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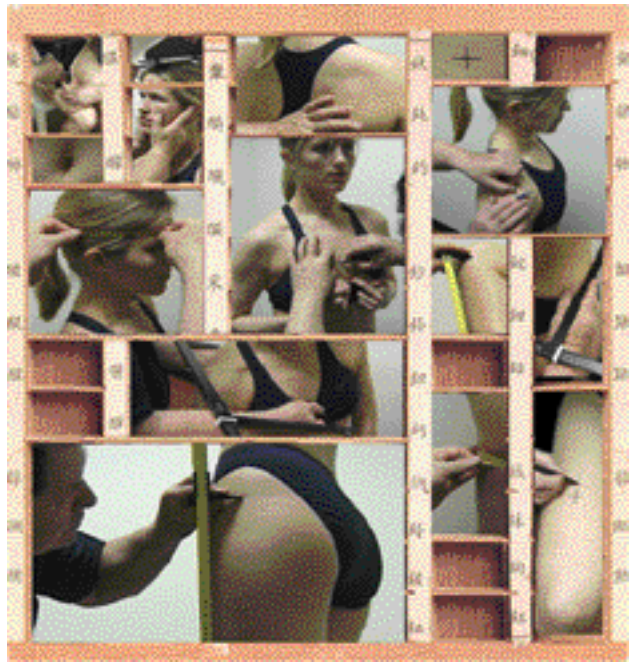

International Standards for Anthropometric Assessment

International Standards for Anthropometric Assessment

published by the

International Society for the Advancement of Kinanthropometry

Published by THE INTERNATIONAL SOCIETY FOR THE ADVANCEMENT OF KINANTHROPOMETRY

✉ The Secretary-General
School of Physical Education, Exercise and Sport Studies
The University of South Australia
Holbrooks Rd, Underdale, SA, Australia
☎ +61 8 8302 6596
Fax +61 8 8302 6658
Email: **kevin.norton@unisa.edu.au**

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Foreword

It is a pleasure to present to you ISAK's **International Standards for Anthropometric Assessment** – a reference manual for use in teaching, in the laboratory and in the field.

For the past five years, ISAK has referred members to Chapter 2 of **Anthropometrica** (edited by Kevin Norton and Tim Olds, 1996) as the recommended presentation of ISAK assessment standards (and I acknowledge the important contribution that text has made to anthropometry as a result). Now, in response to a concerted call for ISAK to define its standards under its own banner, it is publishing this manual, which is the outcome of a great deal of thought and effort on the part of many.

With Chapter 2 of **Anthropometrica** as its starting point, an ISAK Executive Council team, of Kevin Norton, Lindsay Carter, Tim Olds and I, Mike Marfell-Jones, has held determinative discussion within itself and consulted with the other members of the Council, with all ISAK Criterion Anthropometrists and many ISAK Level 3 anthropometrists to produce an up-to-date manual for the use of all our members and for the education and guidance of those who wish to follow ISAK practice.

Errors have been rectified, new and improved figures have been included, and descriptions have been clarified to improve both anatomical and methodological precision. One landmark (Xiphoidale) has been omitted, as has one measurement item (Mid-axilla skinfold), on the grounds that their identification and measurement contribute insufficient additional information about the subject to warrant their inclusion in a standard assessment protocol.

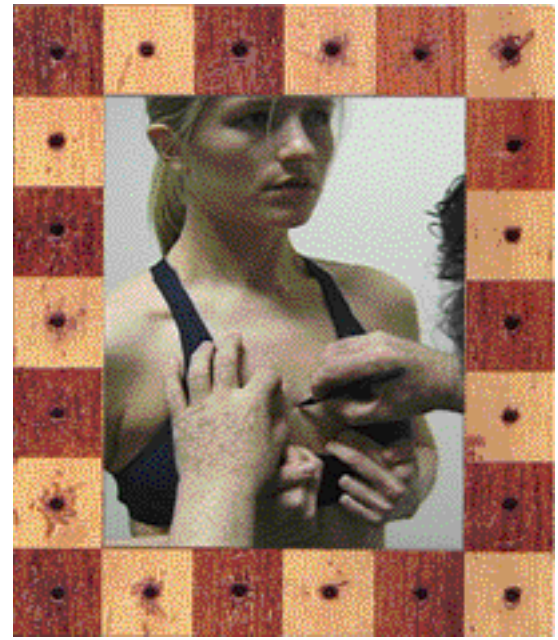
An appendix has been included to provide information about what equipment is available and where it can be obtained. ISAK does not favour any one equipment brand or supplier, but is happy to endorse those products which, its experience has shown, meet anthropometrists' needs.

