.4.68 Radiale-Stylion Length

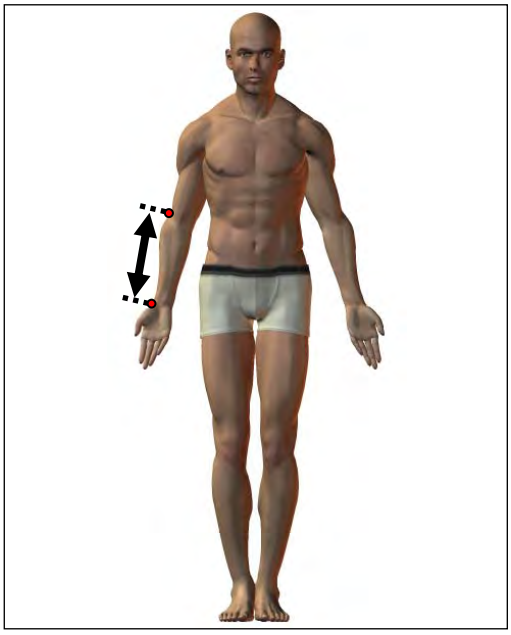
DESCRIPTION: The distance between the radiale landmark on the right elbow and the stylion landmark on the right wrist.

DRAWN LANDMARKS: Radiale; Stylion.

PROCEDURE: Participant stands with the arms relaxed at the sides and the right palm facing forward. Stand at the right of the participant 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.

INSTRUMENT: Beam caliper.





6.4.69 Shoulder Circumference

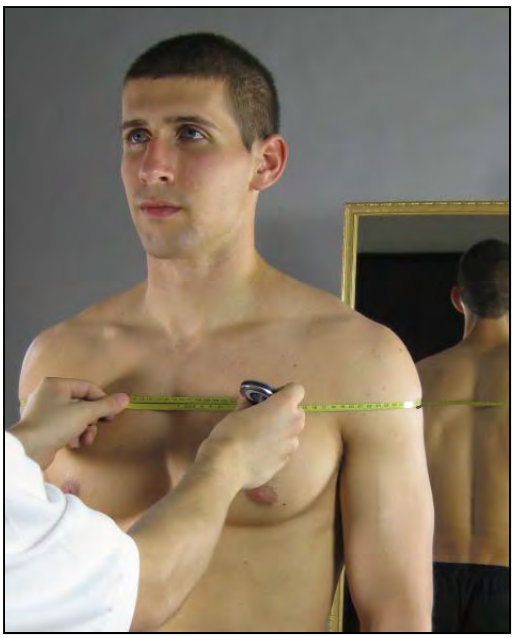
DESCRIPTION: The circumference of the shoulders at the level of the midpoints of the right and left deltoid muscles.

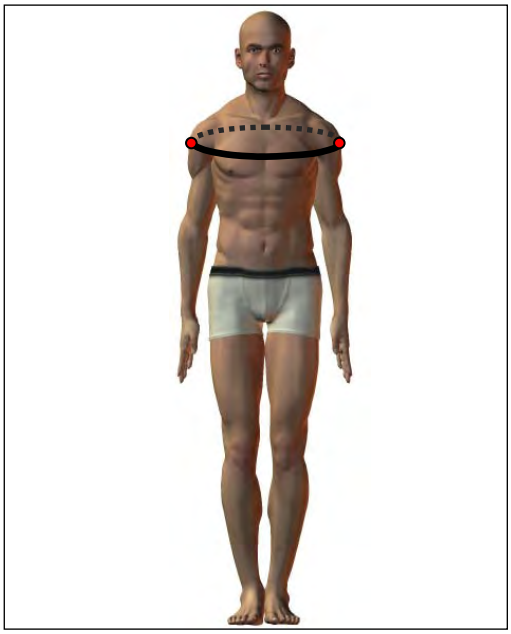
DRAWN LANDMARKS: Deltoid point, right and left.

PROCEDURE: Participant is in the anthropometric standing position with his/her back to a mirror. Stand in front of the participant, and use a tape to measure the circumference of the shoulders at the level of deltoid landmarks. Use the mirror to check the position of the tape as it crosses the participant'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.

INSTRUMENT: Steel tape.

CAUTION: As the level of the two shoulders is often slightly different, this measurement may not always be horizontal.





6.4.70 Shoulder-Elbow Length

DESCRIPTION: The distance between the right acromion landmark and the olecranon landmark on the bottom of the right elbow.

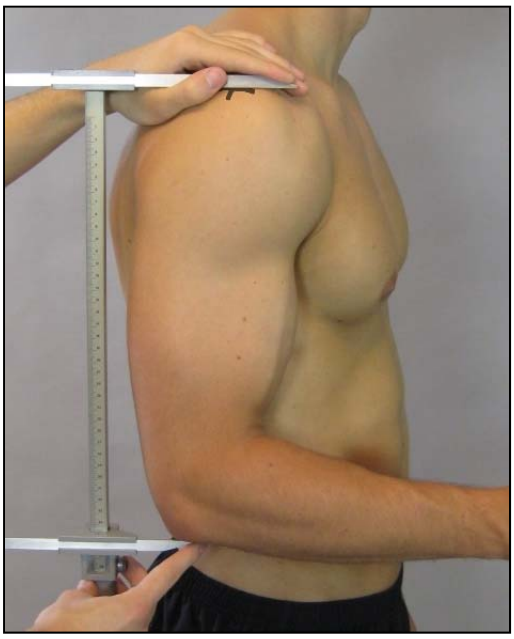
DRAWN LANDMARK: Acromion, right

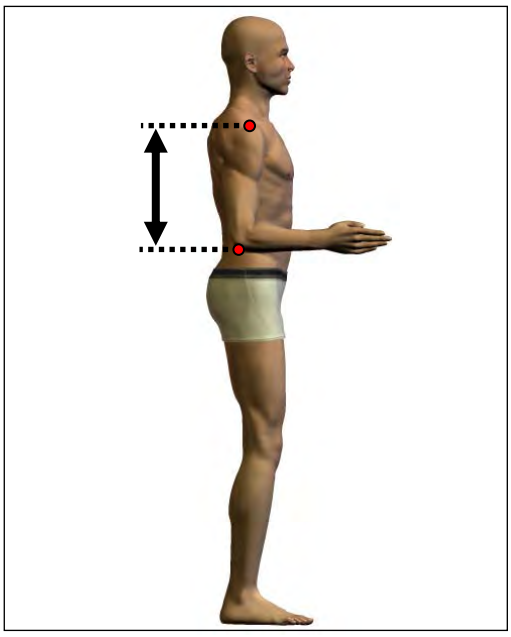
UNDRAWN LANDMARK: Olecranon, bottom.

PROCEDURE: Participant stands erect with the upper arm hanging at the side and the elbow flexed 90°. The hand is straight, and the palm faces inward (medially). Stand at the right of the participant, 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.

INSTRUMENT: Beam caliper.

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.





6.4.71 Shoulder Length

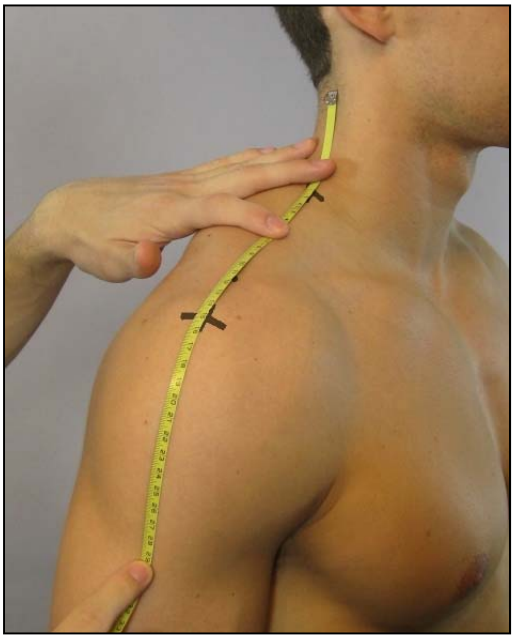
DESCRIPTION: The surface distance between the trapezius landmark and the acromion landmark on the right shoulder.

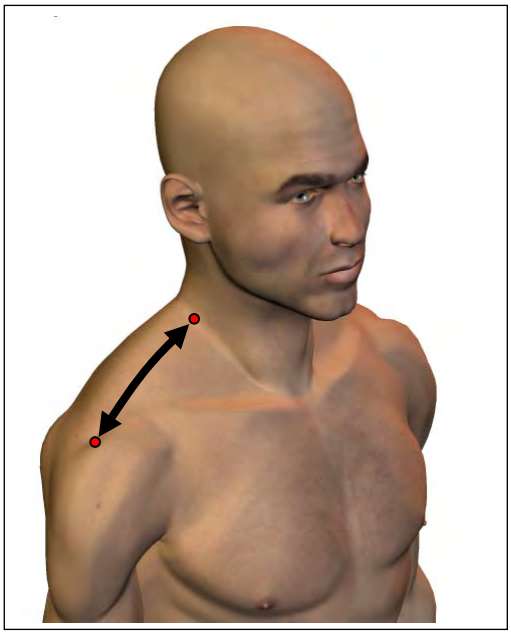
DRAWN LANDMARKS: Trapezius point, right; Acromion, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand at the right of the participant, 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**.**

INSTRUMENT: Steel tape.

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





6.4.72 Sitting Height

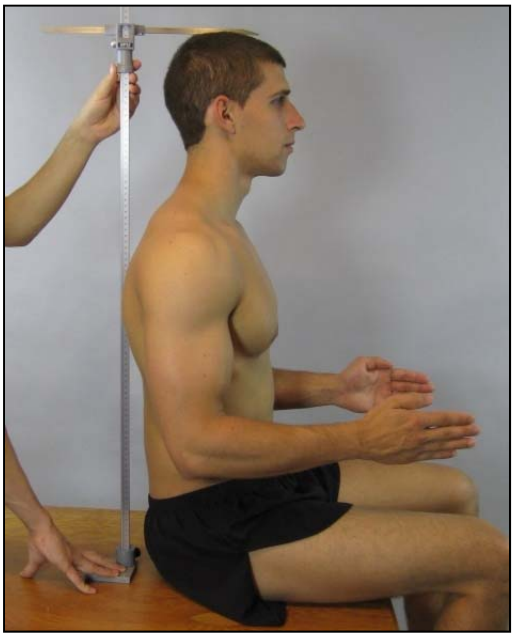
DESCRIPTION: The vertical distance between a sitting surface and the top of the head.

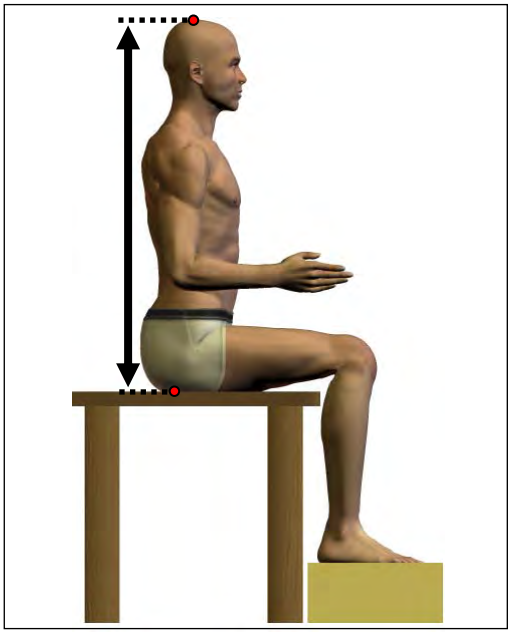
UNDRAWN LANDMARK: Top of head (vertex).

PROCEDURE: Participant is in the anthropometric sitting position with the head in the Frankfurt plane. Stand at the right rear of the participant, 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.

INSTRUMENT: Anthropometer.

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





6.4.73 Sleeve Length: Spine-Wrist

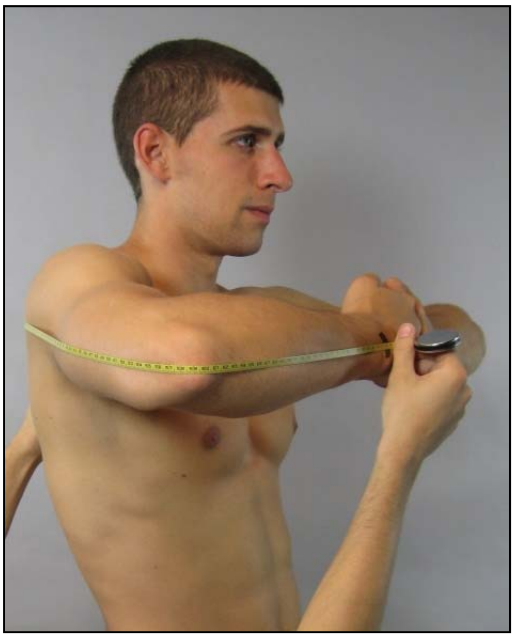
DESCRIPTION: The horizontal distance from the midspine landmark, across the olecranon, center, landmark to the dorsal wrist landmark.

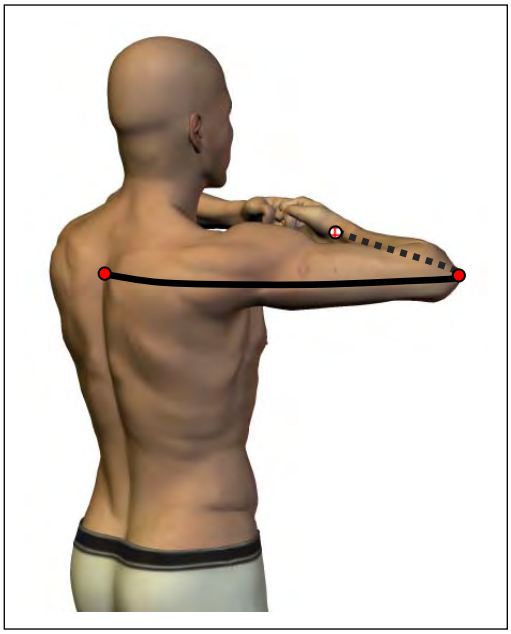
DRAWN LANDMARKS: Midspine; Dorsal stylion; Olecranon, center.

PROCEDURE: Participant 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 participant 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 participant, and use a tape to measure the horizontal surface distance between the midpoint of the spine (drawn midspine landmark) and the drawn dorsal stylion landmark. The tape passes over the 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.

INSTRUMENT: Steel tape.

CAUTION: The shoulders are relaxed, and the participant 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.





6.4.74 Sleeve Outseam

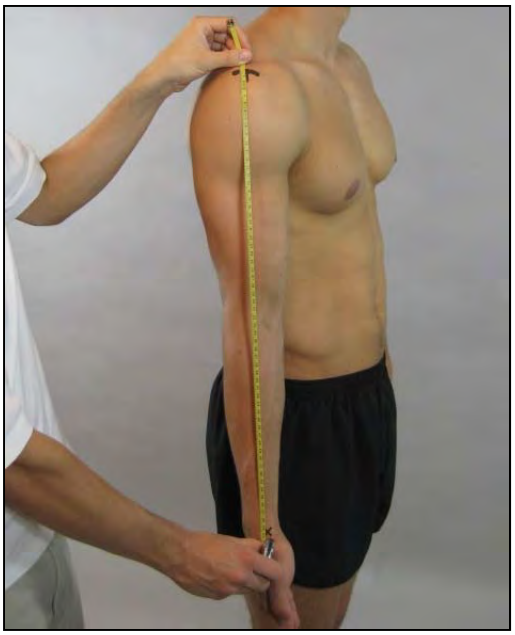
DESCRIPTION: The distance between the acromion landmark on the tip of the right shoulder and the stylion landmark.

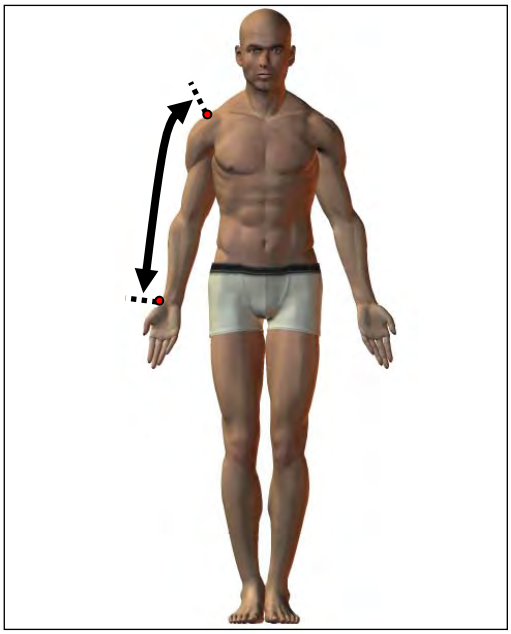
DRAWN LANDMARKS: Acromion, right; Stylion.

PROCEDURE: Participant 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 participant, and use a tape to measure the straight-line distance between the acromion landmark and the stylion landmark. The tape follows the surface of the shoulder and deltoid muscle, but will span body hollows as it moves down the arm. Be sure the zero point of the tape is on the acromion landmark.

INSTRUMENT: Tape.

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





6.4.75 Span

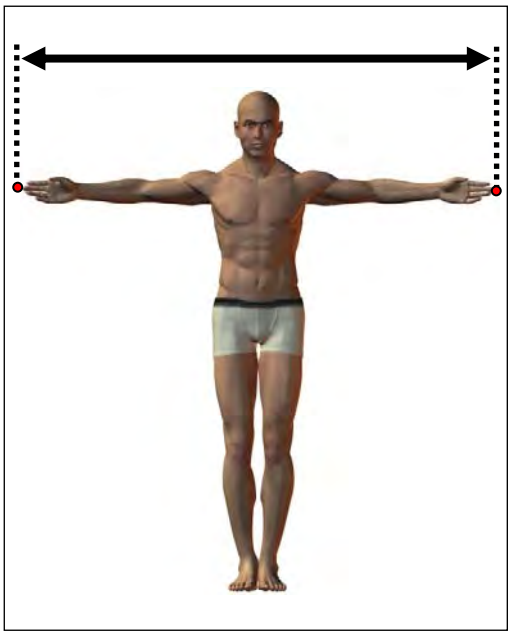
DESCRIPTION: The distance between the tips of the middle fingers of horizontally outstretched arms.

UNDRAWN LANDMARKS: Dactylion III, right and left.

PROCEDURE: Participant 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 palms facing outward and the tip of the third finger of one hand just touching a side wall. Stand near the hand of the participant 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 participant'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.

INSTRUMENTS: Wall chart; Block.

CAUTION: Urge the participant to stretch the arms laterally as much as possible. Check that the arms remain in the required position. On very muscular individuals or individuals with a larger upper torso, the arms may not necessarily be against the wall.



6.4.76 Stature

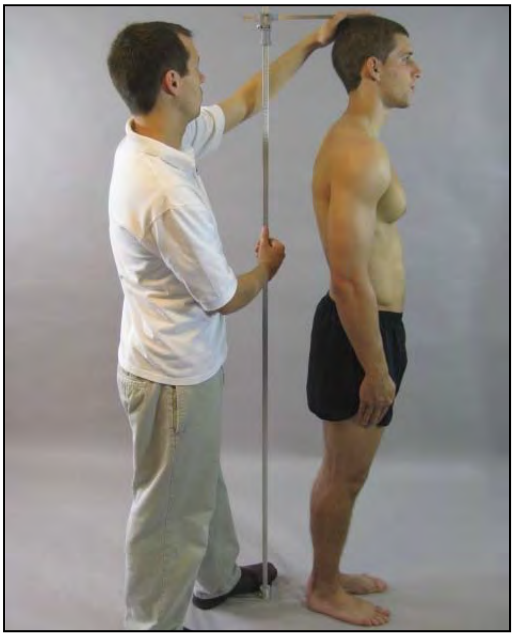
DESCRIPTION: The vertical distance from a standing surface to the top of the head.

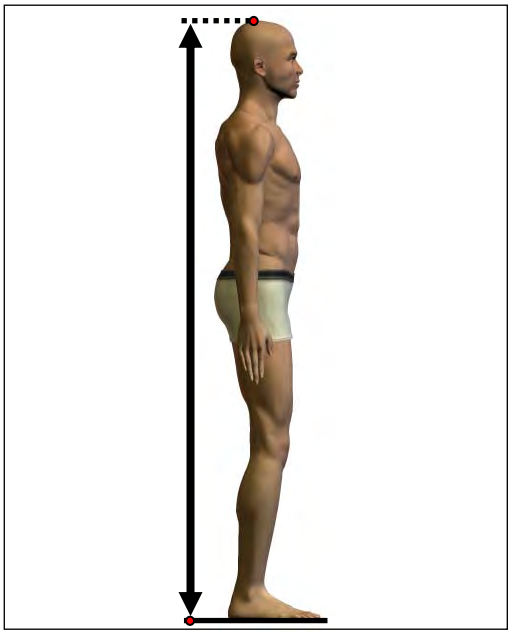
UNDRAWN LANDMARK: Top of head (vertex).

PROCEDURE: Participant is in the anthropometric standing position with the head in the Frankfurt plane. Stand at one side of the participant, 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 participant's hair. The measurement is taken at the maximum point of quiet respiration.

INSTRUMENT: Anthropometer.

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





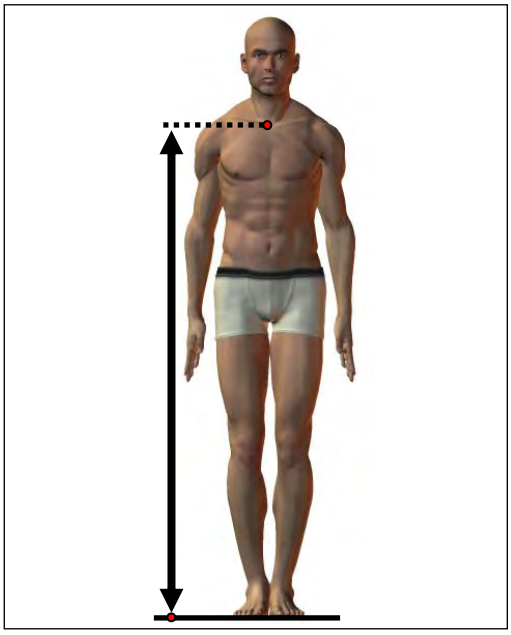
6.4.77 Suprasternale Height

DESCRIPTION: The vertical distance between a standing surface and the suprasternale landmark.

DRAWN LANDMARK: Suprasternale, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant, 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. Measurer may wish to place one foot on the anthropometer base to stabilize.

INSTRUMENT: Anthropometer.



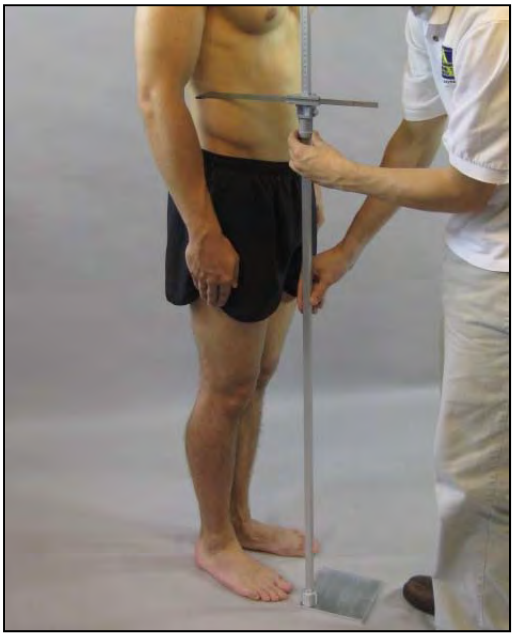
6.4.78 Tenth Rib Height

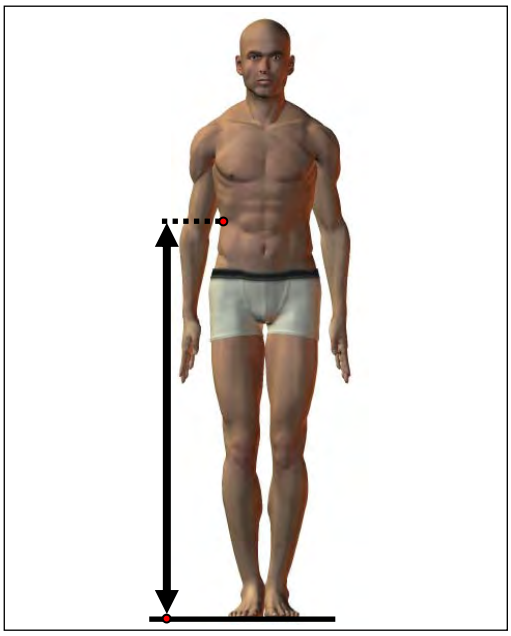
DESCRIPTION: The vertical distance between a standing surface and the tenth rib landmark.

DRAWN LANDMARK: Tenth rib, right.

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant, 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.

INSTRUMENT: Anthropometer.





6.4.79 Thigh Circumference

DESCRIPTION: The circumference of the thigh at its juncture with the buttock.

DRAWN LANDMARK: Gluteal furrow point, right.

PROCEDURE: Participant 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 participant, and use a tape to measure the circumference of the thigh at its juncture with the buttock (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.

INSTRUMENT: Steel tape.

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

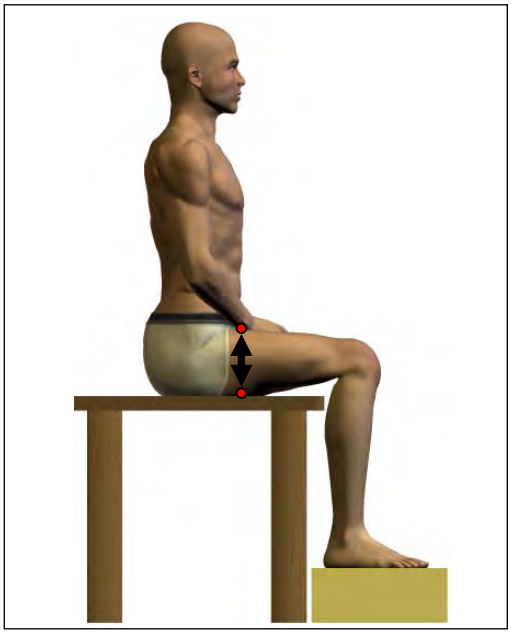
6.4.80 Thigh Clearance

DESCRIPTION: The vertical distance between a sitting surface and the highest point on top of the right thigh.

UNDRAWN LANDMARK: Thigh point, top.

PROCEDURE: Participant sits with the thighs parallel, knees flexed 90°, and the feet in line with the thighs. The arms are relaxed on the lap. Stand at the right of the participant, 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.

INSTRUMENT: Anthropometer.



6.4.81 Thumbtip Reach

DESCRIPTION: The horizontal distance from a back wall to the tip of the right thumb.

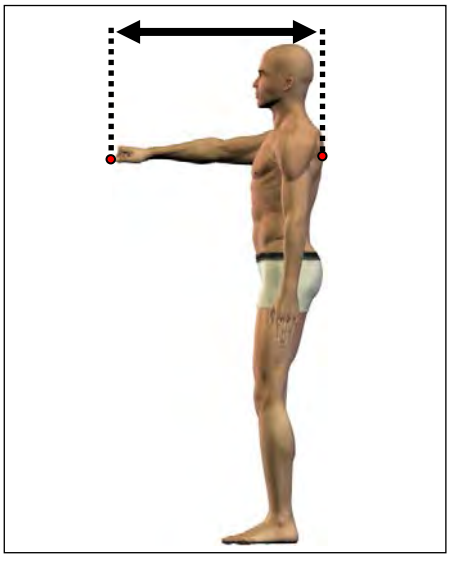
UNDRAWN LANDMARK: Thumbtip, right.

PROCEDURE: Participant 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 remaining fingers are curled into a fist. Stand in front of the participant, and hold the participant's right shoulder against the rear wall (not shown in photo). 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.*

INSTRUMENT: Wall chart; Block.

CAUTION: Measurer should continue to hold the right shoulder while taking the measurement. The participant’s arm should extend forward and may not have contact with the wall.

* 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. 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; and (3) if both differences are greater than the allowable error, all three measurements are made again.



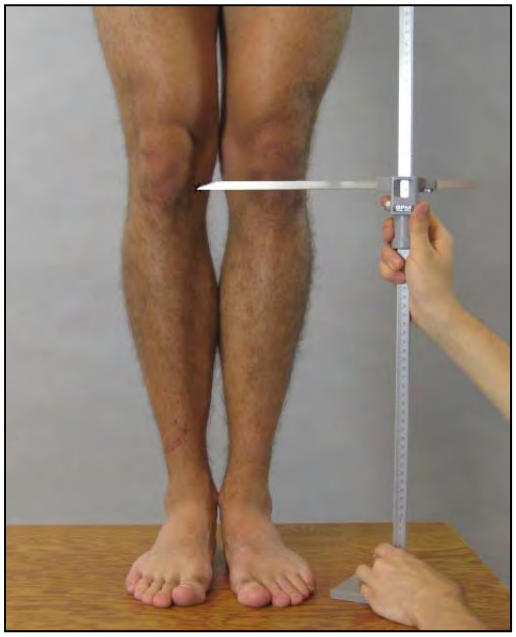
6.4.82 Tibial Height

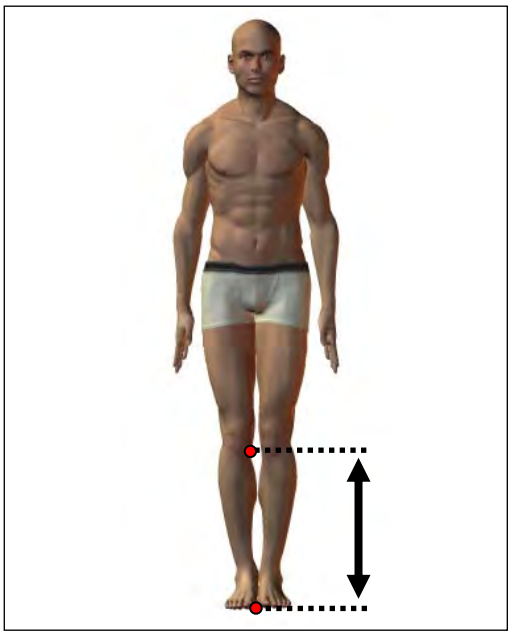
DESCRIPTION: The vertical distance between a standing surface and the tibiale landmark.

DRAWN LANDMARK: Tibiale, right.

PROCEDURE: Participant stands erect on a table with the feet together and the weight distributed equally on both feet. Stand in front of the participant, and use an anthropometer to measure the vertical distance between the standing surface and the tibiale landmark below the knee on the medial side.

INSTRUMENT: Anthropometer.





6.4.83 Tragion-Top of Head

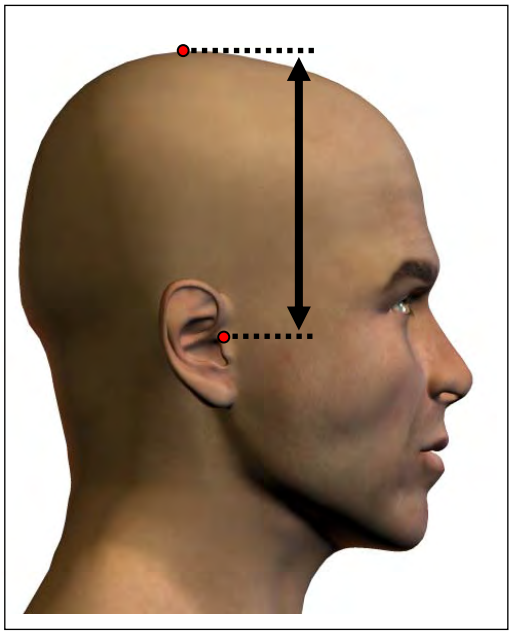
DESCRIPTION: The vertical distance between the right tragion landmark on the cartilaginous flap in front of the earhole and the horizontal plane tangent to the top of the head.

DRAWN LANDMARK: Tragion, right.

UNDRAWN LANDMARK: Top of head (vertex).

PROCEDURE: Participant sits with the head in the Frankfurt plane. Stand to the right of the participant, and use a beam caliper with paddle blade to measure the vertical distance between the right tragion landmark and the top of the head. The fixed blade is on tragion. Be sure the beam is parallel to the long axis of the head. Exert sufficient pressure to obtain contact between the paddle blade and the skin.

INSTRUMENT: Beam caliper with paddle blade.



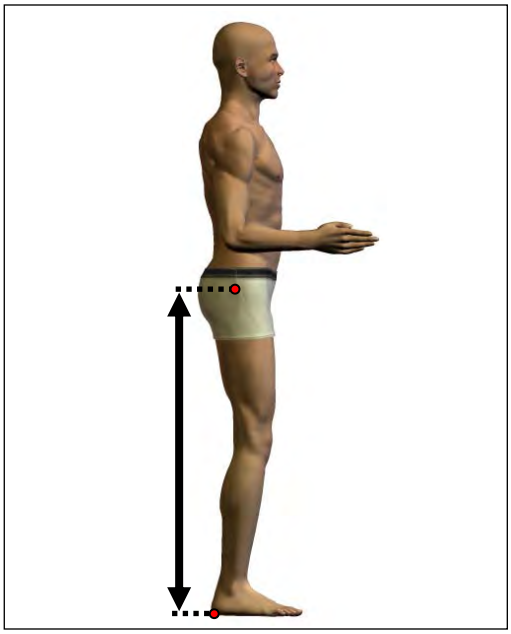
6.4.84 Trochanterion Height

DESCRIPTION: The vertical distance between a standing surface and the trochanterion landmark on the upper side of the right thigh.

DRAWN LANDMARK: Trochanterion, right.

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

INSTRUMENT: Anthropometer.



6.4.85 Vertical Trunk Circumference (USA)

DESCRIPTION: The vertical circumference of the trunk on a line passing through the crotch and over the fullest part of the chest, midshoulder, and buttock point, posterior.

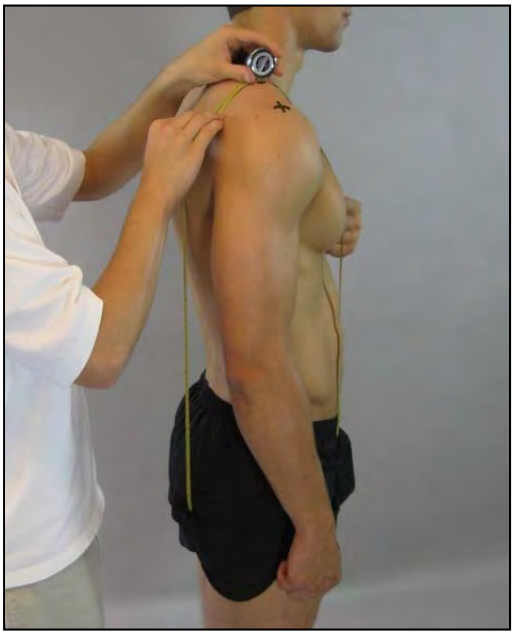
DRAWN LANDMARK: Midshoulder, right.

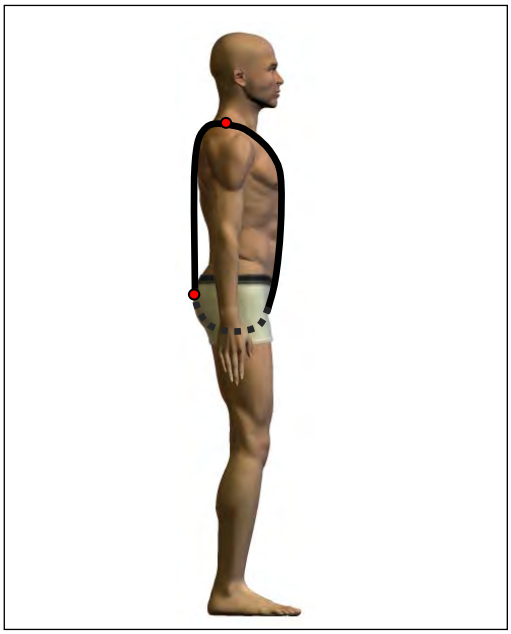
UNDRAWN LANDMARK: Buttock point, posterior.

PROCEDURE: The participant 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 participant. The zero end of the tape is brought upward to pass midway between the sternum and the anterior axillary fold and over the 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 participant 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.

INSTRUMENT: Steel tape.

CAUTION: The participant must not change the position of the shoulders.





6.4.86 Waist Back Length (Omphalion)

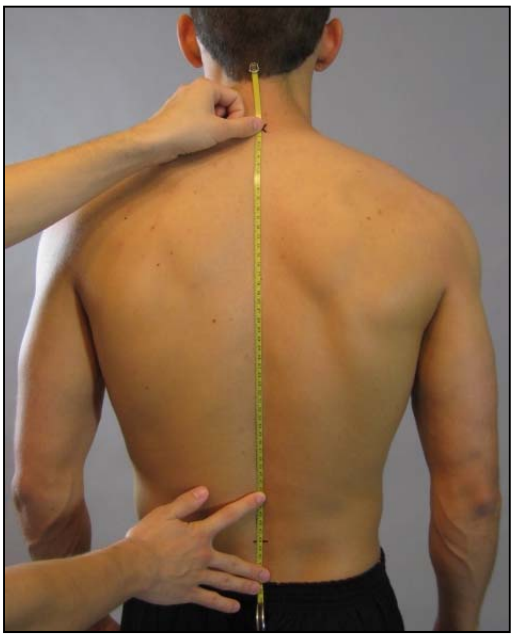
DESCRIPTION: The surface distance between the cervicale landmark at the back of the neck and the waist (omphalion), posterior landmark.

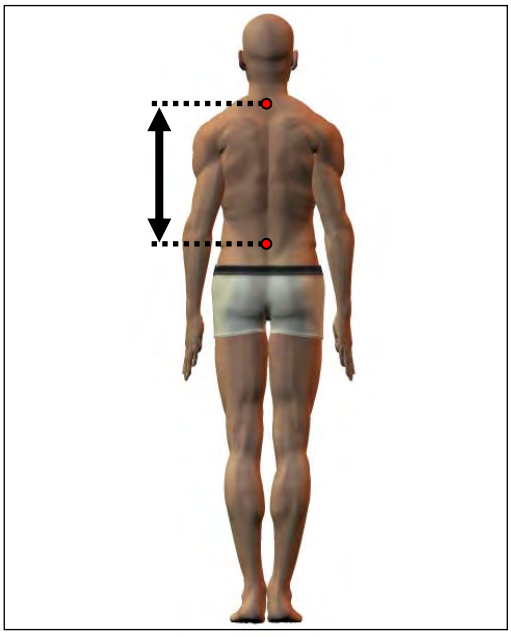
DRAWN LANDMARKS: Cervicale; Waist (omphalion), posterior.

PROCEDURE: Participant is in the anthropometric standing position with the head in the Frankfurt plane. Stand behind the participant, and use a tape to measure the vertical surface distance between the landmarks at cervicale and waist (omphalion), posterior. The tape follows body contours. For women the tape passes underneath the bra. 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.

INSTRUMENT: Steel tape.

CAUTION: Be sure that the head is in the Frankfurt 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 participant's back to maintain skin contact.





6.4.87 Waist Breadth

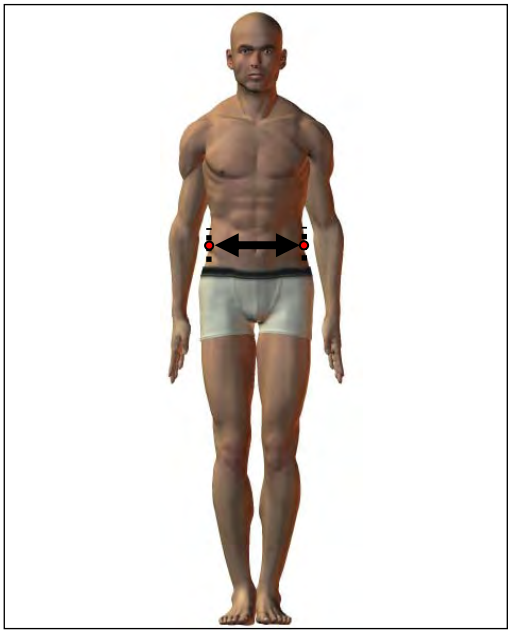
DESCRIPTION: The horizontal breadth of the waist at the level of omphalion.

DRAWN LANDMARKS: Waist (omphalion), right and left.

PROCEDURE: Participant is in the anthropometric standing position. Stand in front of the participant, 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.

INSTRUMENT: Beam caliper.

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



6.4.88 Waist Circumference (Omphalion)

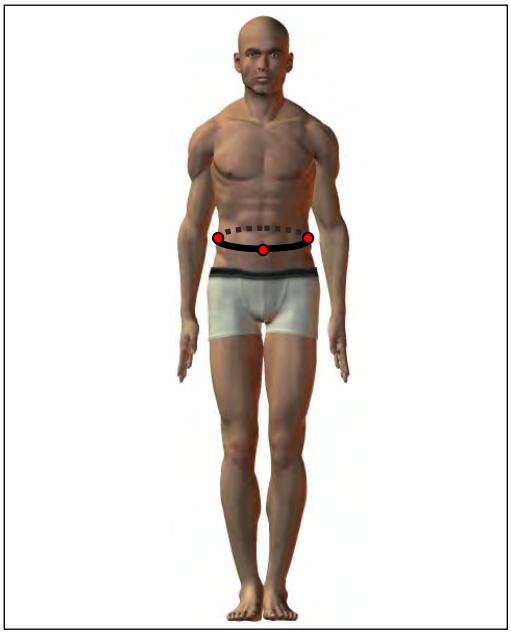
DESCRIPTION: The horizontal circumference of the waist at the level of omphalion encompassing the waist (omphalion) landmarks.

DRAWN LANDMARKS: Waist (omphalion), right, left, anterior and posterior.

PROCEDURE: Participant is in the anthropometric standing position in front of a mirror. Stand in front of the participant, 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 participant'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.

INSTRUMENT: Steel tape.

CAUTION: The participant must not tense the abdominal muscles.



6.4.89 Waist Depth

DESCRIPTION: The horizontal distance between the front and the back of the waist at the level of omphalion.

DRAWN LANDMARKS: Waist (omphalion), anterior and posterior.

PROCEDURE: Participant is in the anthropometric standing position, but with the right hand on the chest. Stand at the right of the participant, 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.

INSTRUMENT: Beam caliper.

CAUTION: The participant must not tense the abdominal muscles.

6.4.90 Waist Front Length, Sitting

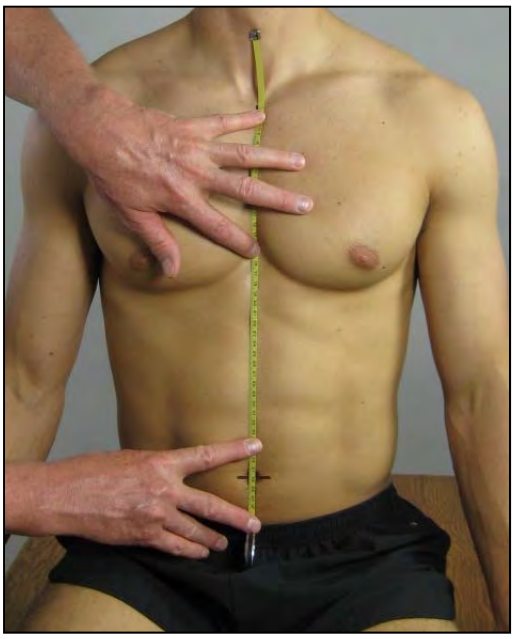
DESCRIPTION: The surface distance between the suprasternale landmark at the lowest point of the notch at the top of the breastbone and omphalion.

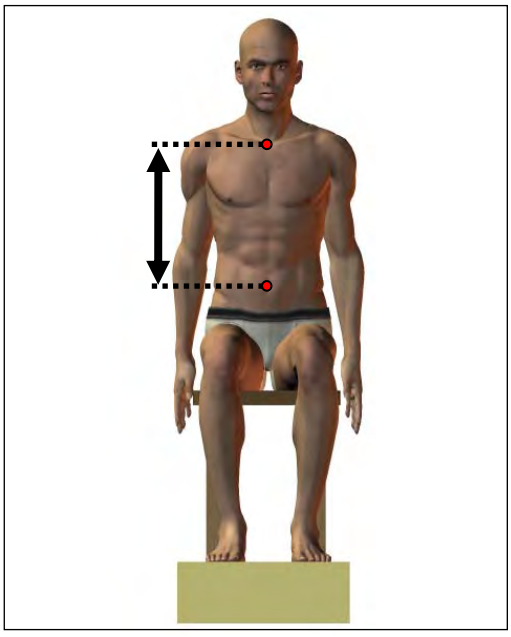
DRAWN LANDMARKS: Suprasternale, right; Waist (omphalion), anterior.

PROCEDURE: Participant is in the anthropometric sitting position with the head in the Frankfurt plane, but with the arms relaxed at the sides. Stand in front of the participant, and use a tape to measure the surface distance between the drawn suprasternale landmark and the drawn anterior waist (omphalion) landmark. For females, ask the participant to pass the tape underneath the bra. The zero point of the tape is placed on the suprasternale landmark. Exert only enough tension to prevent slack in the tape. The measurement is made at the maximum point of quiet respiration.

INSTRUMENT: Steel tape.

CAUTION: Be sure that the participant's head is in the Frankfurt plane and that the zero point of the tape is on the suprasternale landmark when the measurement is taken. The participant must not tense the abdominal muscles.





6.4.91 Waist Height (Omphalion)

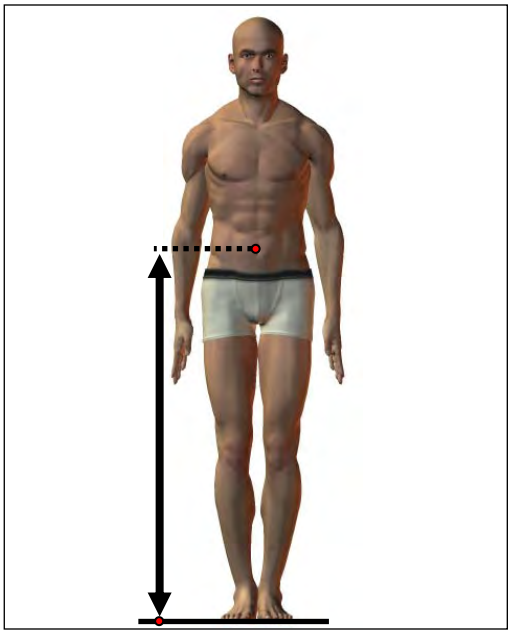
DESCRIPTION: The vertical distance between a standing surface and omphalion.

DRAWN LANDMARKS: Waist (omphalion), anterior.

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

INSTRUMENT: Anthropometer.

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



6.4.92 Weight

PROCEDURE: Participant stands on the platform of the scale with weight distributed evenly on both legs. Stand in front of the participant, and take the weight of the participant to the nearest tenth of a kilogram.

INSTRUMENT: Scale.

6.4.93 Wrist Circumference

DESCRIPTION: The circumference of the wrist at the level of stylion and perpendicular to the long axis of the forearm.

DRAWN LANDMARK: Stylion.

PROCEDURE: Participant stands with the upper arm relaxed and the elbow flexed 90° with the palm up. Stand in front of the participant, 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.

INSTRUMENT: Steel tape.

6.4.94 Wrist Height

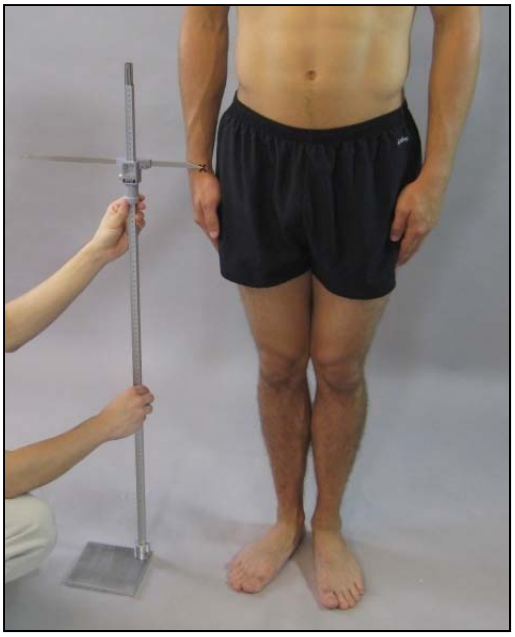
DESCRIPTION: The vertical distance between a standing surface and the stylion landmark.

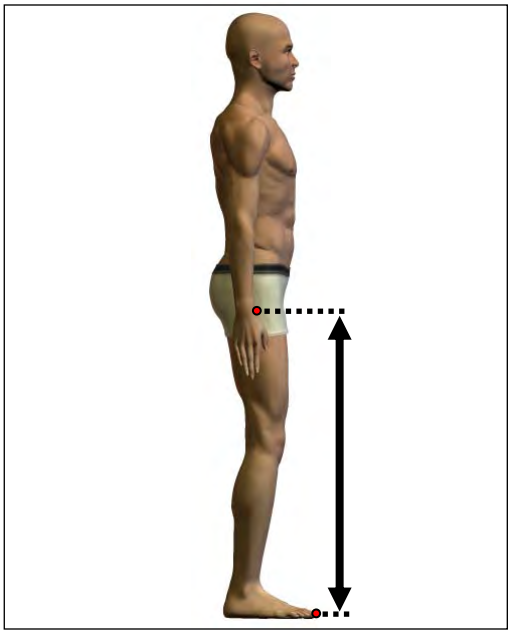
DRAWN LANDMARK: Stylion.

PROCEDURE: Participant stands erect 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 inward (medially). Stand in front of the participant, 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.

INSTRUMENT: Anthropometer.

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





7. USE OF THE DIMENSIONS

Participants often ask why certain dimensions are being measured. You too may wonder what the purpose is for some of the measurements that are taken. Table 3 lists all the dimensions to be measured in the Army and Marine surveys and designates which of the seven categories of uses they may serve. Anthropometrists should become familiar with the applications made of at least the 25 or so dimensions for which they are responsible**.** The 3-D scans, of course, have many uses. In general, however, the head scan is used for protective head gear, communications equipment and protective eyewear. The foot scan is used for boots and other footwear. The whole body scan is used for modeling, body armor, and load-carrying systems. The seven use categories are briefly described in the paragraphs following Table 3.

TABLE 3
Uses for Measured Dimensions[10]

Applications for the Dimensions to be Measured in the Marine and Army Survey	Describing Overall Body Size and Proportions	Clothing and Personal Protection Design, Sizing, and Issue	Workstation Design	Occupational Selection	Digital Human Models	3-D Scan Validation	International Standards for Ergonomic Design
Abdominal Extension Depth, Sitting			✓	✓			✓
Acromial Height		✓			✓	✓	✓
Acromion-Radiale Length	✓				✓	✓	✓
Acromion-Wall Depth							✓
Ankle Circumference	✓	✓			✓		
Axilla Height		✓			✓		✓
Ball of Foot Circumference		✓					
Ball of Foot Length		✓			✓		✓
Biacromial Breadth	✓	✓	✓		✓	✓	✓
Biceps Circumference, Flexed	✓	✓			✓		
Bicristal Breadth					✓		
Bideltoid Breadth	✓		✓	✓	✓	✓	✓
Bimalleolar Breadth	✓				✓		
Bitragion Chin Arc		✓					
Bitragion Submandibular Arc		✓					

[10] After Clauser et al., 1986

TABLE 3 CONTINUED
Uses for Measured Dimensions[11]

Applications for the Dimensions to be Measured in the Marine and Army Survey	Describing Overall Body Size and Proportions	Clothing and Personal Protection Design, Sizing, and Issue	Workstation Design	Occupational Selection	Digital Human Models	3-D Scan Validation	International Standards for Ergonomic Design
Bizygomatic Breadth	✓	✓		✓	✓	✓	
Buttock Circumference	✓	✓		✓	✓	✓	✓
Buttock Depth			✓		✓		
Buttock Height	✓	✓			✓	✓	
Buttock-Knee Length			✓	✓	✓		✓
Buttock-Popliteal Length			✓	✓	✓		✓
Calf Circumference	✓	✓			✓	✓	✓
Cervicale Height	✓	✓		✓	✓	✓	✓
Chest Breadth	✓	✓			✓		
Chest Circumference	✓	✓		✓	✓	✓	✓
Chest Depth	✓		✓		✓		✓
Chest Height		✓			✓	✓	
Crotch Height	✓	✓		✓	✓		✓
Crotch Length (Omphalion)		✓			✓		
Crotch Length, Posterior (Omph)		✓					
Ear Breadth	✓	✓				✓	
Ear Length	✓	✓				✓	
Ear Protrusion		✓					
Elbow Rest Height			✓		✓		✓
Eye Height, Sitting	✓		✓	✓	✓		✓
Foot Breadth, Horizontal	✓	✓		✓	✓		✓
Foot Length	✓	✓	✓	✓	✓		✓
Forearm-Center of Grip Length					✓		✓
Forearm Circumference, Flexed		✓			✓		
Forearm-Forearm Breadth			✓	✓	✓		✓
Forearm-Hand Length	✓		✓		✓		✓
Functional Leg Length				✓	✓		
Hand Breadth	✓	✓	✓		✓		✓
Hand Circumference	✓	✓		✓	✓		✓
Hand Length	✓	✓	✓	✓	✓		✓

[11] After Clauser et al., 1986

TABLE 3 CONTINUED
Uses for Measured Dimensions[12]

Applications for the Dimensions to be Measured in the Marine and Army Survey	Describing Overall Body Size and Proportions	Clothing and Personal Protection Design, Sizing, and Issue	Workstation Design	Occupational Selection	Digital Human Models	3-D Scan Validation	International Standards for Ergonomic Design
Head Breadth	✓	✓		✓	✓		✓
Head Circumference	✓	✓		✓	✓		✓
Head Length	✓	✓		✓	✓		✓
Heel Ankle Circumference		✓					
Heel Breadth	✓	✓					
Hip Breadth	✓		✓		✓	✓	✓
Hip Breadth, Sitting	✓		✓	✓	✓		✓
Iliocristale Height		✓			✓	✓	
Interpupillary Breadth		✓			✓		
Interscye I		✓			✓		
Interscye II		✓			✓		
Knee Height, Midpatella		✓			✓		
Knee Height, Sitting	✓		✓	✓	✓		✓
Lateral Femoral Epicondyle Ht	✓				✓		
Lateral Malleolus Height		✓			✓		
Lower Thigh Circumference		✓		✓	✓	✓	
Menton-Sellion Length	✓	✓		✓	✓		
Neck Circumference	✓	✓			✓	✓	✓
Neck Circumference, Base		✓		✓	✓	✓	✓
Overhead Fingertip Reach, Sitting			✓	✓	✓		
Palm Length		✓			✓		✓
Popliteal Height			✓	✓	✓		✓
Radiale-Stylion Length	✓				✓	✓	✓
Shoulder Circumference	✓	✓			✓	✓	
Shoulder-Elbow Length			✓	✓	✓		✓
Shoulder Length		✓			✓		
Sitting Height	✓		✓	✓	✓		✓
Sleeve Length: Spine-Wrist		✓					
Sleeve Outseam	✓	✓		✓			✓
Span	✓		✓	✓	✓		✓

[12] After Clauser et al., 1986

TABLE 3 CONTINUED
Uses for Measured Dimensions[13]

Applications for the Dimensions to be Measured in the Marine and Army Survey	Describing Overall Body Size and Proportions	Clothing and Personal Protection Design, Sizing, and Issue	Workstation Design	Occupational Selection	Digital Human Models	3-D Scan Validation	International Standards for Ergonomic Design
Stature	✓	✓	✓	✓	✓	✓	✓
Suprasternale Height	✓				✓		
Tenth Rib Height					✓		
Thigh Circumference	✓	✓		✓	✓	✓	✓
Thigh Clearance			✓	✓	✓		✓
Thumbtip Reach	✓		✓	✓	✓		✓
Tibial Height					✓		✓
Tragion-Top of Head	✓	✓			✓		
Trochanterion Height	✓				✓		✓
Vertical Trunk Circ (USA)		✓		✓	✓		✓
Waist Back Length (Omphalion)		✓			✓		
Waist Breadth	✓				✓		
Waist Circumference (Omphalion)	✓	✓			✓	✓	✓
Waist Depth					✓		
Waist Front Length, Sitting		✓					
Waist Height (Omphalion)	✓	✓			✓		
Weight	✓	✓	✓	✓	✓		✓
Wrist Circumference	✓	✓			✓		✓
Wrist Height			✓		✓		

Describing Overall Body Size and Proportions: 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 participants 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). Further, these dimensions are commonly used in anthropometric studies world-wide, and their definitions are generally agreed upon. This means that international population comparisons using these dimensions are valid.

[13] After Clauser et al., 1986

Clothing and Personal Protection Design, Sizing, and Issue: These dimensions are useful for the design and sizing of Army and Marine uniforms, utility garments, and personal protective equipment (e.g., body armor, respirators, chemical defense clothing). In this context, “personal protection” also includes boots, gloves, helmets, goggles and various special purpose items.

Workstation Design: Dimensions in this group are central to the design and layout of single- and multi-person workstations occupied by Army and Marine personnel. They are also of paramount importance in the design and layout of workstations of Army and Marine 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.

Occupational Selection: These dimensions are used to screen candidates for anthropometric incompatibility when job assignments are being made. The physical constraints inherent in some occupations, e.g. the dimensions of a helicopter cockpit, preclude individuals of certain sizes and proportions from safely carrying out those missions.

Digital Human Models: These dimensions are needed for developing digital 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 and USMC crewstations and workstations. Digital models are increasingly used in the design process for seated and standing workstations, as well as group modeling for battlefield scenarios.

3-D Scan Validation: The dimensions in this group are those required to create and refine automated scan data extraction algorithms. As scanners are more frequently used as a substitute for actual anthropometric data collection, it becomes more critical than ever to assure users of the data that the measurements arising from 3D scans are equivalent to those taken with tapes and calipers. As data extraction applications are continuously improving, this is an achievable goal. In the interim, however, it is necessary to collect traditional (tape & caliper) dimensions that can be used to test the validity of these applications, the assumptions and the algorithms that underlie them.

International Standards for Ergonomic Design: These dimensions are useful for comparing data sets between nations, and are measured according to the protocol in ISO 7250-1, as well as other international standards. Further, these dimensions form part of a minimum set of dimensions recommended for collection any time humans are measured. The inclusion of these dimensions in ANSUR assures that the US Army is using internationally recognized Best Practices in its survey design.

UNCLASSIFIED

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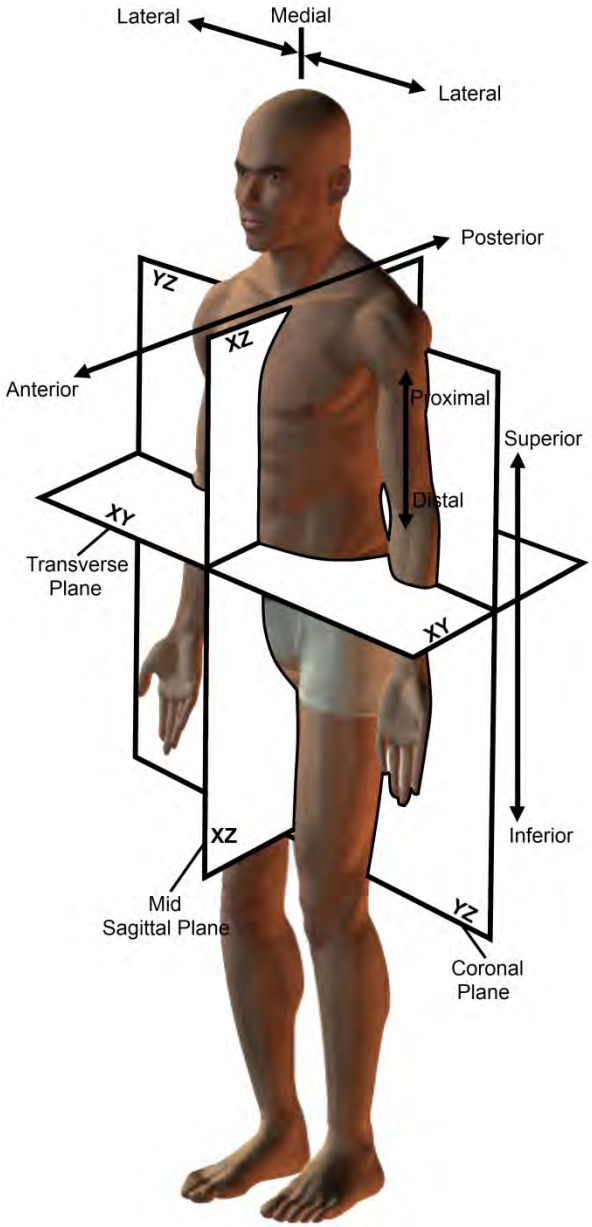
GLOSSARY OF ANATOMICAL AND ANTHROPOMETRIC TERMS

acromion – tip of the shoulder

acromial process – an oblong portion of the shoulder blade at the top of the shoulder

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



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

anthropometric standing position – described in Section 6.1.1 and shown in Figure 19

anthropometric sitting position –described in Section 6.1.2 and shown in Figure 20

axilla - armpit

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

biceps – used to refer to the two heads of a muscle; the term is most commonly used to refer to the large muscle on the anterior surface of the upper arm (biceps brachii).

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

coronal plane - any vertical plane at right angles to the midsagittal plane; divides the body into anterior and posterior divisions (see anatomical position diagram on previous page)

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

distal - farther from the trunk of the body, as opposed to proximal (see anatomical position diagram on previous page)

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 and on the foot, its top surface as opposed to plantar).

epicondyle - the bony prominence at the distal end of the humerus and femur (bones)

extend - to move adjacent segments of limbs 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 limbs in such a direction as to bring the two parts together, as when the elbow is bent; as opposed to extend

Frankfurt plane - the standard horizontal plane 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); see Figure 21

gluteal furrow – the crease at the juncture of the buttock and the thigh

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

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

iliac crest – the superior rim of a pelvic bone

inferior - below, in relation to another structure; lower (see anatomical position diagram on first page of Glossary)

lateral - away from the midline of the body; as opposed to medial (see anatomical position diagram on first page of Glossary)

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 lower jawbone

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 anatomical position diagram on first page of Glossary)

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 - the vertical plane that divides the body into equal right and left halves (see anatomical position diagram on first page of Glossary)

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

omphalion - the navel

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 protuberance just below the fleshy pad at the base of the palm

popliteal fossa – dorsal juncture of the calf and thigh; back of the knee

posterior – pertaining to the back of the body; as opposed to anterior (see anatomical position diagram on first page of Glossary)

proximal - closer to the trunk of the body; as opposed to distal (see anatomical position diagram on first page of Glossary)

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

scye – a tailoring term referring to the armhole of a garment

sternum – breast bone

stylion – the lowest point at the bottom of the radius (bone)

superior - above, in relation to another structure (see anatomical position diagram on first page of Glossary)

supra – prefix designating above or on.

supraorbital ridges – the brow ridges above the eye sockets at the bottom of the forehead

tibia - shin bone

tragion – the juncture of the top of the cartilaginous flap of the ear with the head

tragus – the cartilaginous flap of the ear near the earhole

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

trochanter – a point in the center of the lateral side of the large prominence at the top of the thigh bone (femur), located on a sitting subject

ventral – front or inside surface

vertebra – a bone of the spine; in humans there are 7 cervical (neck), 12 thoracic (chest), 5 lumbar (lower back), 5 sacral (fused), and 4 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

APPENDIX A
WHOLE BODY SCANNER (WBX)

A.1 GENERAL INFORMATION

The whole body scanner (WBX) is a low-power infrared laser system (Figure A-1) that will not damage the body in any way. It is comparable to a flash bulb on a camera. Scanning takes approximately 15-20 seconds to complete. The most delicate part of a scanner is referred to as the head. The scanner head contains a camera, a laser, and a mirror. It is important never to touch or bump the scanner heads. Any such impacts could cause misalignment of the components within the head that may render it impossible to fix or recalibrate. The software for subject scanning, CyScan, runs on the Windows XP operating system. The computer associated with the scanner has been set up so that it will only connect with the in-house Anthrotech network. Scan data files should be transferred over this network via Ethernet data cable connection to the system server; a CD/DVD can be used if necessary.

CyScan software on the WBX runs in conjunction with the EARS (Enhanced Anthropometric Rating System) program. EARS is used as an evaluation step to assist the operator in gathering high quality scans. CyScan will automatically activate EARS as needed; the operator does not need to switch the program on or off.

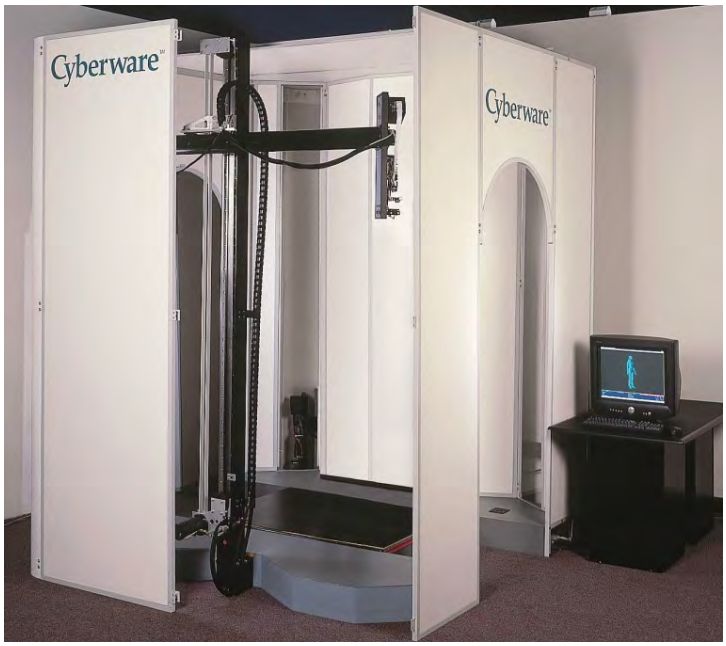


FIGURE A-1
Whole Body Scanner (WBX)

A.2 WBX DAILY SYSTEM BOOT-UP

The computer system needs to be fully booted up prior to starting the WBX system controller.

1. The WBX USB cable should be connected to the computer. Make sure the cable is properly and firmly seated in its appropriate connecting slots on both the computer and system controller.
2. Next, the WBX system controller should be powered up. Turn on the system power switch. The WBX scanner will take approximately five minutes to power up properly.
3. You can check to see if all the WBX components have loaded up by going to the computer management window. Look for the WBX system hardware. Click on the "+" sign next to the WBX system hardware; this should bring up a list of nine WBX system components. If hardware components do not appear, disconnect and reconnect the WBX USB cable on both ends. Wait for components to appear in the computer management window.

A.3 WBX DAILY CALIBRATION

Calibration must be performed on a daily basis. This is done through the use of a calibration object. The calibration object is a dark gray cylinder, 1.5 feet in length and 112.96 millimeters in diameter, with five colored dots arranged in a column on the outer surface.

<u>Part 1</u>

1. Place the calibration cylinder in the center of scanner platform, making sure that the column of dots is facing one of the two towers. (Note that the towers are labeled and referred to as Tower 0 and Tower 1.)
2. Open CyScan: Full Body software by double clicking the icon.
    a. If an error message occurs while loading CyScan, click OK. Exit out of the software and restart. If an error occurs again check the USB cable on the hardware.
3. Click the green "scan" button to begin the scanning process. The scanning process is complete when the WBX scan monitoring bar equals 100%.
4. Once the scan is complete, click "grayscale" and "smooth shaded surface."

<u>Part 2</u>

5. Next, check the image for texture issues, voids, and misalignments in several steps. To do that you will need to know how to rotate the image.
    a. To rotate the image on a 360° center axis, place the mouse cursor over the center of the image. Click and hold the left mouse button.
    b. Moving the mouse across the middle of the image from left to right or vice versa will produce a front to back rotation.
    c. Moving the mouse across the center of the image from top to bottom or vice versa will produce a head to foot rotation.

6. View the image from the point of view of each of the four cameras by turning each one off and on, one at a time. The controls for the cameras are located in the lower right hand corner of the program window.
7. Check the image for such things as texture quality and accurate shading. If the texture and shading are incorrect then the program needs to be restarted.

Part 3

8. Next, check the image alignment. Click “quick points” and “default color.” Then, go to “view” in the upper menu bar; select “orthographic.”
9. Rotate the image until you can see a circle (from top view of the cylinder).
    a. To zoom in or out on the image hold “CTRL” on the keyboard and click and hold the right mouse button. Move the mouse to create the zooming action.
    b. If the circle appears continuous and all lines match up then the image is aligned. If the image appears broken or contains extraneous lines then the image requires alignment.
10. To align the image (if required), first click “CTRL+SHIFT+U” to bring up the “utility” function in the upper menu bar.
11. Select “utility” and click on “range calibration.” This will bring up the range calibration window.
12. Click “calculate,” compare measured diameter with the true value (112.96 mm). If the measured diameter is off more than 1 mm, perform step 13 to do “range align.”
13. Go to “range align” in the utility menu. This menu allows you to shift cameras, as necessary, on the y and z axes (y = left-to-right adjustment; z = up-to-down adjustment). Note: Clicking in the blue stat fields allows you to make single increment adjustments.
14. Line up individual images as close to the actual cylinder diameter as possible. The diameter of the image should be within 1mm of the cylinder diameter to be acceptable. Use stat fields to correct diameter readings.
15. Save the alignment preset before performing an alignment. A warning will appear to prevent an accidental save.
16. Recalculate the range calibration after adjustment.
17. Save changes to the calibration.

Part 4 (Skip this section if luminance mode is set.)

18. Finally, calibrate the image texture. Go to “texture calibration” in the utility menu.
19. Turn on “default color” to check if colored dots are properly sized and aligned with surface dots on the calibration cylinder image.
20. Turn cameras on and off to find individual color alignments and placements.
    a. You can perform this alignment using the fields marked with “m” and “n.”
    b. If the color is distorted, use the scale fields to resize color patch-to-dot size.
21. Be sure to click “auto update” or alignment and sizing will not appear in real time while adjusting settings.
22. Save changes; turn the WBX off and then on.

A.4 PARTICIPANT PROCEDURAL GUIDE FOR WBX

A.4.1 Prior to Scanning

When the participant enters the scanning room, a technician will show the participant to the changing room and ask him/her to change into the appropriately sized scan wear. A wig cap will be placed on the participant's head in order to produce the highest quality scans. After the participant is changed, the technician will place adhesive dots on specific landmarks for scanning. Several 2-D orange dots will be placed over the appropriate landmarks, and wood plugs over the acromion landmarks. The participant will then be directed to whichever scanner is available.

A.4.2 When Participant Arrives at WBX

1. Introduce yourself: "Hi, my name is _____. I will walk you through the scan process and perform the scan functions today."
2. Scanning process
    a. Lead the participant to the scanner; explain that the scanner uses low-power infrared lasers that are not harmful to the eyes (will not penetrate the liquid in the cornea). Inform participants that the scanner produces a bright white light to light up the space during of the 17-second scan. Ask them to keep their eyes open if possible.
    b. Ask participants to step on to the scan platform, check to make sure that their shorts and top are wrinkle free, their wig caps are on correctly, and their landmark dots are in place
    c. <u>Remember:</u> Ask permission before touching a participant; do not assume!
    d. Check participant's body position and posture before leaving the scanner station (see **WBX Subject Positioning** and Figure A-2 below for positioning details).
    e. Let the participant know you are starting the scan and ask him/her to hold as still as possible.
    f. Once the scan is complete let the participant know that he or she may relax but needs to remain in the scanner until told otherwise (rescans may be necessary).
3. Thank the participant after the scan process is complete.

Remember that the participants are volunteers and may stop the process at any time they choose. If this occurs inform the field supervisor who will speak with the military liaison.

A.4.3 WBX Subject Positioning

Positioning for the WBX scanner is as follows and is shown in Figure A-2:

1. Feet
    a. Place toe and heel on foot markers.
    b. Make sure feet are straight.
    c. Feet must be equally distanced and lined up with each other.
2. Upper Torso
    a. The participant should face forward.
    b. Shoulders should be aligned horizontally. Both shoulders should be at the same height (if not limited by a previous injury).
    c. The participant should stand up straight, in between “attention” and “at ease.”
    d. The arms should be raised evenly (equidistant from waist), hands in a fist, and thumbs forward.
    e. The hands should not pass beyond markers on platform.
    f. The arms should be in a locked position at the elbow and aligned evenly with the center of the body.
3. Head
    a. The participant’s head should be facing forward.
    b. The head should be aligned in the Frankfurt plane.
    c. Ask the participant to look straight ahead.
    d. Check to make sure the wig cap is properly placed.

FIGURE A-2
Participant Positioning for the Whole Body Scanner (WBX)

A.5 OPERATIONAL GUIDE FOR THE WBX

1. Bring up CyScan (WBX) software for the whole body scanner. (This is different from calibration software).
2. Verbally prepare the participant for scanning (see the introductory explanation above).
3. Perform a positioning check for correct posturing of subject (see above).
4. Scan in the participant's barcode (with the hand-held barcode scanner)
5. Scan the participant. EARS will only respond if necessary.
6. Once the scan is complete, perform an evaluation of the image. This should be done in "grayscale." Look for:
   - Voids
   - Texture issues
   - Alignment
   - Correct posture
   - Landmarks
7. If the scan image passes checks, then the participant is finished. If it does not pass, then correct for appropriate errors and rescan.
8. Due to time constraints, do not perform more than two scans per subject unless the immediate cause of error is known.

A.6 WBX SCANNER ASSEMBLY

1. Remove bolts and klimps from crate #'s 1 and 4. Slide the front out of the crate and pull the crate top off the palette.
2. Remove tie-downs, straps, and clamps from around objects in the crate.
3. Remove the main truss from the crate and place it into the desired position on the floor.
4. Remove both legs from the crate. Place Leg 0 on the right side of Tower 0. Leg 1 is placed on the left side of Tower 0.
5. Locate the metal tower pins and frame bolts in the scanner's toolbox. There are four pins per leg, two on each side. Place the pins in the center holes. Tap them in place with a rubber mallet.
6. There are four bolts per leg. Place bolts in outer holes. Tighten bolts with a half-inch wrench, a half-inch socket and socket wrench.
7. Place footpads beneath the scanner frame's legs and truss. The smaller pads go under the tips of Leg 0 and Leg 1. The double-stacked pad goes under the truss frame, where it connects with Tower 1.
8. Locate the support block and place it in front of Tower 1's bracket.
9. Remove Tower 1 from the crate. Align it with Tower 1's bracket.
10. Once aligned, put a bolt through the aligned bolt holes. Do <u>not</u> tighten the bolt. <u>Make certain that the track and motor are facing up.</u>
11. Raise the tower into the upright position. Place metal pins into the center holes of the bracket. Tap in securely with a rubber mallet. <u>Do not hold or lift</u>

the vertical towers using the scan head arm support. Only use the black painted surfaces of the towers or the rubberized handles.

12. Insert the three remaining bolts, and tighten all of them.
13. Place a support block on one of the legs in front of Tower 0's bracket (on the side from which you will be lifting.)
14. Remove Tower 0 from the crate; make sure that the track is facing away from Tower 1.
15. Repeat Steps 8 through10.
16. Level the frame at this point.
17. Remove the counterweight locking bolts.
18. Slowly lower the motion carriage, by hand, to approximately three feet above the ground. Pinch the belt together and fasten with two clamps.
19. Carefully remove the scanner head's arms from the crate.
20. Have two assistants hold the scanner arm in place. Align it with the motion carriage and thread the M8 screws (three per arm) into place; hand tighten.
21. Keep the belt pinched with hand pressure. Remove both clamps. The arm should be balanced with the counter weight. Remove hand slowly from the belt.
22. Raise the arm slowly, using the belt, until it's in the upper position.
23. Attach and plug wires into their proper positions. (Wires and all corresponding locations on the towers are labeled).
24. The wires running along the truss should be tucked underneath it.
25. Place the platforms over the truss. Make certain you don't catch any wires under the sides of the platform as this may damage the wires.
26. Level platforms.
27. Assemble the enclosure/tent around the scanner.

A.7 WBX SCANNER DISASSEMBLY

1. Exit the scanning software if it is currently running.
2. Turn the power off at the scanner's power supply.
3. Disconnect the USB cable that runs from the scanner to the PC.
4. Disconnect the AC cord.
5. Disconnect the scan head power cables and USB cables from the scan heads.
6. Remove the cables from the holding clips on the scan head arms.
7. Remove the power supply from the enclosure, if necessary.
8. At the power supply, disconnect the motor, encoder, and home switch cables.
9. Disconnect the USB multi-switches and remove them from each tower.
10. Disconnect any remaining cables and place all cables into a shipping container.
11. Draw the motion carriage on Tower 1 toward the floor by carefully pulling the belt attached to it. There is a 30-pound counterweight attached to the carriage, so exercise extreme care not to release the belt or allow it to run free. Bring the carriage to a distance of one meter (3 feet) above the floor.

12. Use the clamps to pinch the belt on Tower 1 together, in order to provide enough friction to hold the counterweight. Slip the belt on itself slightly to ensure that the teeth lock into one another.
13. Dismount Arm 2/3 by removing the M8 × 20 screws while two assistants support the ends of the scan head arm. Do not remove the motion carriage.
14. Carefully move the arm to a location near the shipping container and gently set it down.
15. Draw the motion carriage on Tower 0 toward the floor by carefully pulling on the belt attached to it until it is one meter (three feet) above the floor. Use the same care you used for Tower 1 (step 11.)
16. Repeat Step 12 for Tower 0, and Steps 13 and 14 for Arm 0/1.
17. Place the two arms (with scan heads fully attached) into the crate.
18. Hold the belt in place and then release the clamps. Do not allow the motion carriage to drop. Hold it in position by squeezing the belt together and keeping the teeth of the belt tightly locked.
19. Slowly raise the motion carriage until the counterweight is at the bottom of the tower.
20. Place the counterweight locking bolt into position before lowering the tower.
21. Locate the 180mm × 90mm × 90mm (7" × 3.5" × 3.5") assembly block in the toolbox.
22. Remove the taper pins from Tower 1 by pulling them out with pliers. Leave the nut, washers, and bolt from the top inside hole (only) in the tower mounting bracket to provide a pivot point to lower the tower.
23. One or two assistants should now steady the tower in preparation for removing the remaining bolts. Do not hold or lift the vertical towers using the scan head arm support bracket. Only use the black painted surfaces of the towers or the rubberized handles.
24. Remove the three remaining bolts, three flat washers, three lock washers and three nuts. Thread the nuts to the bolts and place them into the appropriate bag for shipping.
25. Place the support block into position on the main truss, near Tower 0.
26. Lower Tower 1 until it contacts the support block.
27. Remove the remaining bolt from the mounting bracket, then place the tower into the shipping crate.
28. Move the support block to the end of Tower 1’s main truss in preparation for lowering Tower 0.
29. Repeat Steps 18 through 27 for Tower 0.
30. Raise the leg end (the end of the main truss that the platform legs attach to) of the main truss using a 2" × 4" board or some other piece of wood (large telephone directories also work well). This will make the removal of the hardware easier to accomplish.
31. Use pliers to remove the eight taper pins that align the legs to the main truss.
32. Remove the platform legs from the main truss; eight ½" × 13” nuts, 5½" bolts, lock washers, and flat washers for each leg. This procedure requires a half-inch wrench and a half-inch socket and socket wrench.

33. Place all fasteners and taper pins into a bag and secure them in the scanner's toolbox.
34. Place the two legs in the shipping container.
35. Place the main truss in the shipping container.
36. Secure the scanner in the shipping container using tie-downs, straps, and clamps.
37. Slide the crate top over the shipping crate.
38. Secure the top of the crate to the crate by a series of bolts and klimps.

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APPENDIX B
HEAD SCANNER (PX)

B.1 GENERAL INFORMATION

The head scanner (PX) is a low-power infrared laser system (Figure B-1) that will not damage the body in any way. It is comparable to a flash bulb on a camera. The scans take approximately 15-20 seconds to complete. The most delicate part of a scanner is referred to as the head. The scanner head contains four cameras, two lasers, and four mirrors. It is important never to touch or bump the scanner heads. Any such impacts could cause misalignment of the components within the head that may render it impossible to fix or recalibrate. The software for subject scanning, CyScan, runs on the Windows XP operating system. The computer associated with the scanner has been set up so that it will only connect with the in-house Anthrotech network. Scan data files should be transferred over this network via Ethernet data cable connection to the system server; a CD/DVD can be used if necessary.

FIGURE B-1
Head Scanner (PX)

B.2 PX DAILY SYSTEM BOOT-UP

1. Remove the black plexiglass covers from the camera and laser slots on the scanner heads.
2. The computer system needs to be fully booted up prior to starting the PX systems controller.
3. The PX USB cable should be connected to the computer. Make sure the cable is properly and firmly seated in its appropriate connecting slots on both the computer and system controller.
4. Next the PX system controller should be powered up. The PX scanner will take approximately five minutes to power up properly.
    a. You can check to see if all the PX components have loaded up by going to the computer management window.
    b. Look for the PX system hardware. Click on the “+” sign next to the PX system hardware. This should bring up a list of nine PX system components.
    c. If hardware components do not appear, disconnect and reconnect the PX USB cable on both ends. Wait for components to appear in the computer management window.

B.3 PX DAILY CALIBRATION

Calibration must be performed on a daily basis. This is done through the use of a calibration object. The calibration object is a dark gray cylinder, 1.5 feet in length and 112.73 millimeters in diameter, with five colored dots arranged in a column on the outer surface.

1. Place the calibration object on the stand.
2. Double click “CyScan Head” icon to open the program.
3. Click the green “scan” button to begin the scan. The scanner head will return to its starting position before performing the scan.
4. Press “CTRL+SHIFT+U” to bring up the “utility” menu and select “range calibration.”
5. Enter the target cylinder diameter: 112.73 mm.
6. When prompted, pick a point approximately two inches from the bottom of the cylinder.
7. Next pick a point approximately two inches from the top of the cylinder.
8. The computer will calculate the alignment. If the alignment falls outside of the acceptable +/- .35 range, re-alignment is required. Save both alignment adjustment columns and the software will perform the automatic alignment. This should be done for maps 0 – 3 in range calibration.

B.3.1 Prior to Scanning

When the participant enters the scanning room, a technician will show the participant to the changing room and ask him/her to change into the appropriately sized scan wear. A wig cap will be placed on the participant's head in order to produce the highest quality scans. After the participant is changed, the technician will place adhesive dots on specific landmarks for scanning. Several 2-D orange dots will be placed over the appropriate landmarks, and wood plugs over the acromion landmarks. The participant will then be directed to whichever scanner is available.

B.3.2 PX Participant Positioning

1. Once the participant is seated, make sure his/her head is within the scanner field by adjusting the height of the chair.
2. Ask the participant to look straight ahead, aligning the head in the Frankfurt plane. Then, ask the participant to lift his/her chin slightly; this allows the scanner to clearly see the region beneath the chin.
3. The stabilizer should be aligned with the vertex region. Adjust the position of the head, torso, and waist to achieve this alignment.
4. Make sure that all landmark dots are in place and the wig cap is placed correctly.

B.4 OPERATIONAL GUIDE FOR THE PX

1. Double click "CyScan Head" icon to open the program.
2. Click the green "scan" button to begin the scan.
3. Bring up CyScan Head software for the head scanner.
4. Perform a positioning check for correct posturing of subject (see above).
5. Scan in the participant's barcode (with the hand-held barcode scanner)
6. Scan the participant.
7. Once the scan is complete, perform an evaluation of the image.
8. If the scan image passes checks, then the participant is finished. If it does not pass, then correct for appropriate errors and rescan.
9. Due to time constraints, do not perform more than two scans per subject unless the immediate cause of error is known.

B.5 PX ASSEMBLY

1. Unpack the arm, base, foot plates, chair, and ground pad from shipping Crate #3.
2. Place the base onto the foot plates.
3. Place the arm on to the base. Align the opening in the hub flange with the guide pin.

4. Place and tighten screws. Be sure to place a washer first, then a screw/nut lock, and then the screw.
5. Use a level to level the base. The feet must be rotated using a wrench.
6. Carefully unpack and remove the scanner head from shipping Crate #2. Two people should support the shipping arm and a third person should support and guide the hub.
7. Guide the hub flange up so that it aligns with the guide pin. The hub should be resting on the guide pin. Place and tighten the screws.
8. Once the scanner head is positioned and secured, remove the shipping arm.
9. Connect the stabilizer to the hub.
10. Have a single operator go over every bolt to double check washer/lock/bolt to check for correct placement and tightness.
11. Connect all the cables. Be sure to connect cables (located on the arm's frame) both to the scanner heads and to the power/data unit.
12. Place the ground pad into position with the chair centered directly under the stabilizer.
13. Attach the PX scanner's USB cable to the PX computer.
14. Recheck the level of the base and adjust as needed. Make sure motion arm is along the guide arm of the scanner.

B.6 PX DISASSEMBLY AND PACKING INSTRUCTIONS

The PX Scanner is transported in two separate crates. The head is transported in Crate #2, and the arm, base, foot plates, chair, and ground pad are transported in Crate #3.

1. Turn off the system and disconnect it from the power sources.
2. Clear the area around the scanner of any chairs, tables, or other obstructions.
3. Disconnect the cables that attach near the head's arm joint.
4. Remove the stabilizer from the hub.
5. Rotate the arm away from the frame.
6. Install the shipping arm. Make sure it is against the upper camera head.
7. Station two people, one at each end of the shipping arm. They should provide stabilization of the scanner head while the next step is performed. The hub may rotate slightly on the support pin as the screws are removed.
8. Loosen and remove all but one of the hub attachment screws. (Do not remove the top guide pin. This pin serves as a guide and support for the hub and should remain attached to the frame.
9. Position three people as follows: one at either end of the shipping arm and the third at the hub. Remove the last screw, and lift the hub from the support pin. All three people should lift slowly and carefully. Once the hub flange is clear of the frame arm, the hub should be lowered into the cradle. The shipping arm's mounting block should be located directly over the marked screw holes.
10. Check to make sure the scanner head is secure in the mounts.

11. Place the hub's cover block over the hub and strap in place.
12. Align and thread the four attaching screws to secure the shipping arm's mounting plate.
13. Crate #2 can now be closed and readied for shipping.
14. Next, loosen and remove all but one of the arm attachment screws. (Do not remove the rear guide pin. This pin serves as a guide and support for the scan arm and should remain attached to the frame.
15. While one person supports the arm, remove the remaining screw. Swing the arm off the base, taking care not to torque the guide pin.
16. Pack arm, base, feet plates, chair, and ground pad into Crate #3.

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APPENDIX C
FOOT SCANNER

C.1 GENERAL INFORMATION

The foot scanner is a low level laser system that will not damage the body in any way. It is comparable supermarket checkout scanner. The software for participant scanning, INFOOT, runs on the Windows XP operating system. The computer associated with the scanner has been set up so that it will only connect with the in-house Anthrotech network. Scan data files should be transferred over this network via Ethernet data cable connection to the system server, or using a CD/DVD if necessary. The system is automated between the software and hardware, with scans taking approximately 15 – 20 seconds to complete.

C.2 ASSEMBLY

1. Remove the foot scanner from the case along with the 2 foot stages and the 3 components of the hand rail.
2. Attach the foot stages to the left and right sides of the foot scanner (Figure C-1).
3. Attach handrail 1 and 2 by screwing the large screws into the left and right sides of the scanner cover (Figure C-1).
4. Place handrail 3 on top of handrail 1 and 2 and secure by screwing the small screws into place (Figure C-1).

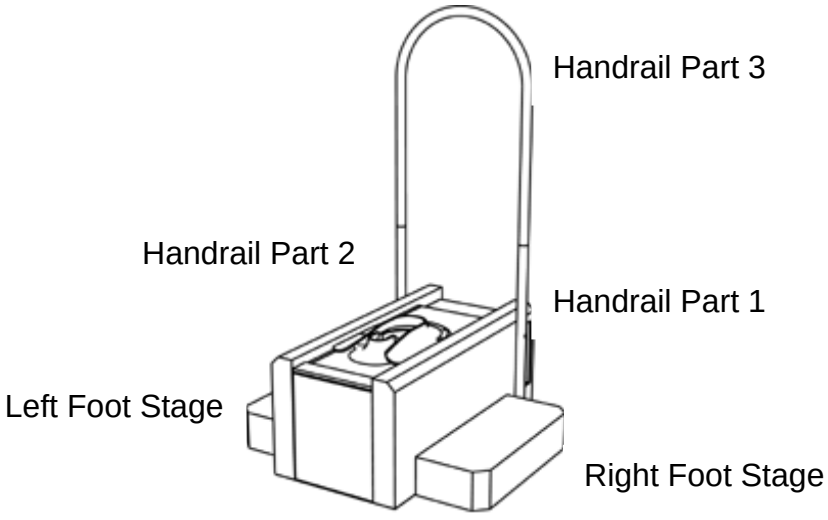

FIGURE C-1
Foot Scanner

C.3 DAILY SYSTEM BOOT-UP

1. Connect power cord to scanner and power source.
2. Connect USB 2.0 cable to scanner and PC.
3. Turn scanner on.
4. Start PC. After PC execution, the INFOOT driver is recognized. The INFOOT system will automatically start to move scanner head to original position. Wait until scanner head stops before proceeding.

C.4 CALIBRATION

1. Locate the calibration tools, jig A and B.
2. Flip the glass plate at the bottom of the scanner.
3. Start INFOOT Tester program.
4. Select calibration from the menu bar.
5. Press “Load Voltage” button to load camera voltage and laser voltage, then press the two “Set” buttons.
6. Create layer table by scanning the calibration tools in the four proper positions:
   Y-Layer 1 = position 1
   Z-Layer 1 = position 2
   Y-Layer 2 = position 3
   Z-Layer 2 = position 4
7. Click each button to scan the calibration tool for each position and then press “Create Layer Table.”
8. Flip the glass plate at the bottom of the scanner to the original position.
9. Scan an individual’s foot. Be sure to protect the scan area from outside light. After the foot is scanned, select “Cross Section View” and move slider to view the scanned cross sections.
10. Black and red lines should be aligned. If they are not aligned, adjust the red and black color lines until they appear as one line. Adjustments are completed in the “Start Field Set” area. Use the movement direction chart to adjust values.
11. In the horizontal movement, entering plus values moves the line left and negative values moves the line right.
12. In the vertical movement, entering plus values moves the line down and negative values moves the line up.
13. Once finished with the layer table, click “Save Layer Data.”
14. To erase noise, select camera view and view mask. A mask is generated by the Y and Z plate scan images of the same camera number. The red color mask line shows corresponding double layered area by starting fields. The red color mask line should be inside of the black color plate area.
15. If an irregular area (black color) appears outside of the red line, trim the irregular plate area by selecting an eraser appropriate for the noise area and erase any noise. Next click the “Redraw” button. Repeat this process for

each camera under each layer.

16. Click “Save layer data” button to save data and start field numeric values.
17. After erasing all of the noise of the camera, create a final calibration table by clicking “Layer Table Create” button.
18. Save the calibration table by clicking “Save Calib Table” button to save created calibration table.

C.5 DAILY OPERATION AND HARDWARE CHECK

1. Start the INFOOT Tester program.
2. Check devices:
    a. Laser check: Click laser ON/OFF button and observe if lasers are working.
    b. Motor check: Click forward, backward and stop button to check actuator movement.
3. Check cross sections:
    a. Scan an individual’s foot.
    b. Click the cross section view and move the slider. The scanned data appears as cross sectioned data. Observe colored cross section. If all of the dots are aligned, the foot scanner is ready for participant scanning. If cross section is not aligned, recalibration is needed.

C.6 PARTICIPANT PROCEDURAL GUIDE FOR FOOT SCANNER

1. Introduce yourself. “Hi, my name is [name]; I will walk you through the scan process and perform the scan functions today.”
2. Scanning process
    a. Lead participant to the scanner; explain that the scanner uses low power lasers that are not harmful.
    b. If the participant has noticeable leg hair, ask the participant to put on a stocking from ankle to knee to compress the hair to prevent scan distortion. REMEMBER: Ask participant’s permission before touching them, do not assume!
    c. Ask participants to step onto the left foot stage with their left foot, and place their right foot into the scanner. Wrap the sanitary protective paper around the leg just below the knee where the scanner will close around the leg. Align the center of the foot with the center of the bar at the bottom of the scanner. Close the top of the foot scanner and wrap the light blocking plastic around the participant’s leg and the opening of the foot scanner. Have the participant distribute their weight evenly between both feet.
    d. Let participant know you are starting scan and to hold their foot as still as possible.

e. Once the scan is complete let the participant know. Inform them that they may relax but need to remain in scanner until told otherwise (rescans may be necessary).

3. Thank participant after scan process is complete.

Remember the participant is a volunteer here under informed consent and may stop the process at any time they choose. If this occurs inform the field supervisor who will speak with the military liaison.

APPENDIX D

SOURCES AND SPECIFICATIONS FOR ANTHROPOMETRIC AND LANDMARKING INSTRUMENTS

Standard anthropometric instruments are made by GPM, Switzerland and by Holtain LTD, Great Britain. Seritex, Inc., 1 Madison Street, East Rutherford NJ 07073 (www.seritex.com) is the US distributor for both companies. The steel tape measure is a Lufkin Executive Diameter metric tape measure (W606PM) manufactured by Cooper Hand Tools and available from on-line retailers at www.cooperhandtools.com.

These instruments are illustrated below in Figures D-1 through D-7.

FIGURE D-1
Anthropometer: Assembled and in Parts

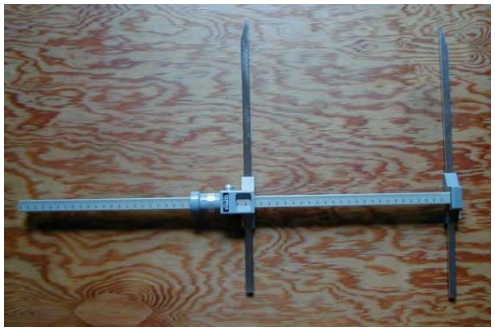

FIGURE D-2
Beam Caliper

FIGURE D-3
Spreading Caliper

FIGURE D-4
Sliding Caliper

FIGURE D-5
Holtain Caliper

FIGURE D-6
Poech Sliding Caliper

FIGURE D-7
Steel Tape

A battery operated digital scale manufactured by Seca is used for measuring body weight (Figure D-8). It is widely available through a number of online retailers.

FIGURE D-8
Scale

A digital read out Hoya pupillometer using corneal reflection/hairline alignment method is used to measure interpupillary distance (Figure D-9). This pupillometer can be ordered online from www.GetOptic.com.

FIGURE D-9
Pupillometer

Measuring instruments that were modified or created for the survey include: foot measuring devices, a modified Vernier height gauge, and a wall chart.

The foot measuring devices are a Men's Brannock Device size 4-16/width 3A-3E (used for both men and women) and a Pro Series Brannock Device size 10-25 (used for large sizes); both were modified with Kreg Model KMS729 L-R reading metric measuring tape (Figure D-10). They can be obtained from The Brannock Device Company, Inc., 116 Luther Avenue, Liverpool NY 13088 (www.brannock.com) and Kreg Tool Company, 201 Campus Drive, Huxley IA 50124 (www.kregtool.com).

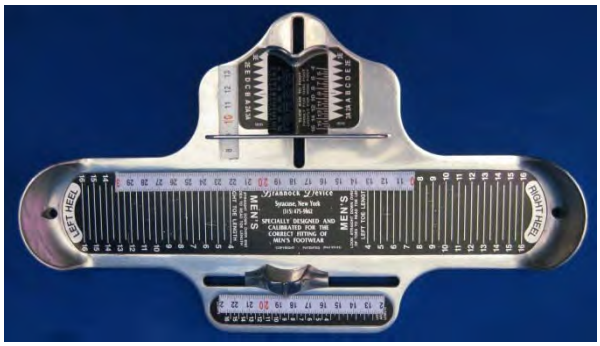

FIGURE D-10
Modified Brannock Device

A standard metric Vernier height gauge was modified to use in measuring LATERAL MALLEOLUS HEIGHT and ACROMION-WALL DEPTH (Figure D-11). The metal base was replaced with a wooden base and its carbide tip was blunted. A similar model (Series H04, Id: 161-103k) can be obtained at the Tresna On-Line-Store (www.tresnainstruments.com).

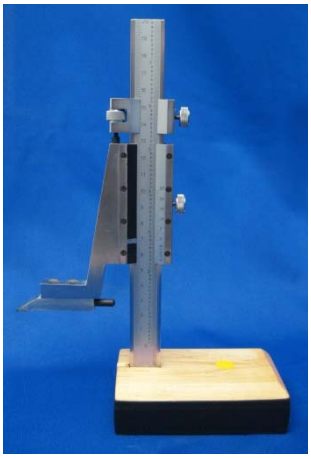

FIGURE D-11
Modified Height Gauge

A wall graph made of drafting mm graph paper sealed in Mylar sheeting is used to measure THUMBTIP REACH and SPAN (Figure D-12). The graph paper is marked with 5 cm and 10 cm divisions. This graph is 230 cm wide and 50 cm from an adjacent wall, which serves as the back plane for the measurements.

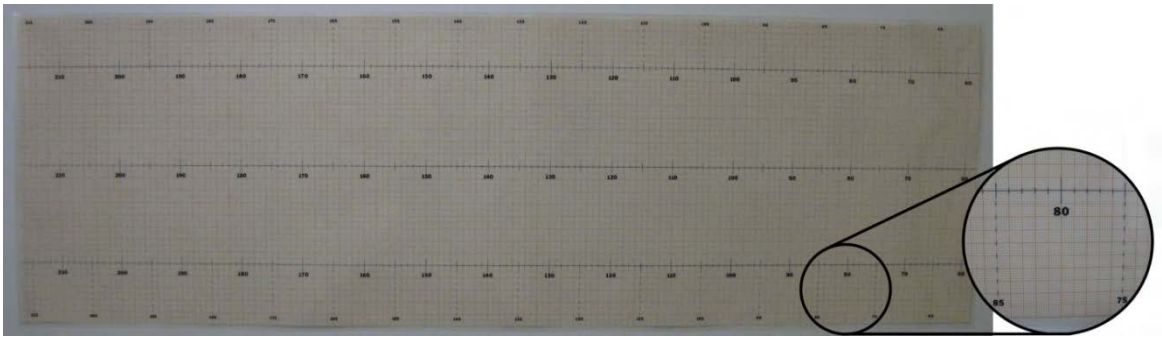

FIGURE D-12
Wall Chart

A number of measuring and marking aids are used in this study including a landmark transfer rod, scye marking aid, and a modified tape. The base of the landmark transfer rod has five casters, on the bottom to permit the device to be easily rolled around the subject (Figure D-13). A slide that can be moved up and down is mounted on the vertical rod. The device is used to transfer landmarks from one side of the body to the same level on the other side. The dimensions of the landmark transfer rod are as follows:

Total height = 184 cm
Pentagonal base measuring 21 cm on each of the 5 sides
Arm length = 34 cm
Arm end width = 35 cm
Rod diameter = 1.85 cm
Wheel circumference = 15.8 cm
Ground to base height (bottom) = 6.2 cm
Ground to base height (top) = 6.8 cm
Base thickness = 1.9 cm
Square base on pentagonal base = 20 cm x 20 cm

FIGURE D-13
Landmark Transfer Rod

The scye marking aid is a rigid plexiglass straight edge 480 mm long, 35 mm wide, and 3 mm thick (Figure D-14). A line level is epoxied to the lower left margin of the straight edge. This device is used to establish the anterior and posterior scye marks.

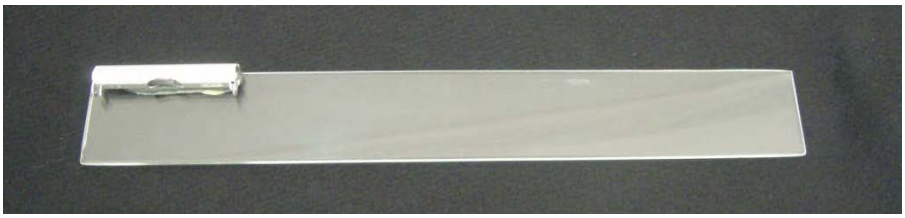

FIGURE D-14
Scye Marking Aid

The modified steel tape, used for CROTCH LENGTH, POSTERIOR (OMPHALION), is made by attaching a dowel (5" long by 1/4" in diameter) to the zero end of the standard steel tape as a hand hold (Figure D-15). A 2-cm triangular plastic pennant is affixed at the zero mark of the tape.

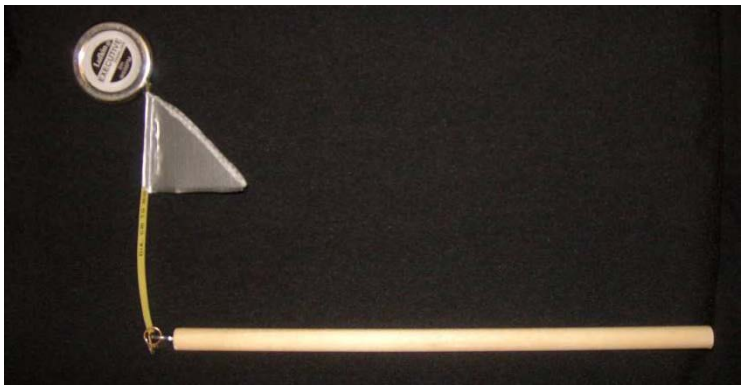

FIGURE D-15
Modified Steel Tape

APPENDIX E

DATA FORMS

(Reprint of original)

ANSUR II - MC-ANSUR STATION HEAD/HAND/FOOT

SUBJECT _____ MEASURER _____

TIME IN _____ RECORDER _____

TIME OUT _____ DATE _____

HAND CIRCUMFERENCE	_____
HAND BREADTH	_____
HAND LENGTH	_____
PALM LENGTH	_____
INTERPUPIL BREADTH	_____
TRAGION-TOP OF HEAD	_____
MENTON-SELLION LGTH	_____
EAR LENGTH	_____
EAR BREADTH	_____
EAR PROTRUSION	_____
HEAD BREADTH	_____
HEAD LENGTH	_____
BIZYGOMATIC BREADTH	_____
BITRAG CHIN ARC	_____
BITRAG SUBMAND ARC	_____
HEAD CIRCUMFERENCE	_____
CALF CIRC (3 X'S)	_____ _____ _____
ANKLE CIRCUMFERENCE	_____
HEEL ANKLE CIRC	_____
BALL OF FOOT CIRC	_____
BIMALLEOLAR BREADTH	_____
HEEL BREADTH	_____
LAT MALLEOLUS HEIGHT	_____
BALL OF FOOT LENGTH	_____
FOOT LENGTH	_____
FOOT BREADTH HORIZ	_____

ANSUR II - MC-ANSUR STATION REACHES

SUBJECT _____ MEASURER _____

TIME IN _____ RECORDER _____

TIME OUT _____ DATE _____

SITTING HEIGHT	_____		
EYE HEIGHT SITTING	_____		
ELBOW REST HEIGHT	_____		
THIGH CLEARANCE	_____		
KNEE HEIGHT SITTING	_____		
POPLITEAL HEIGHT	_____		
BUTTOCK-KNEE LENGTH	_____		
BUTTOCK-POP LENGTH	_____		
WAIST FRONT LENGTH (supr-omph)	_____		
BIACROMIAL BREADTH	_____		
BIDELTOID BREADTH	_____		
FOREARM-FOREARM BREADTH	_____		
ABDOM EXT DEPTH SITTING	_____		
HIP BREADTH SITTING	_____		
FUNCTNL LEG LENGTH	_____		
OVHD FGTP REACH SITTING	_____		
ACROMION TO WALL	_____		
THUMBTIP REACH (3 X'S)	_____	_____	_____
SPAN	_____		

ANSUR II - MC-ANSUR STATION STANDING

SUBJECT _____ MEASURER _____

TIME IN _____ RECORDER _____

TIME OUT _____ DATE _____

STATURE	
CERVICALE HEIGHT	
ACROMIAL HEIGHT	
SUPRASTERNALE HEIGHT	
AXILLA HEIGHT	
TENTH RIB HEIGHT	
ILIOCRISTALE HEIGHT	
WAIST HEIGHT OMPH	
WRIST HEIGHT	
ACROM-RADIALE LENGTH	
RADIALE-STYLION LENGTH	
SHOULDR-ELBOW LENGTH	
FOREARM-HAND LENGTH	
FOREARM-CTR OF GRIP LGTH	
NECK CIRCUMFERENCE	
NECK CIRCUMFERENCE BASE	
WAIST BACK LENGTH OMPH	
INTERSCYE I	
INTERSCYE II	
SLEEVE L SPNE-WRST	
SHOULDER LENGTH	
SLEEVE OUTSEAM	
BICEPS CIRC FLEXED	
FOREARM CIRC FLEXED	
WRIST CIRCUMFERENCE	
WEIGHT	

ANSUR II - MC-ANSUR STATION TORSO

SUBJECT _____ MEASURER _____

TIME IN _____ RECORDER _____

TIME OUT _____ DATE _____

SHOULDER CIRCUMFERENCE _____

CHEST CIRCUMFERENCE _____

WAIST CIRC OMPH _____

VTC (USA) _____

CHEST BREADTH _____

WAIST BREADTH _____

BICRISTAL BREADTH _____

CHEST DEPTH _____

WAIST DEPTH _____

CHEST HEIGHT _____

BUTTOCK HEIGHT _____

TROCHANTERION HEIGHT _____

LAT FEM EPICOND HEIGHT _____

KNEE HEIGHT MIDPATELLA _____

TIBIAL HEIGHT _____

CROTCH HEIGHT _____

BUTTOCK DEPTH _____

HIP BREADTH _____

BUTTOCK CIRCUMFERENCE _____

THIGH CIRCUMFERENCE _____

LOWER THIGH CIRC _____

CROTCH LENGTH OMPH _____

CROTCH L POST OMPH _____

USMC Anthropometric Survey (MC-ANSUR)

Natick Soldier Research, Development & Engineering Center

Biographical Questionnaire

Thank-you for helping to update the USMC's anthropometric database.

INSTRUCTIONS:

Please respond to the questions on the following pages by completely filling in the bubble that corresponds with your answer. Please do not use checkmarks or Xs.

Marking Instructions
Use a No. 2 pencil, only. Do not use ink, ballpoint pen, or felt tip pens.
Make solid marks that fill the response completely.
Erase cleanly any marks that you want to change.
Make any write-in responses on the lines or boxes provided.
Correct: ′ Incorrect: 

1. Last Name: _____ First Name: _____

2. What is your gender? ϒ Male ϒ Female

3. What is your current rank / grade?

Enlisted		Warrant Officer		Officer	
1	Pvt	1	WO	1	2nd Lt
2	PFC	2	CW02	2	1st Lt
3	LCpl	3	CW03	3	Capt
4	Cpl	4	CW04	4	Maj
5	Sgt	5	CW05	5	LtCol
6	SSgt			6	Col
7	GySgt			7	BGen
8	MSgt			8	MajGen
8	1stSgt			9	LtGen
9	MGySgt			)	Gen
9	SgtMaj				
9	SgtMaj MC				

4. Today's date: (mm/dd/yyyy) _____ / _____ / _____

5. Installation: _____

6. Component: ϒ Regular USMC ϒ USMC Reserve

7. Element you are in:
   - ϒ Command Element (CE)
   - ϒ Aviation Combat Element (ACE)
   - ϒ Ground Combat Element (GCE)
   - ϒ Logistics Combat Element (LCE)

8. Please identify your unit: (ex, 1st Battalion First Marines, 9th Comm Battalion)
   _____

9. Please identify your primary MOS: (ex: 03 field 0311 Basic Infantryman, etc)
   _____

10. Please identify the state, territory, foreign country or military installation where you were born. _____

11. Your Population Subgroup: (please mark all that apply)
    - ϒ White, not of Hispanic Origin
    - ϒ Black, not of Hispanic Origin
    - ϒ Hispanic (please mark all that apply)
      - ϒ Mexican
      - ϒ Latin American: _____
      - ϒ Puerto Rican
      - ϒ Other Hispanic: _____
      - ϒ Cuban
    - ϒ Asian or Pacific Islander (please mark all that apply)
      - ϒ Chinese
      - ϒ Japanese
      - ϒ Korean
      - ϒ Vietnamese
      - ϒ Filipino
      - ϒ Samoan
      - ϒ Guamanian/Chamorro
      - ϒ Melanesian
      - ϒ Micronesian
      - ϒ Polynesian
      - ϒ Other Pacific Islander: _____
      - ϒ Other Asian: _____
    - ϒ Native American (please mark all that apply)
      - ϒ Eskimo
      - ϒ Aleut
      - ϒ U.S./Canadian Tribe(s): _____
    - ϒ Other (please mark all that apply)
      - ϒ East / Asian Indian
      - ϒ Arab or Middle Eastern
      - ϒ Caribbean Islander
      - ϒ Other: _____

12. Please identify the state, territory, foreign country or military installation where your MOTHER was born. _____

13. Your MOTHER'S Population Subgroup. (Please mark all that apply.)

- ϒ White, not of Hispanic Origin
- ϒ Black, not of Hispanic Origin
- ϒ Hispanic (please specify) _____
- ϒ Asian or Pacific Islander (please specify) _____
- ϒ Native American (please specify) _____
- ϒ Other (please specify) _____
- ϒ Don't know

14. Please identify the state, territory, foreign country or military installation where your FATHER was born. _____

15. Your FATHER'S Population Subgroup. (Please mark all that apply.)

- ϒ White, not of Hispanic Origin
- ϒ Black, not of Hispanic Origin
- ϒ Hispanic (please specify) _____
- ϒ Asian or Pacific Islander (please specify) _____
- ϒ Native American (please specify) _____
- ϒ Other (please specify) _____
- ϒ Don't know

16. When did you return from your last deployment?

ϒ Never deployed ϒ Less than 1 month ago ϒ 1-3 months ago
ϒ 4-6 months ago ϒ 7-12 months ago ϒ More than 1 year ago

17. Where were you last deployed?

ϒ Iraq ϒ Other _____
ϒ Afghanistan ϒ N/A (I have never deployed)

18. Are you scheduled for deployment in the near future?

ϒ Not scheduled ϒ Less than 6 months from now
ϒ More than 6 months from now ϒ Don't know

Write-in answers to the following questions on the lines provided.
Fill in the bubbles below each question to correspond to the numbers you enter on the line.
For numbers which are only 1 digit, fill in a zero in the first column. (See example)

EXAMPLE

__6__

'	0
1	1
2	2
3	3
4	4
5	5
6	'
7	7
8	8
9	9

19. Age_____

0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

20. Birthdate:

Month (mm)_____		Day (dd)_____		Year (yy)_____	
0	0	0	0	0	0
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9

21. Height:

Feet_____	Inches_____	
0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

22. Weight:

Pounds_____

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

23. Writing preference:

ϒ Right hand ϒ Left hand ϒ Either hand (no preference)

Please do not write in the area below this line

US Army Anthropometric Survey (ANSUR II)

Natick Soldier Research, Development & Engineering Center

Biographical Questionnaire

Thank you for helping to update the Army's anthropometric database.

INSTRUCTIONS:

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Marking Instructions

Use a No. 2 pencil, only. Do not use ink, ballpoint pen, or felt tip pens.

Make solid marks that fill the response completely.

Erase cleanly any marks that you want to change.

Make any write-in responses on the lines or boxes provided.

Correct: ● Incorrect: 

1. Last Name: _____ First Name: _____

2. What is your gender? ○ Male ○ Female

3. What is your current rank / grade?

Enlisted	Warrant Officer	Officer
① Private	① W01	① 2LT
② PV2	② CW2	② 1LT
③ PFC	③ CW3	③ CAPT
④ CPL	④ CW4	④ MAJ
④ SPC	⑤ CW5	⑤ LTC
⑤ SGT		⑥ COL
⑥ SSG		⑦ BG
⑦ SFC		⑧ MG
⑧ MSG		⑨ LTG
⑧ 1SG		⑩ GEN
⑨ SGM		
⑨ CSM		
⑨ SMA		

4. Today's date: (mm/dd/yyyy) _____ / _____ / _____

5. Installation: _____

6. Component: ○ Regular Army ○ Army Reserve ○ Army National Guard

7. Branch you are in:
   - ○ Combat Arms
   - ○ Combat Support
   - ○ Combat Service Support (CSS incl: Med, Vet, Dental, JAG, Chaplain, etc.)

8. Please identify your UIC by number: (ex: WJM5BO, W1D1AA, W6DW04)
   _____

9. Please identify your primary MOS: (ex: 11B; 19D; 79R; 13B; 15P; 25X; 38B; 68A)
   _____

10. Please identify the state, territory, foreign country or military installation where you were born. _____

11. Your Population Subgroup: (please mark all that apply)
   - ○ White, not of Hispanic Origin
   - ○ Black, not of Hispanic Origin
   - ○ Hispanic (please mark all that apply)
     - ○ Mexican
     - ○ Puerto Rican
     - ○ Cuban
     - ○ Latin American: _____
     - ○ Other Hispanic: _____
   - ○ Asian or Pacific Islander (please mark all that apply)
     - ○ Chinese
     - ○ Vietnamese
     - ○ Guamanian/Chamorro
     - ○ Polynesian
     - ○ Other Asian: _____
     - ○ Japanese
     - ○ Filipino
     - ○ Melanesian
     - ○ Other Pacific Islander: _____
     - ○ Korean
     - ○ Samoan
     - ○ Micronesian
   - ○ Native American (please mark all that apply)
     - ○ Eskimo
     - ○ Aleut
     - ○ U.S./Canadian Tribe(s): _____
   - ○ Other (please mark all that apply)
     - ○ East / Asian Indian
     - ○ Caribbean Islander
     - ○ Arab or Middle Eastern
     - ○ Other: _____

If you chose more than one population group, or you chose one of the groups under "Other," what group do you usually select on military questionnaires that don't have these options?

○ White ○ Black ○ Hispanic ○ Asian ○ Native Hawaiian/ Pacific Islander ○ Amer. Indian/ Alaskan Native ○ Other

12. Please identify the state, territory, foreign country or military installation where your MOTHER was born. _____

13. Your MOTHER'S Population Subgroup. (Please mark all that apply.)

- ○ White, not of Hispanic Origin
- ○ Black, not of Hispanic Origin
- ○ Hispanic (please specify) _____
- ○ Asian or Pacific Islander (please specify) _____
- ○ Native American (please specify) _____
- ○ Other (please specify) _____
- ○ Don't know

14. Please identify the state, territory, foreign country or military installation where your FATHER was born. _____

15. Your FATHER'S Population Subgroup. (Please mark all that apply.)

- ○ White, not of Hispanic Origin
- ○ Black, not of Hispanic Origin
- ○ Hispanic (please specify) _____
- ○ Asian or Pacific Islander (please specify) _____
- ○ Native American (please specify) _____
- ○ Other (please specify) _____
- ○ Don't know

16. When did you return from your last deployment?

- ○ Never deployed
- ○ Less than 1 month ago
- ○ 1-3 months ago
- ○ 4-6 months ago
- ○ 7-12 months ago
- ○ More than 1 year ago

17. Where were you last deployed?

- ○ Iraq
- ○ Other _____
- ○ Afghanistan
- ○ N/A (I have never deployed)

18. Are you scheduled for deployment in the near future?

- ○ Not scheduled
- ○ Less than 6 months from now
- ○ More than 6 months from now
- ○ Don't know

Continued on other side...

Write-in answers to the following questions on the lines provided.
Fill in the bubbles below each question to correspond to the numbers you enter on the line.
For numbers which are only 1 digit, fill in a zero in the first column. (See example)

6 ● 0 1 2 3 4 5 6 ● 7 8 9	19. Age_____ 0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9	20. Birthdate: Month (mm)_____ 0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 Day (dd)_____ 0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 Year (yy)_____ 0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9
21. Height: Feet_____ 0 1 2 3 4 5 6 7 8 9 Inches_____ 0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9		22. Weight: Pounds_____ 0 0 0 1 1 1 2 2 2 3 3 3 4 4 4 5 5 5 6 6 6 7 7 7 8 8 8 9 9 9

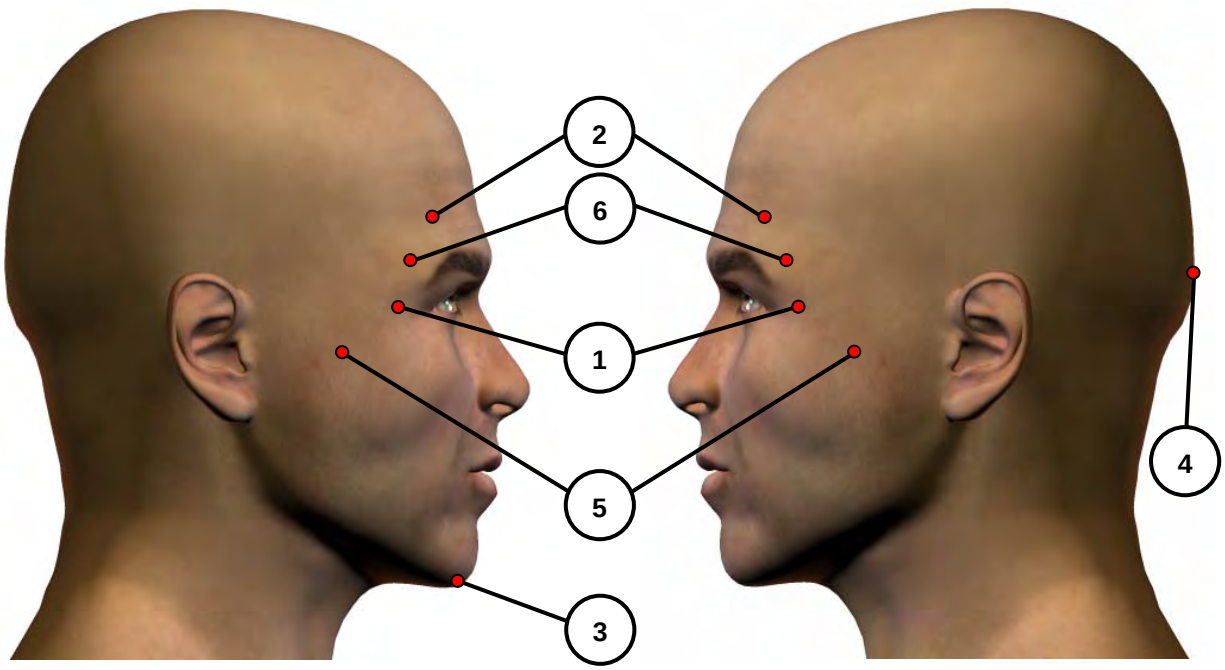
23. Writing preference:

○ Right hand ○ Left hand ○ Either hand (no preference)

Please do not write in the area below this line

○

APPENDIX F
VISUAL INDEX OF SCANNER LANDMARKS



(1) ECTOORBITALE, RIGHT AND LEFT

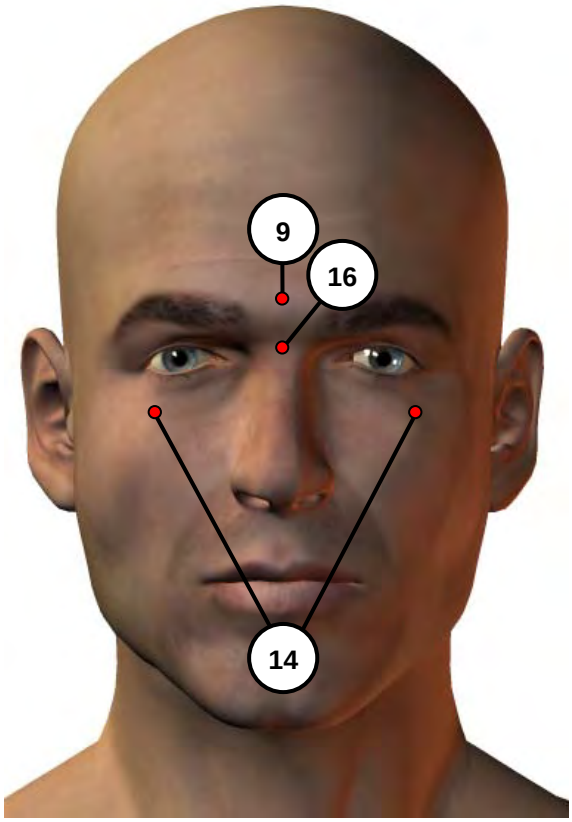
(2) FRONTOTEMPORALE, RIGHT AND LEFT

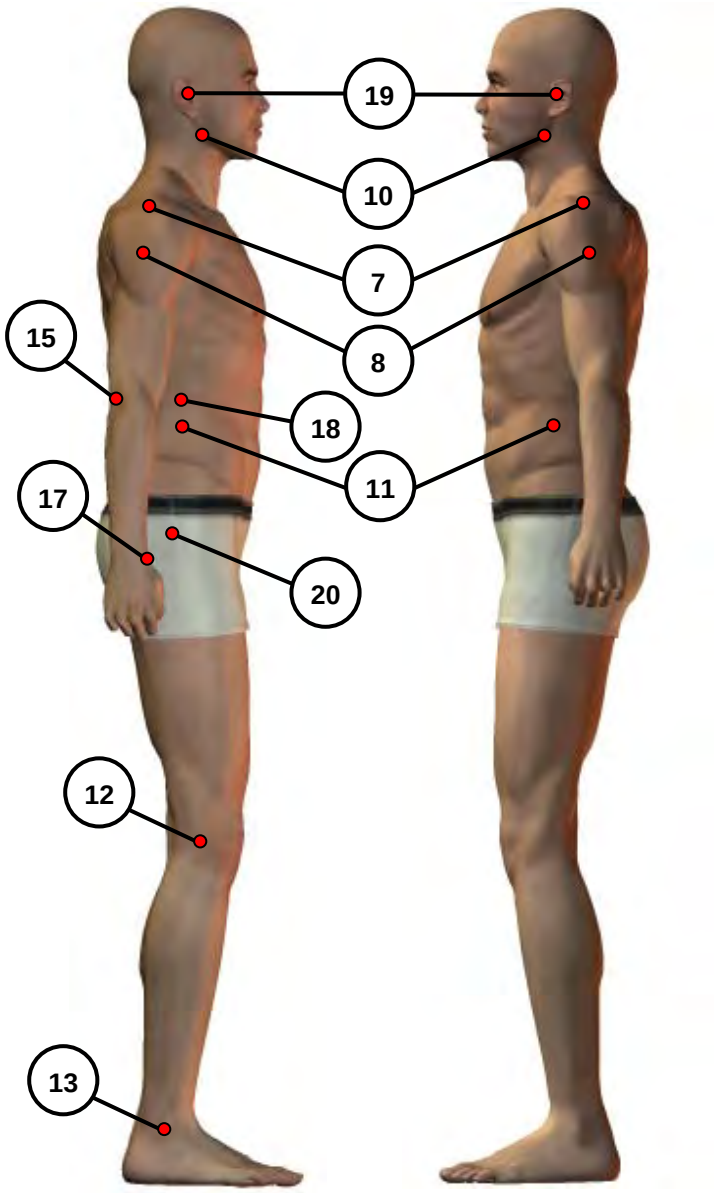
(3) MENTON

(4) OPISTHOCRANION

(5) ZYGION, RIGHT AND LEFT

(6) ZYGOFRONTALE, RIGHT AND LEFT





(7) ACROMION, RIGHT AND LEFT

(8) DELTOID POINT, RIGHT AND LEFT

(9) GLABELLA

(10) GONION, RIGHT AND LEFT

(11) ILIOCRISTALE, RIGHT AND LEFT

(12) LATERAL FEMORAL EPICONDYLE, STANDING, RIGHT

(13) LATERAL MALLEOLUS, RIGHT

(14) ORBITALE, RIGHT AND LEFT

(15) RADIALE, RIGHT

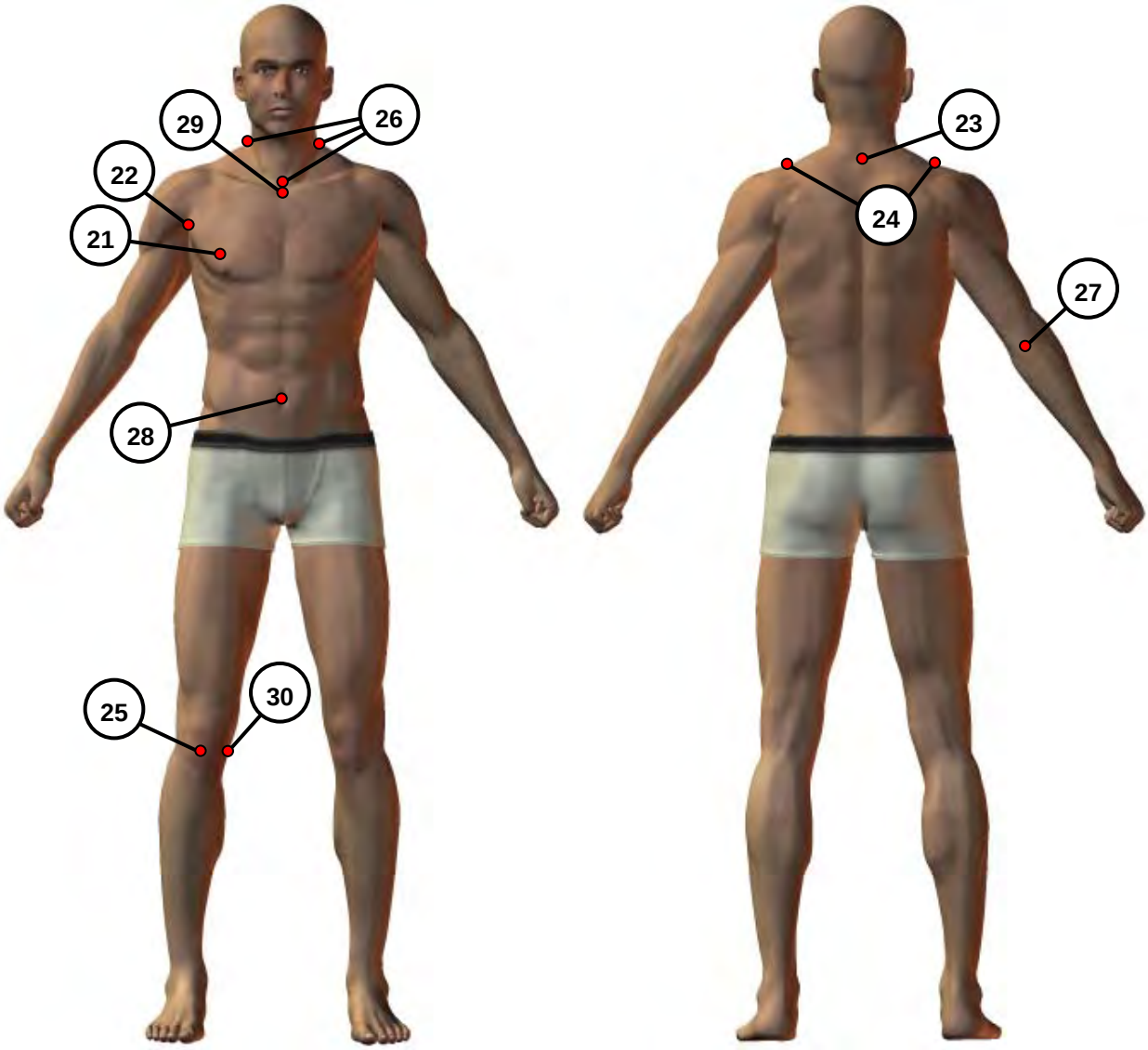
(16) SELLION

(17) STYLION, RIGHT

(18) TENTH RIB, RIGHT

(19) TRAGION, RIGHT AND LEFT

(20) TROCHANTERION, RIGHT



(21) CHEST POINT, ANTEIOR, RIGHT

(22) ANTERIOR SCYE ON THE TORSO, RIGHT

(23) CERVICALE

(24) CLAVICLE POINT, RIGHT AND LEFT

(25) MIDPATELLA, RIGHT

(26) NECK, ANTERIOR, RIGHT LATERAL, LEFT LATERAL

(27) OLECRANON, CENTER, RIGHT

(28) OMPHALION, ANTERIOR

(29) SUPRASTERNALE

(30) TIBIALE, RIGHT

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APPENDIX G
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 participant alike. The problem is particularly acute in military surveys, since participant time is always in lieu of duty time. Some studies of interobserver 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 surveys. This procedure was followed during the 1988 U.S. Army Anthropometric Survey and resulted in high quality data.

G.1 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 participants to learn their assigned dimensions. After the initial practice runs, data will be collected and retained for analysis. 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 participants will be measured and then re-measured 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 are to make daily interobserver error checks. Twice a day, at each station, a subject will be repeat-measured to give error data on actual participants 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 for the survey, 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.

G.2 DETERMINATION OF OBSERVER ERROR

Most of the allowable errors used in this study were established in the 1988 U.S. Army Anthropometric Survey (Gordon et al., 1989). These errors were determined using the following procedures. The dimensions to be measured in the Army survey were measured eight times each on 10 participants. The eight measurement sessions were divided in the following way: four experienced anthropologists each measured each participant twice. Because a single measurement session took between one and two hours, each participant 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 participant 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 misreading 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 participant 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 noted in Table G-1, the amount of allowable error varies considerably among the dimensions. The higher values are generally associated with those measurements which are the most difficult to perform. These include measurements involving the breathing cycle (e.g. chest measurements); those in which participant position is difficult to maintain (e.g. a number of sitting dimensions); those involving participant 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.

The established allowable errors from the 1988 U.S. Army Anthropometric Survey were compared to the actual observer errors. Based on this comparison, the allowable errors on several dimensions were reduced. These dimensions were subjected to a validation trial to verify that reducing the allowable errors was acceptable. For the dimensions that were not part of the previous survey, new allowable errors were established using a procedure similar to that outlined above.

TABLE G-1
Allowable Observer Error for Dimensions in the 2010-2011 USMC Anthropometric Survey and the U.S. Army Anthropometric Survey

Dimensions	Allowable Error (mm)
Abdominal Extension Depth, Sitting	10
Acromial Height	7
Acromion-Radiale Length	4
Acromion-Wall Depth	8
Ankle Circumference	4
Axilla Height	7
Ball of Foot Circumference	4
Ball of Foot Length	2
Biacromial Breadth	8
Biceps Circumference, Flexed	6
Bicristal Breadth	8
Bideltoid Breadth	8
Bimalleolar Breadth	2
Bitragion Chin Arc	8
Bitragion Submandibular Arc	6
Bizygomatic Breadth	2
Buttock Circumference	12
Buttock Depth	8
Buttock Height	4
Buttock-Knee Length	6
Buttock-Popliteal Length	7
Calf Circumference	4
Cervicale Height	7
Chest Breadth	7
Chest Circumference	14
Chest Depth	4
Chest Height	9
Crotch Height	10
Crotch Length (Omphalion)	18
Crotch Length, Posterior (Omphalion)	11
Ear Breadth	2
Ear Length	2
Ear Protrusion	3
Elbow Rest Height	10
Eye Height, Sitting	8
Foot Breadth, Horizontal	2
Foot Length	3
Forearm-Center of Grip Length	7
Forearm Circumference, Flexed	5

TABLE G-1. CONTINUED
Allowable Observer Error for Dimensions in the 2010-2011 USMC Anthropometric Survey and the U.S. Army Anthropometric Survey

Dimensions	Allowable Error (mm)
Forearm-Forearm Breadth	17
Forearm-Hand Length	4
Functional Leg Length	17
Hand Breadth	2
Hand Circumference	3
Hand Length	3
Head Breadth	2
Head Circumference	3
Head Length	2
Heel Ankle Circumference	4
Heel Breadth	2
Hip Breadth	6
Hip Breadth, Sitting	6
Iliocristale Height	5
Interpupillary Breadth	2
Interscye I	10
Interscye II	13
Knee Height, Midpatella	6
Knee Height, Sitting	2
Lateral Femoral Epicondyle Height	3
Lateral Malleolus Height	2
Lower Thigh Circumference	4
Menton-Sellion Length	3
Neck Circumference	6
Neck Circumference, Base	8
Overhead Fingertip Reach, Sitting	20
Palm Length	2
Popliteal Height	6
Radiale-Stylion Length	6
Shoulder Circumference	12
Shoulder-Elbow Length	6
Shoulder Length	3
Sitting Height	6
Sleeve Length: Spine-Wrist	9
Sleeve Outseam	6
Span	10
Stature	6
Suprasternale Height	5
Tenth Rib Height	5
Thigh Circumference	6

TABLE G-1. CONTINUED
Allowable Observer Error for Dimensions in the 2010-2011 USMC Anthropometric Survey and the U.S. Army Anthropometric Survey

Dimensions	Allowable Error (mm)
Thigh Clearance	3
Thumbtip Reach	20
Tibial Height	2
Tragion-Top of Head	4
Trochanterion Height	4
Vertical Trunk Circumference (USA)	24
Waist Back Length (Omphalion)	5
Waist Breadth	6
Waist Circumference (Omphalion)	12
Waist Depth	6
Waist Front Length, Sitting	7
Waist Height (Omphalion)	7
Weight	0.3 kg
Wrist Circumference	3
Wrist Height	11

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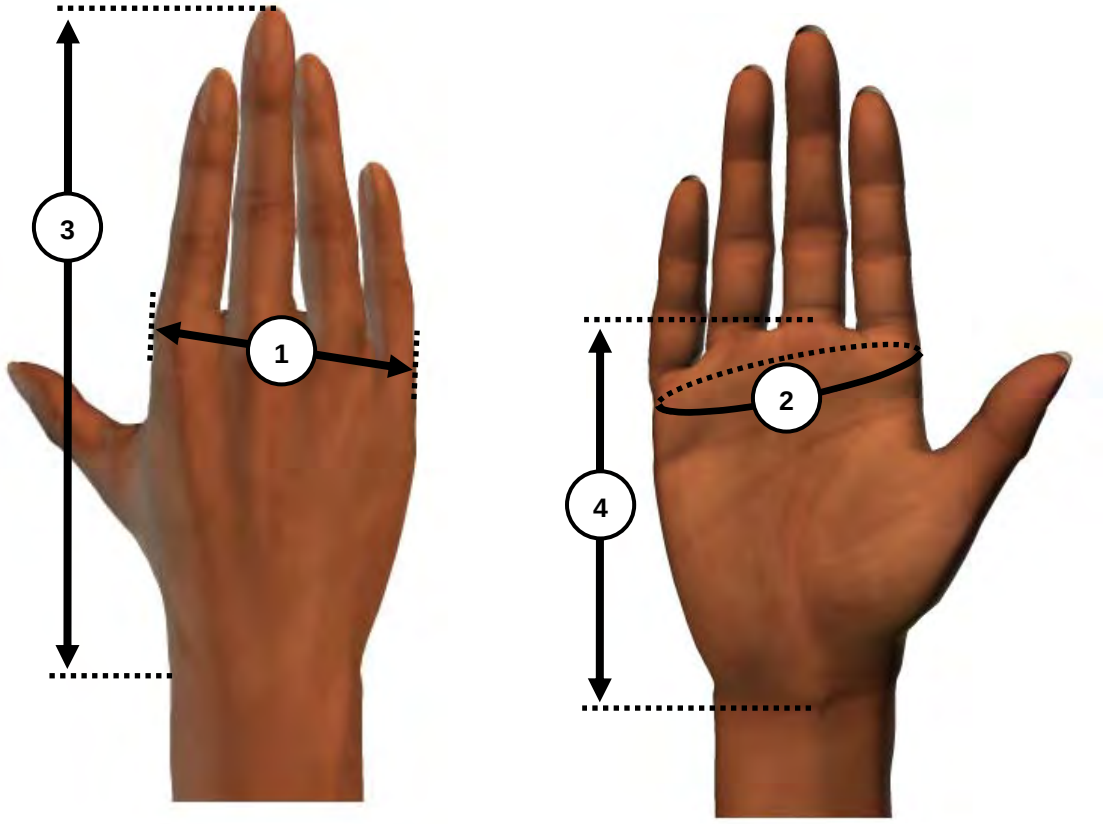
APPENDIX H

VISUAL INDEX OF MEASUREMENTS

Users should note that the body positions represented in the Visual Index are approximate. To confirm exact body positions and measurement procedures, users should consult the specific dimension descriptions found in Section 7.4.

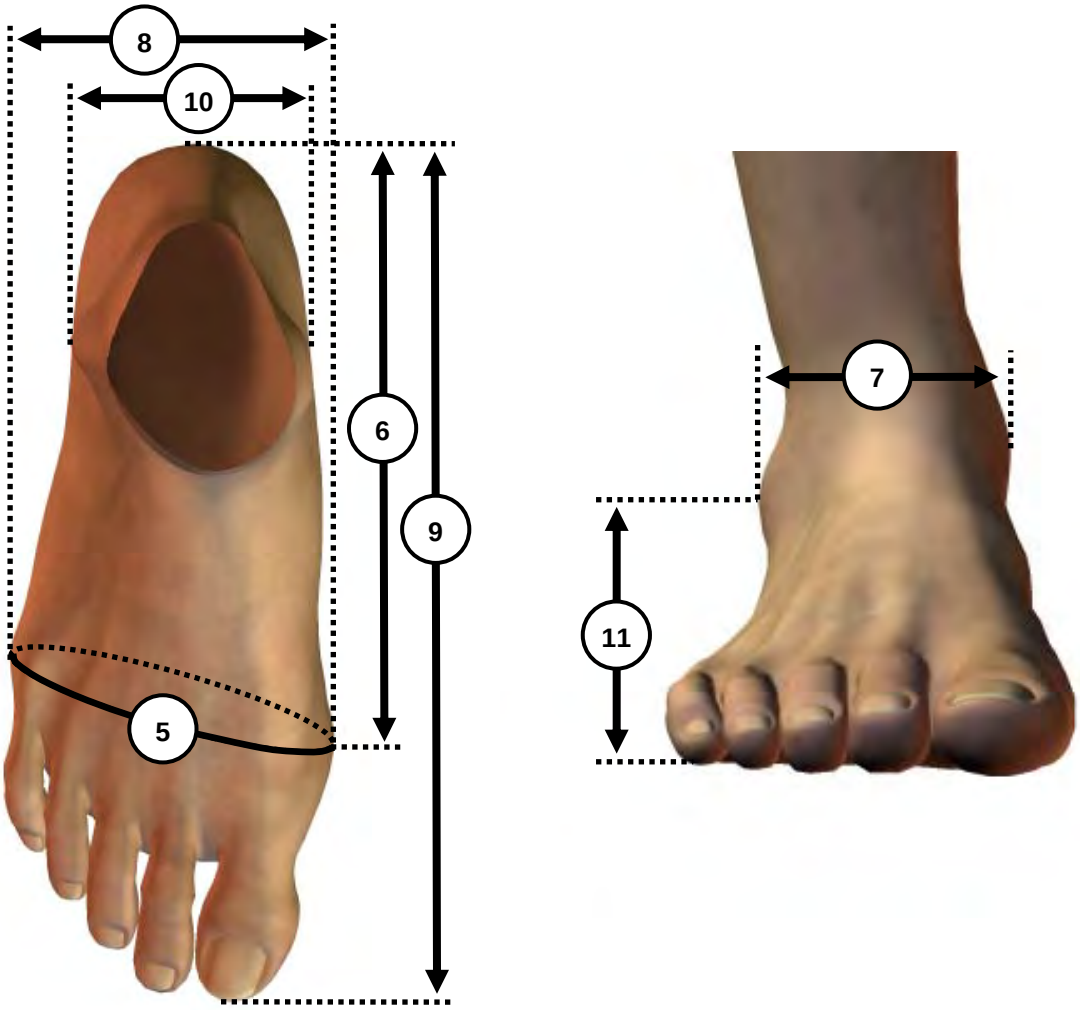


(1) HAND BREADTH

(2) HAND CIRCUMFERENCE

(3) HAND LENGTH

(4) PALM LENGTH



(5) BALL OF FOOT CIRCUMFERENCE

(6) BALL OF FOOT LENGTH

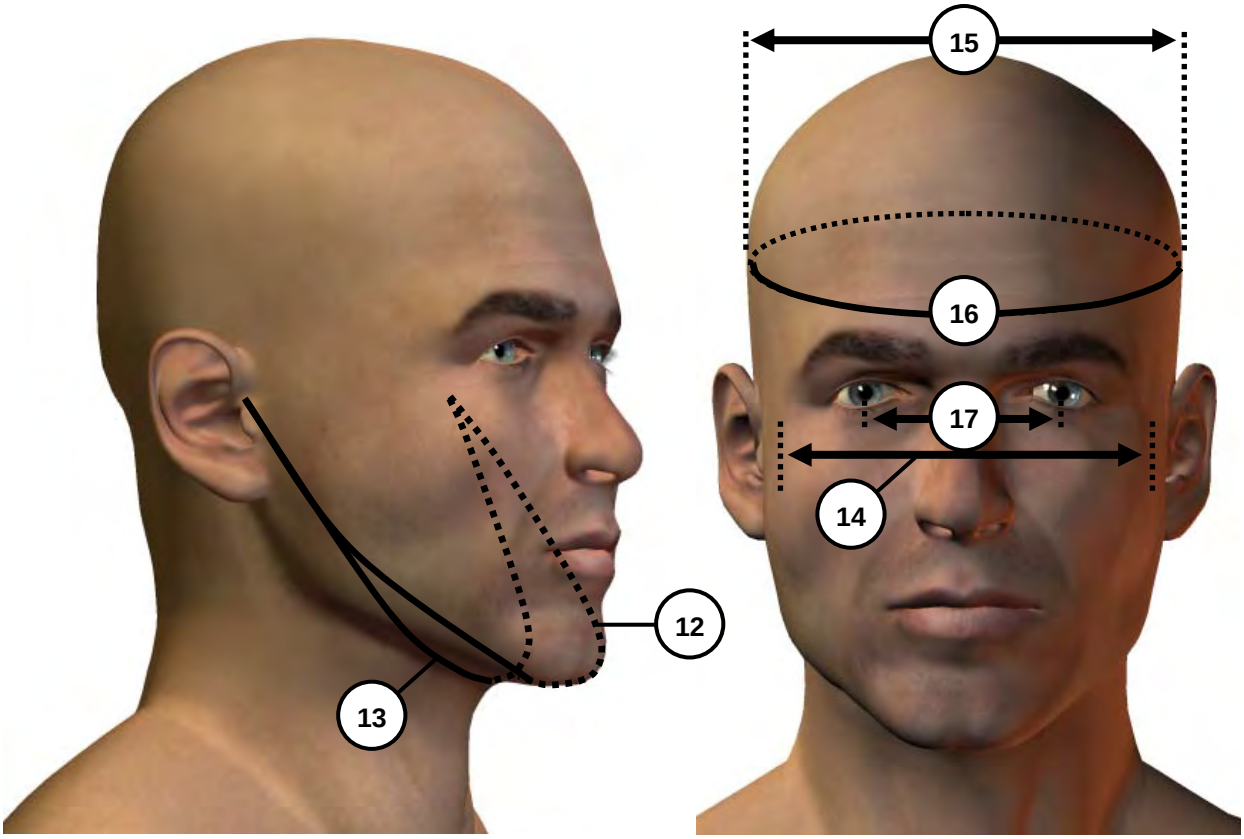
(7) BIMALLEOLAR BREADTH

(8) FOOT BREADTH, HORIZONTAL

(9) FOOT LENGTH

(10) HEEL BREADTH

(11) LATERAL MALLEOLUS HEIGHT



(12) BITRAGION CHIN ARC

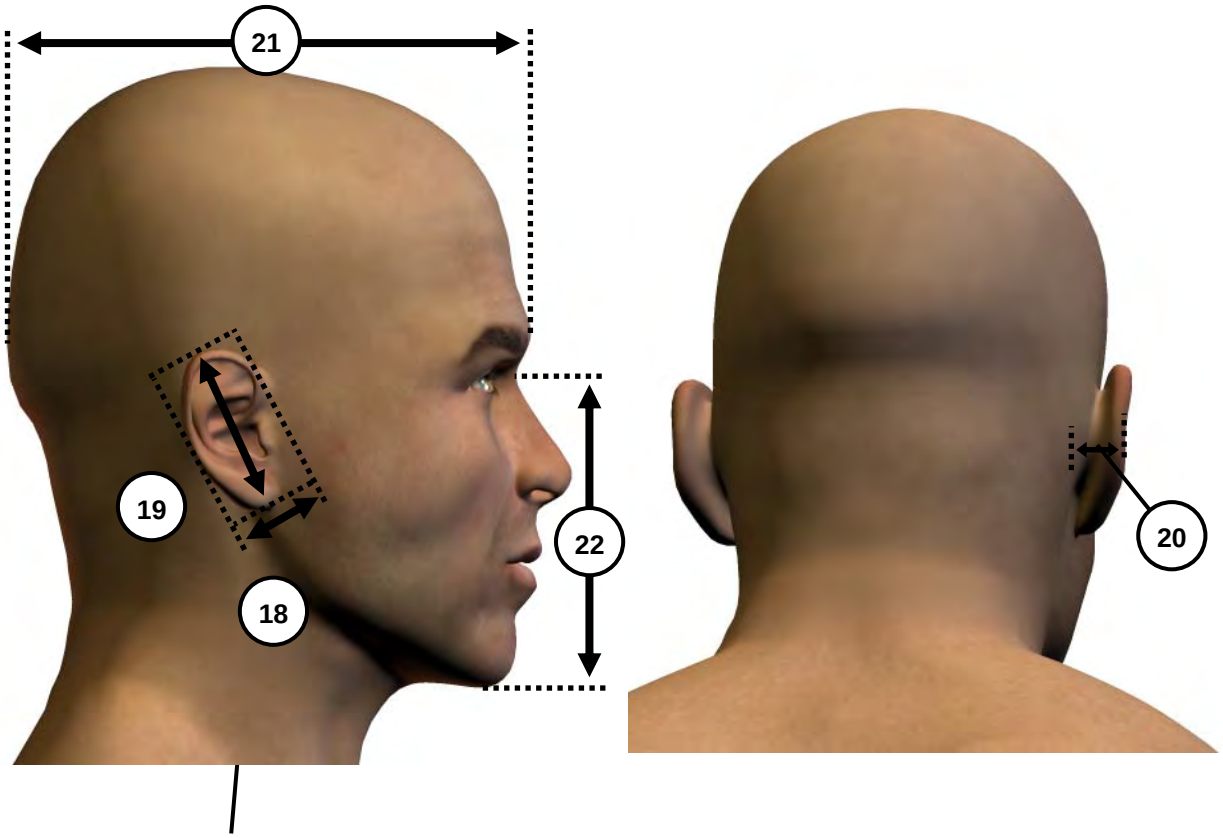
(13) BITRAGION SUBMANDIBULAR ARC

(14) BIZYGOMATIC BREADTH

(15) HEAD BREADTH

(16) HEAD CIRCUMFERENCE

(17) INTERPUPILLARY BREADTH



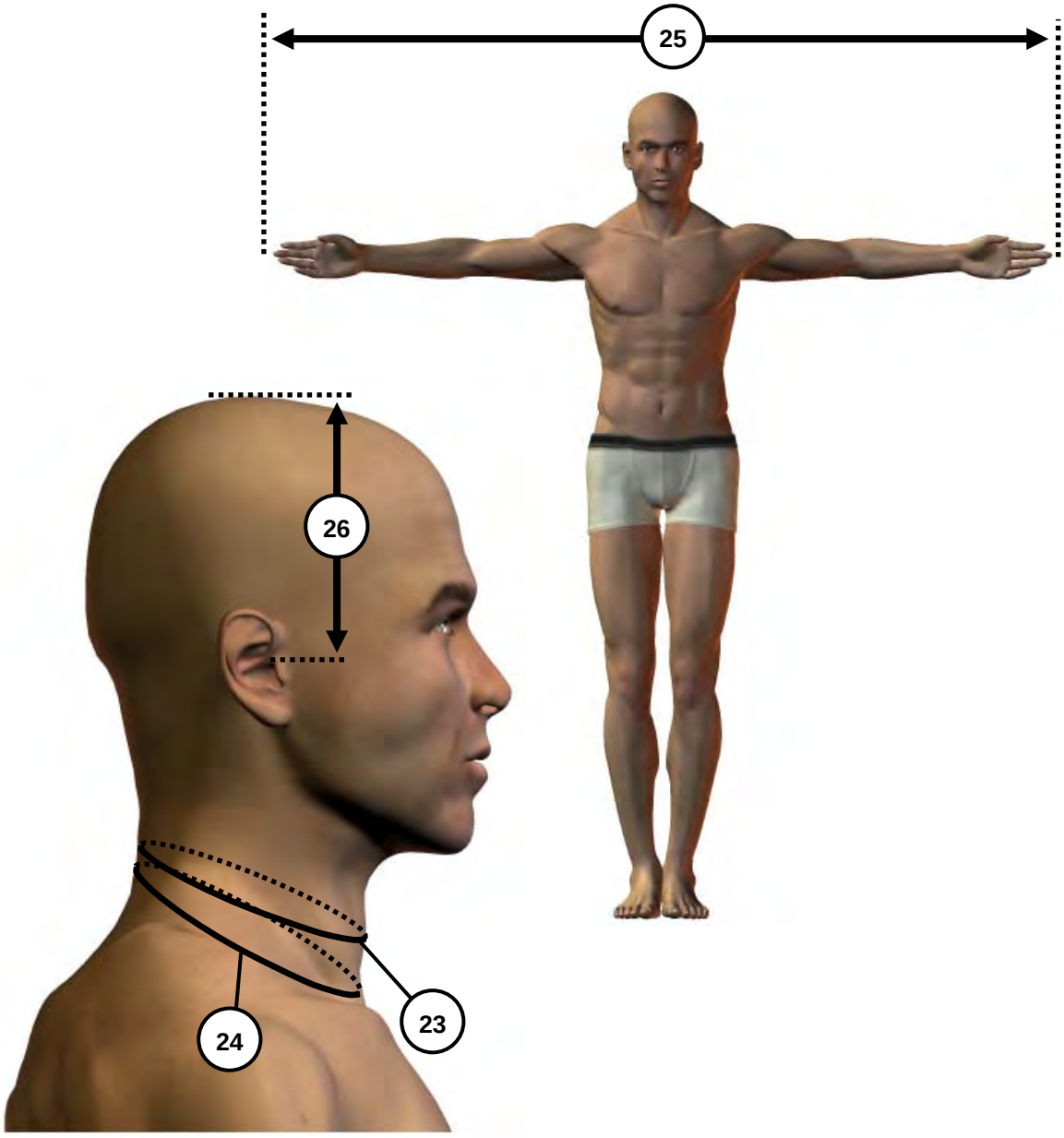
(18) EAR BREADTH

(19) EAR LENGTH

(20) EAR PROTRUSION

(21) HEAD LENGTH

(22) MENTON-SELLION LENGTH

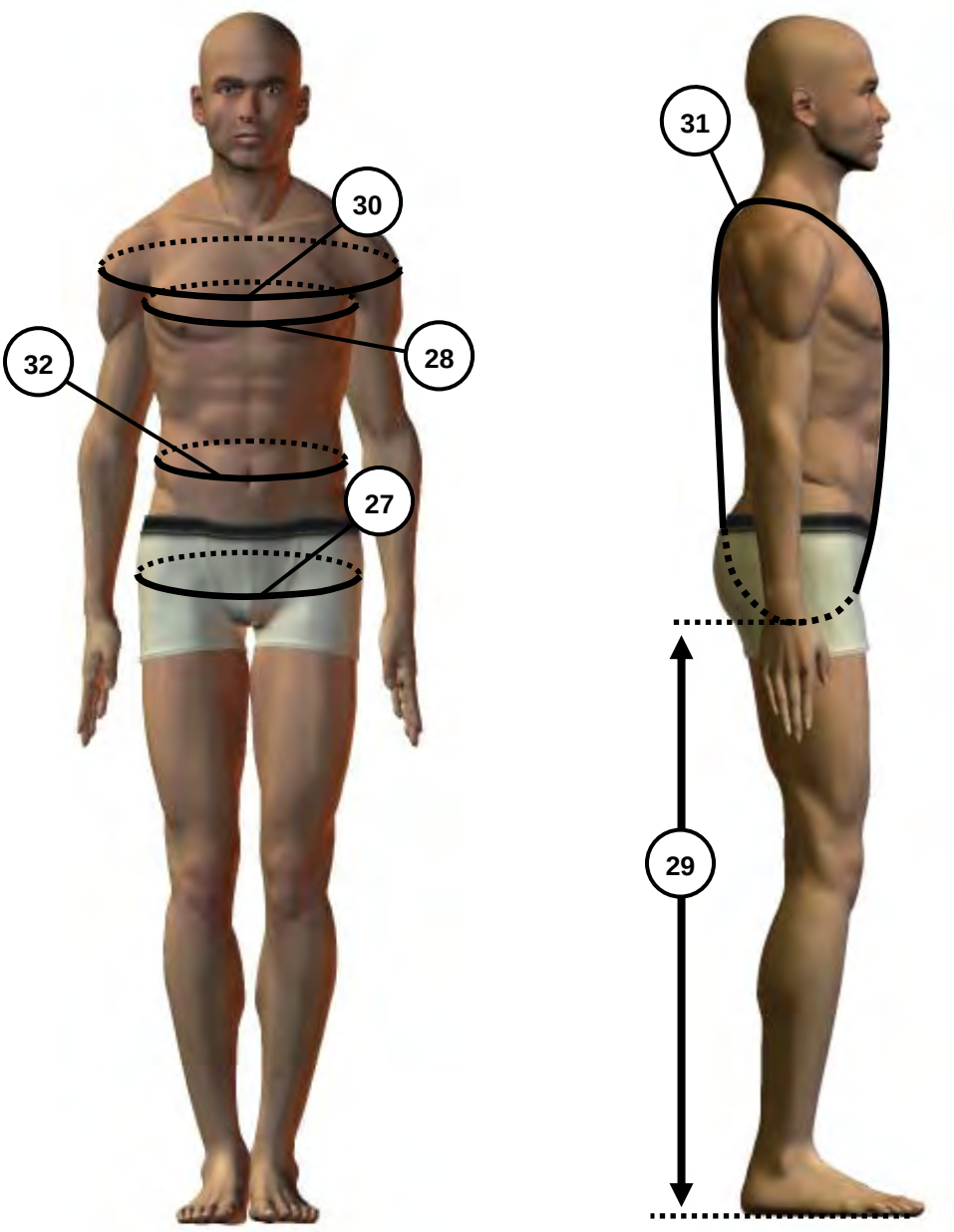


(23) NECK CIRCUMFERENCE

(24) NECK CIRCUMFERENCE, BASE

(25) SPAN

(26) TRAGION–TOP OF HEAD



(27) BUTTOCK CIRCUMFERENCE

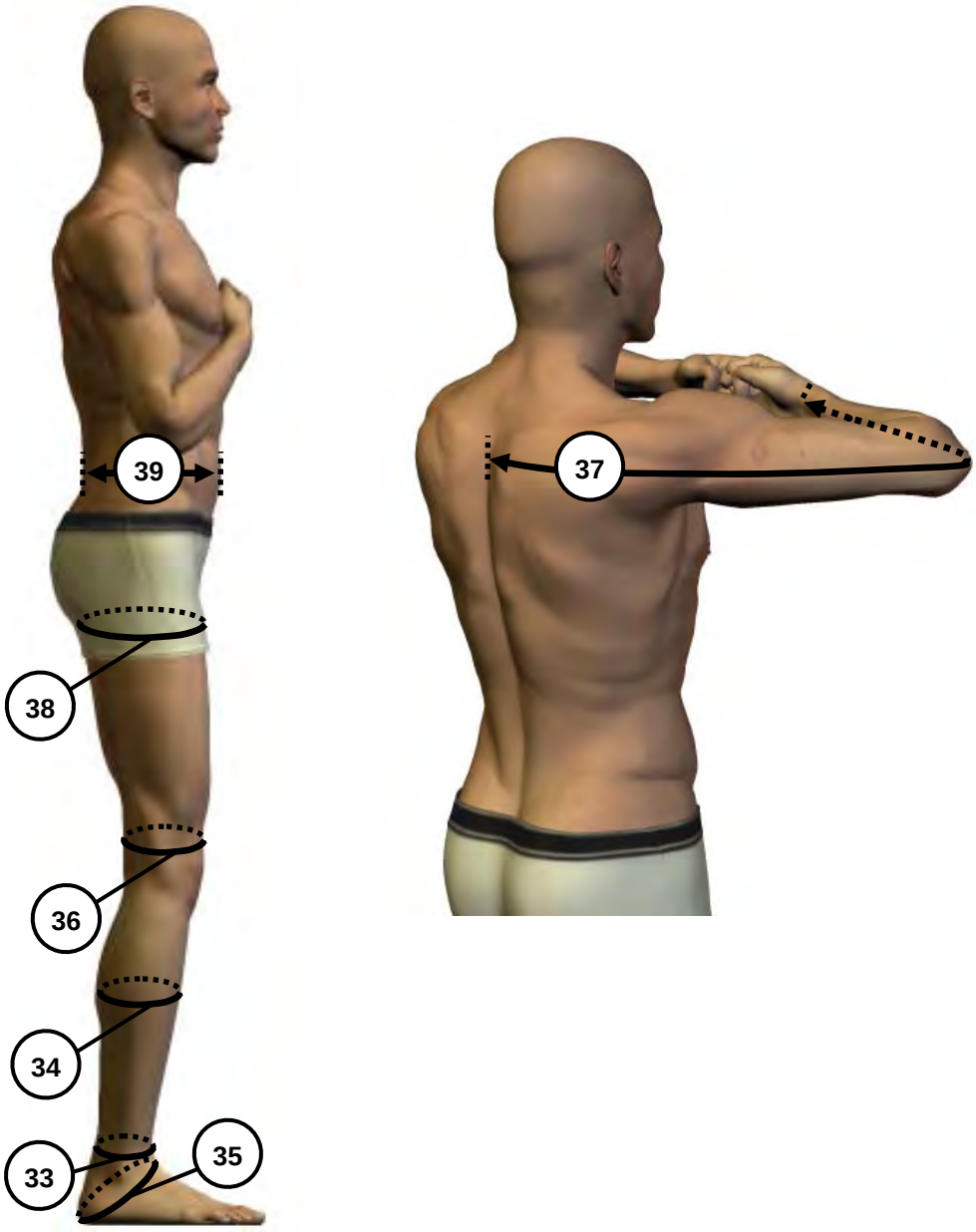
(28) CHEST CIRCUMFERENCE

(29) CROTCH HEIGHT

(30) SHOULDER CIRCUMFERENCE

(31) VERTICAL TRUNK CIRCUMFERENCE (USA)

(32) WAIST CIRCUMFERENCE (OMPHALION)



(33) ANKLE CIRCUMFERENCE

(34) CALF CIRCUMFERENCE

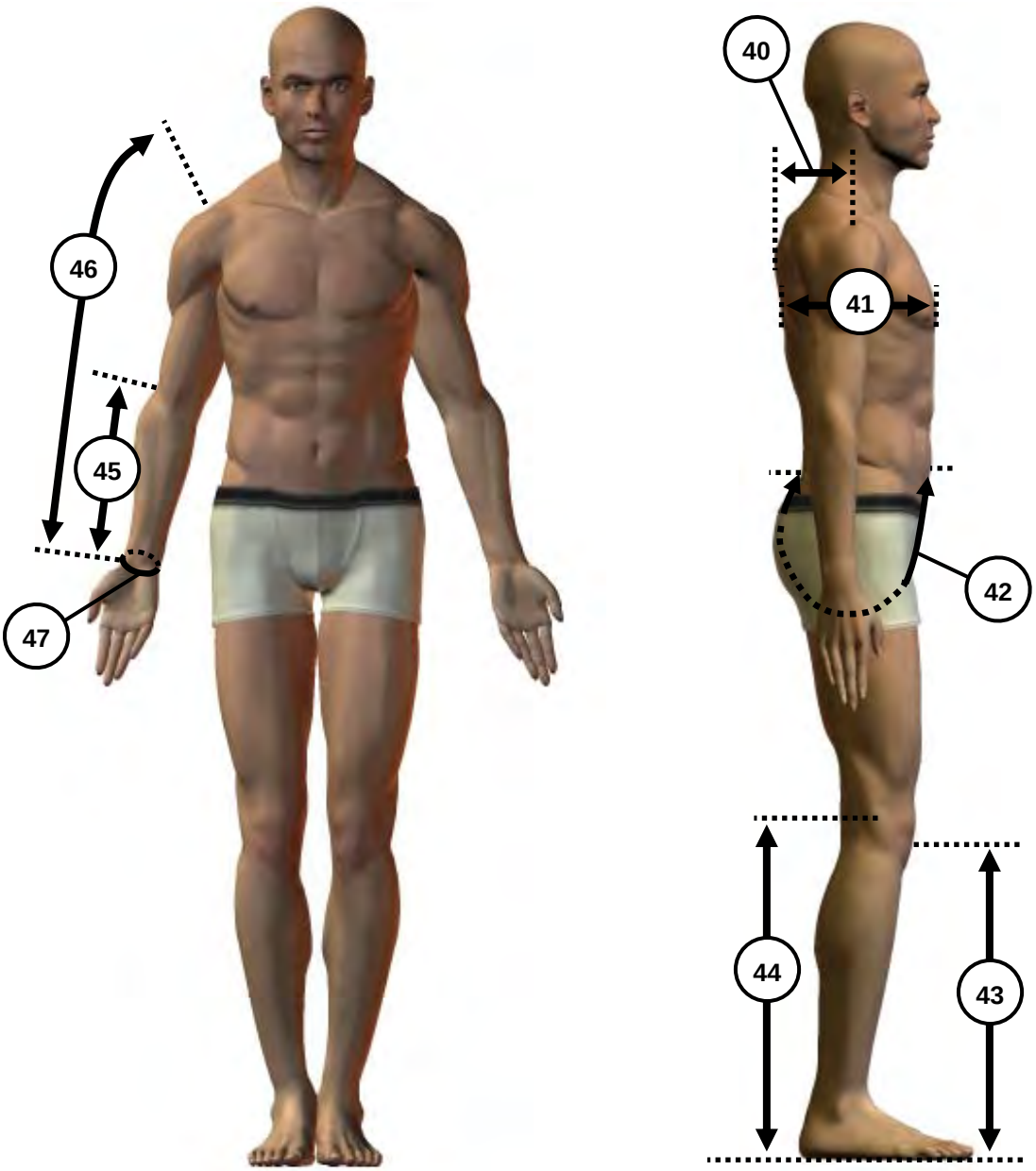
(35) HEEL ANKLE CIRCUMFERENCE

(36) LOWER THIGH CIRCUMFERENCE

(37) SLEEVE LENGTH: SPINE-WRIST

(38) THIGH CIRCUMFERENCE

(39) WAIST DEPTH



(40) ACROMION–WALL DEPTH

(41) CHEST DEPTH

(42) CROTCH LENGTH (OMPHALION)

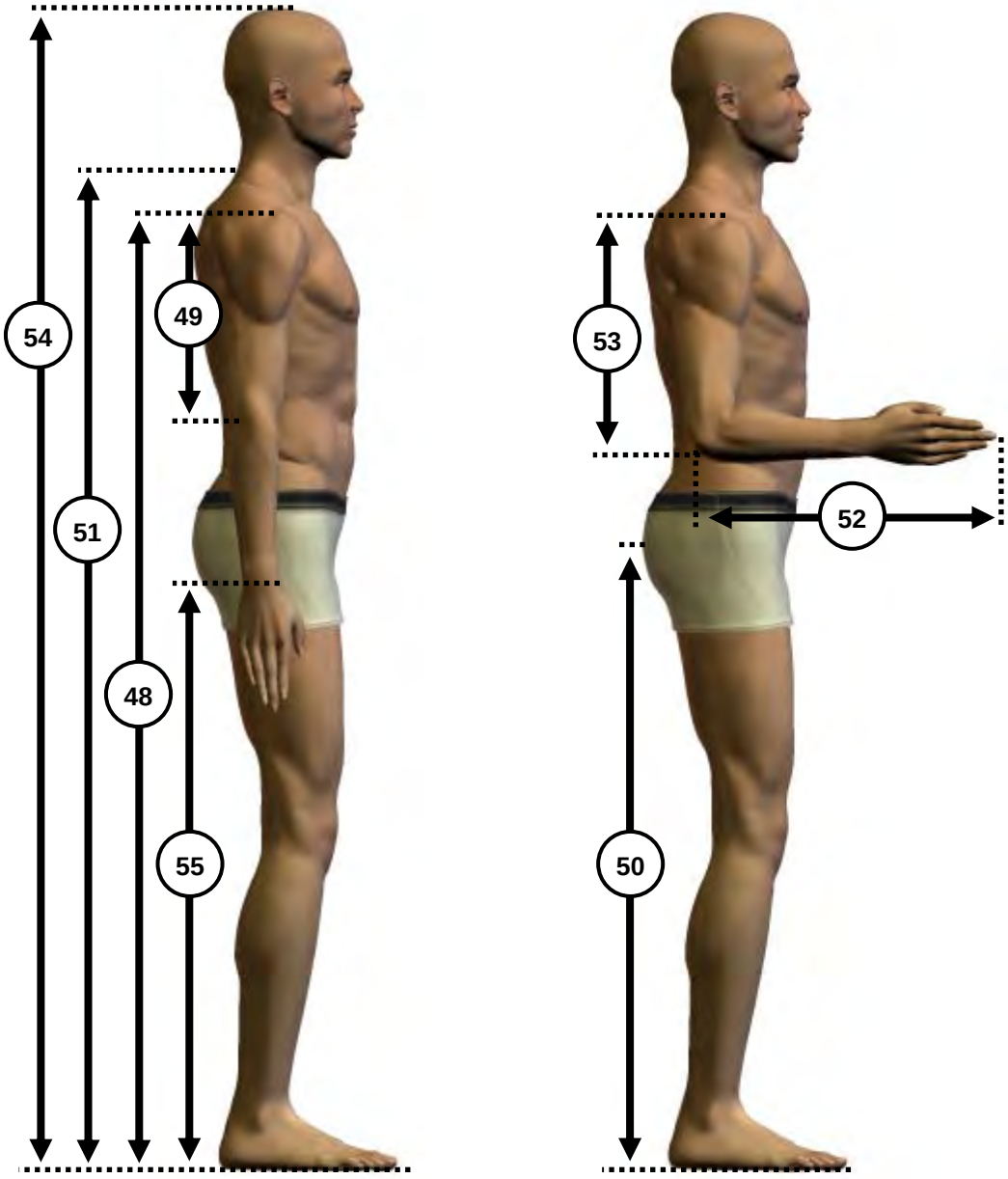
(43) KNEE HEIGHT, MIDPATELLA

(44) LATERAL FEMORAL EPICONDYLE HEIGHT

(45) RADIALE-STYLION LENGTH

(46) SLEEVE OUTSEAM

(47) WRIST CIRCUMFERENCE



(48) ACROMIAL HEIGHT

(49) ACROMION-RADIALE LENGTH

(50) BUTTOCK HEIGHT

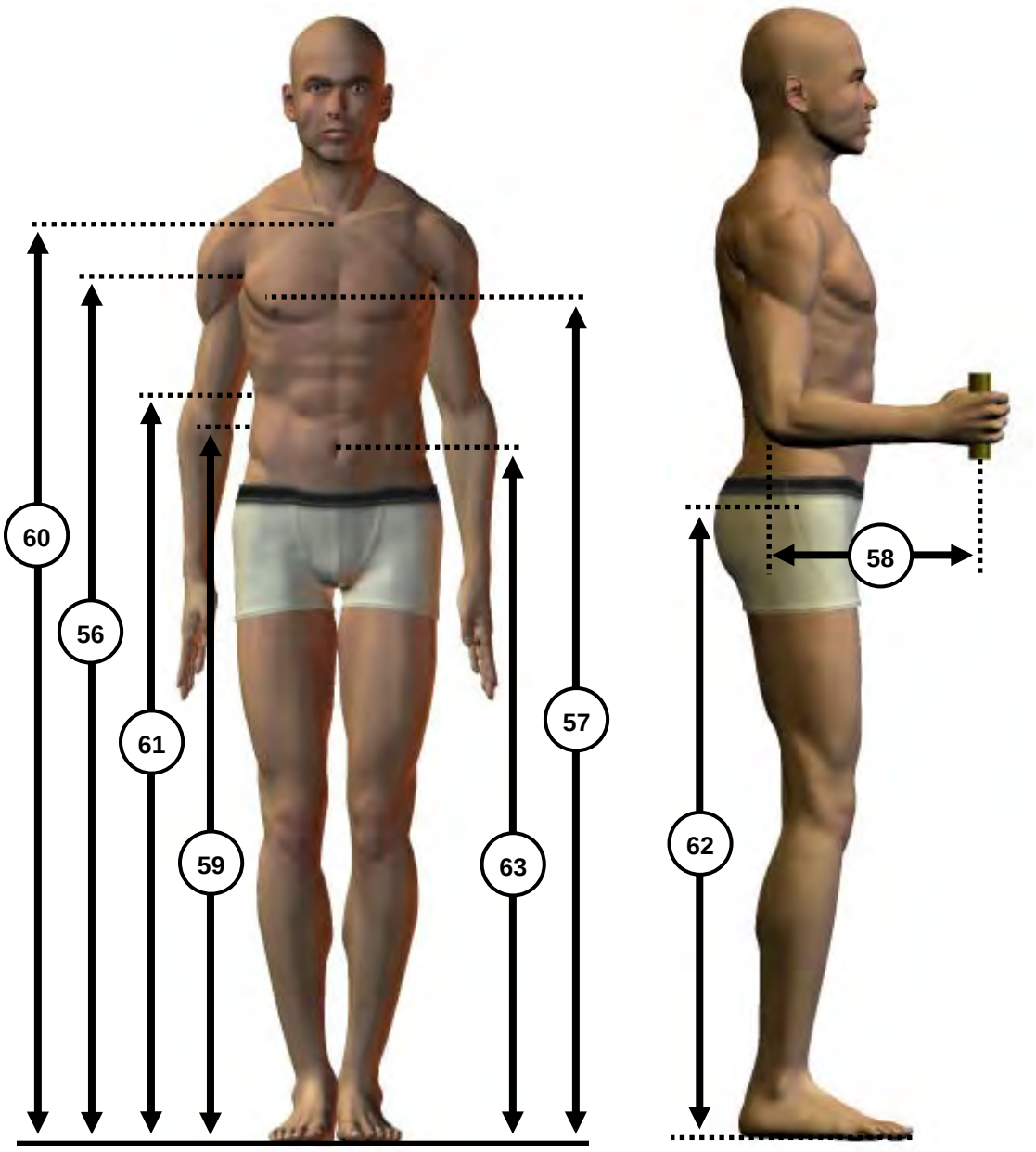
(51) CERVICALE HEIGHT

(52) FOREARM-HAND LENGTH

(53) SHOULDER-ELBOW LENGTH

(54) STATURE

(55) WRIST HEIGHT



(56) AXILLA HEIGHT

(57) CHEST HEIGHT

(58) FOREARM-CENTER OF GRIP LENGTH

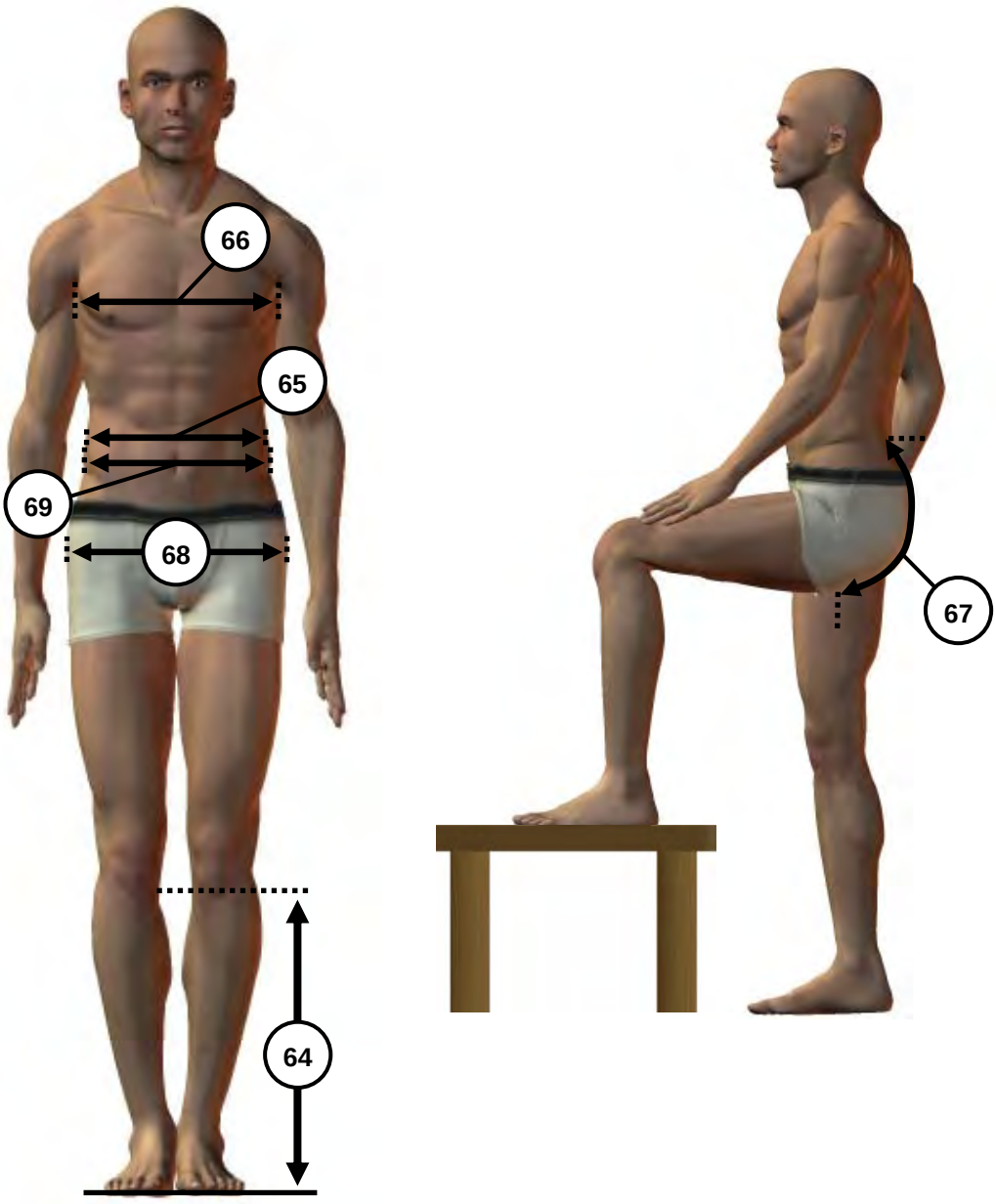
(59) ILIOCRISTALE HEIGHT

(60) SUPRASTERNALE HEIGHT

(61) TENTH RIB HEIGHT

(62) TROCHANTERION HEIGHT

(63) WAIST HEIGHT (OMPHALION)



(64) TIBIAL HEIGHT

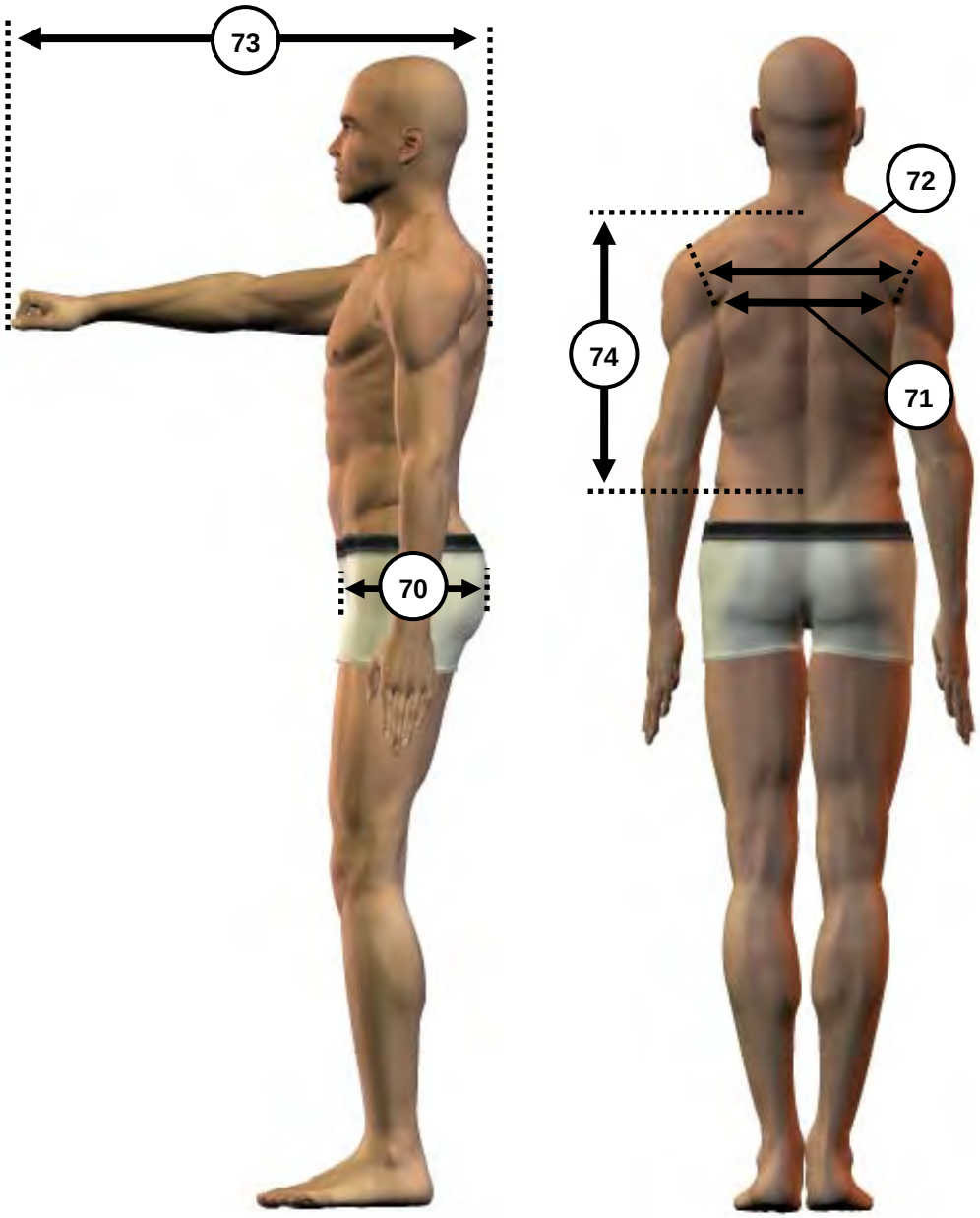
(65) BICRISTAL BREADTH

(66) CHEST BREADTH

(67) CROTCH LENGTH, POSTERIOR (OMPHALION)

(68) HIP BREADTH

(69) WAIST BREADTH



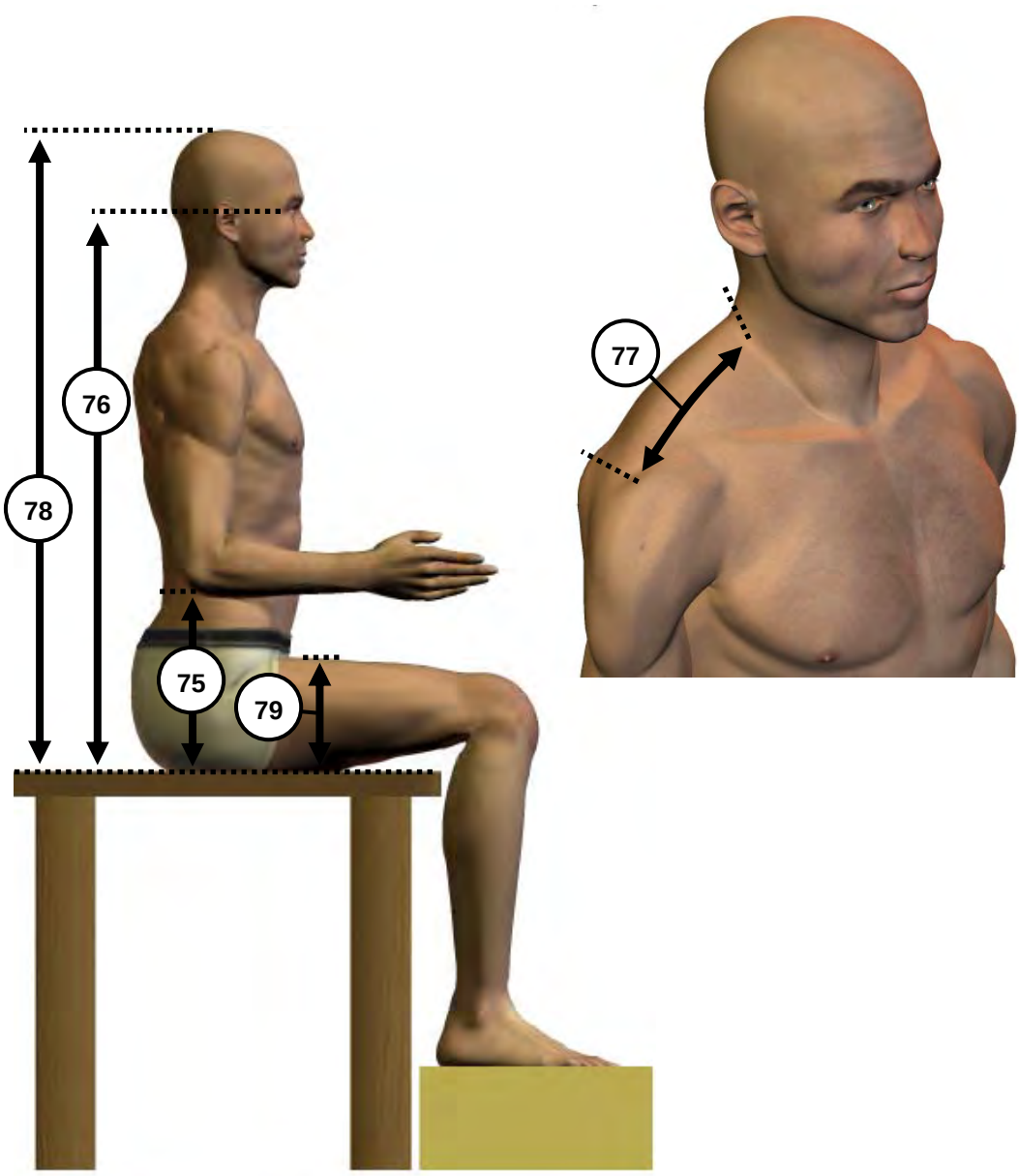
(70) BUTTOCK DEPTH

(71) INTERSCYE I

(72) INTERSCYE II

(73) THUMBTIP REACH

(74) WAIST BACK LENGTH (OMPHALION)



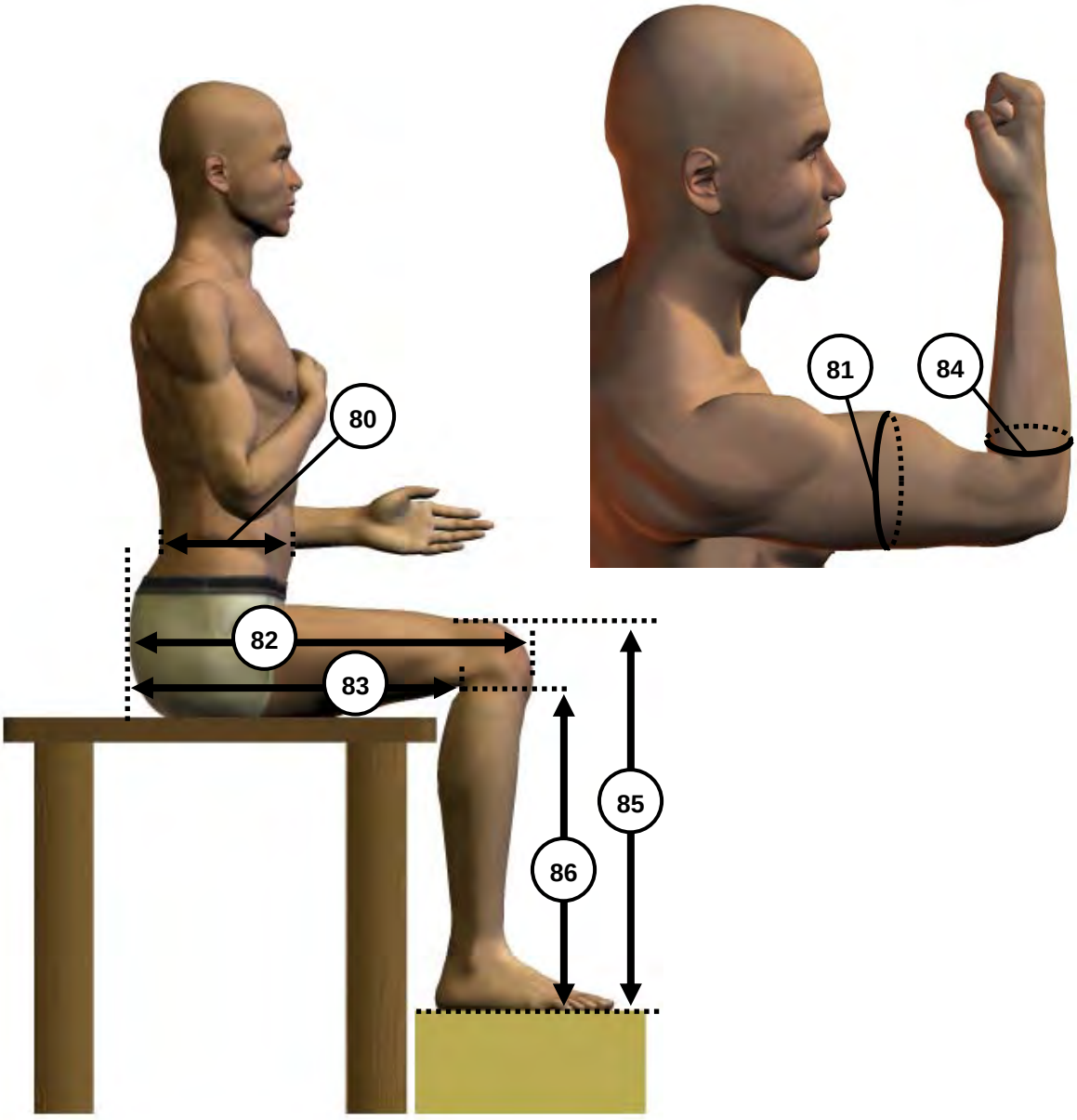
(75) ELBOW REST HEIGHT

(76) EYE HEIGHT, SITTING

(77) SHOULDER LENGTH

(78) SITTING HEIGHT

(79) THIGH CLEARANCE



(80) ABDOMINAL EXTENSION DEPTH, SITTING

(81) BICEPS CIRCUMFERENCE, FLEXED

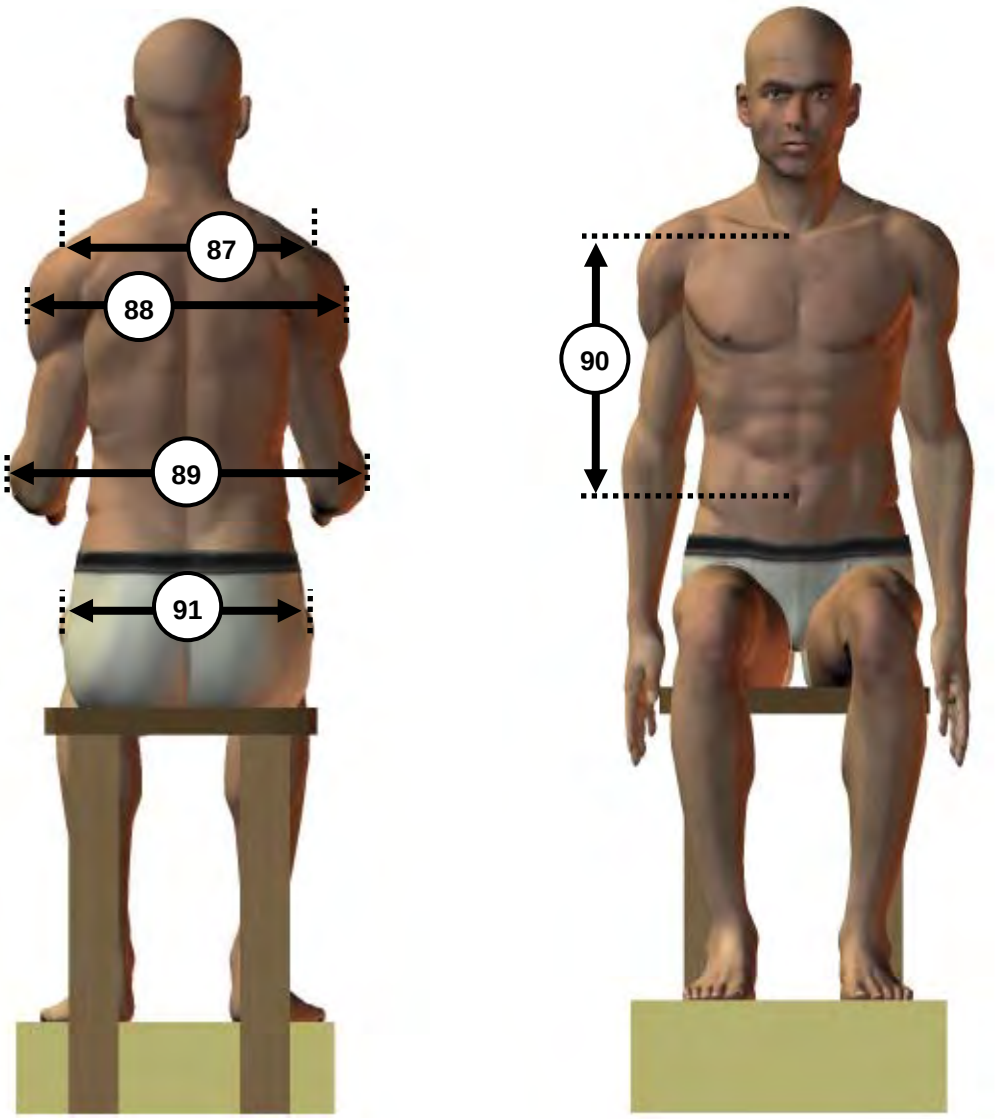
(82) BUTTOCK-KNEE LENGTH

(83) BUTTOCK-POPLITEAL LENGTH

(84) FOREARM CIRCUMFERENCE, FLEXED

(85) KNEE HEIGHT, SITTING

(86) POPLITEAL HEIGHT



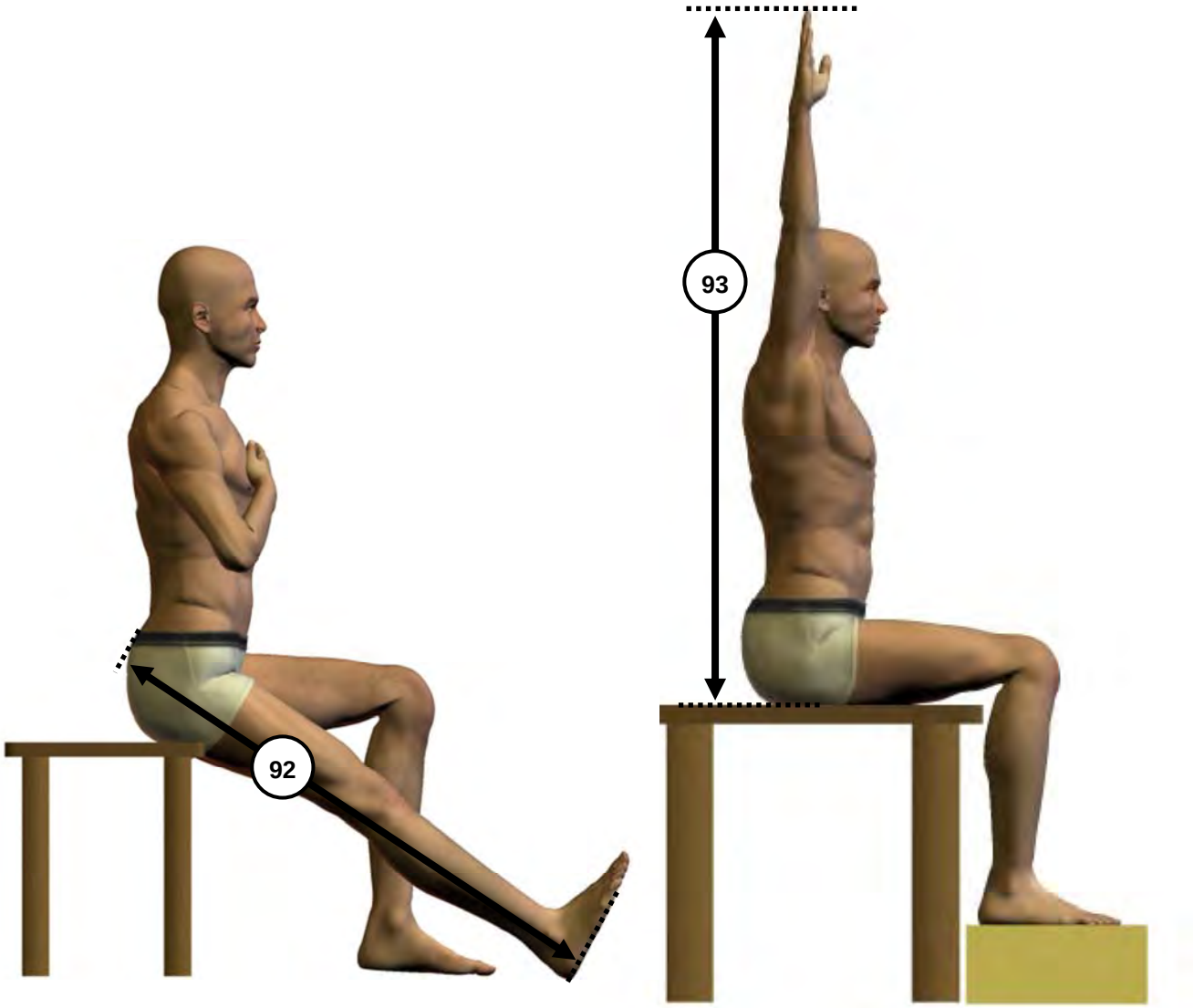
(87) BIACROMIAL BREADTH

(88) BIDELTOID BREADTH

(89) FOREARM-FOREARM BREADTH

(90) WAIST FRONT LENGTH, SITTING

(91) HIP BREADTH, SITTING



(92) FUNCTIONAL LEG LENGTH

(93) OVERHEAD FINGERTIP REACH, SITTING

INDEX