Particular acknowledgement of major contributors to this manual are both necessary and a privilege. To my three colleagues, Tim, Lindsay and Kevin – thank you, firstly for your contribution to the text, its format and the overall presentation of the manual and secondly for your insistence on the maintenance of absolute academic rigour in its development and final production. To Bill Ross, Robin Carr and Lindsay Carter (Rosscraft and Turnpike Electronic Publications), Gary Rodgers (Magnum Images and the Universal College of Learning) and Tim Olds and Kevin Norton (University of South Australia) – thank you for your contribution of an excellent set of photos to enhance the text. Lastly, to those anthropometrists who have gone before – thank you for sowing the seeds of our discipline and charging us with the task of continuing its development so that people of all nations can benefit from its fruits.

The outcome of all this effort is a manual of which members can be justifiably proud. Use it often and diligently, both as a tool in your own practice and to share. ISAK has given you this particular instrument. Show others how to use it, then give it to them in turn.

Michael Marfell-Jones
President
The International Society for the Advancement of Kinanthropometry

✉ Universal College of Learning
Private Bag 11 022, Palmerston North
New Zealand
☎ +64 6 952 7001x7723
Fax +64 6 952 7002
Email: m.marfell-jones@ucol.ac.nz



1 Preliminary considerations

1.1 Introduction

Anthropometry like any other area of science depends upon adherence to the particular rules of measurement as determined by national and international standards bodies. Anthropometry is a very old science, and, like many old sciences, has followed a variety of paths. The diversity of anthropometric paths is both a richness and its bane. One of the consequences of multiple anthropometric traditions has been the lack of standardisation in the identification of measurement sites, and in measurement techniques. This makes comparisons across time and space extremely difficult. The international anthropometric standards detailed in this document are those of the International Society for the Advancement of Kinanthropometry (ISAK). ISAK, which developed from its precursor, the International Working Group on Kinanthropometry (IWGK), has members from over 50 countries and has worked since 1986 to develop standards in anthropometry.

The standards in this document have been assembled by international experts including all ISAK-accredited Level 4 anthropometrists from around the world. The anthropometric techniques in this book have been refined from definitions and descriptions from a series of classic textbooks and congresses throughout the twentieth century. These measurement sites provide the basis for the ISAK accreditation system that has operated since 1996. To date, over 1500 anthropometrists from 18 countries have been accredited in anthropometric measurement techniques under this scheme. The aim of this document is to assist with global standardisation of anthropometry.

This document introduces the anthropometrist to a number of techniques required to obtain a comprehensive anthropometric profile on a person. These measurement sites give a good description of the body as a whole. The sites are those which are routinely taken for a variety of purposes such as monitoring athletes, tracking growth, development, aging and motor performance, and linking physical activity and nutrition interventions to changes in body size, shape and composition. Sites which are known to be predictive of health status in the general population are also included.

Once the measurement of these anthropometric sites is complete, the practitioner can utilise a number of tools using various computations for data analyses. These include somatotyping, fractionation of body mass into bone, muscle, adipose (fat) and residual mass components, proportionality estimates, prediction of body density (and subsequently percent body fat) using a number of regression equations, and transformation of the data into age and gender-specific percentile scores for individual sites, overall obesity and proportional mass rankings, as well as other indices such as waist-hip ratio, sums of skinfolds and skinfold-corrected girths.

There are many reasons why measurements of body dimensions are taken. This document describes the 'core' of body sites which are most often included in an anthropometric profile. Adoption of a standard profile and methodology allows comparisons to be made locally, nationally and internationally between sample groups. It also introduces exciting implications for pooling data from around the world which, for the first time, can be readily achieved by judicious use of the internet. There will be the occasion, however, where specific anthropometric measurement sites not included in these guidelines are required. Anthropometrists shouldn't feel constrained to use only those sites contained in these guidelines when the need for other sites arises.

1.2 The subject

Each subject must be informed as to what measurements are to be taken and local or institutional rules followed regarding consent. Throughout the protocol the subject may be asked to assume different positions. For measurements to be made as quickly and efficiently as possible the subjects should be asked to present themselves in minimal clothing. Swimming costumes (two-piece for females) are ideal for ease of access to all measurement sites. The clothing worn must be of minimal thickness and follow the natural contours of the body. It must also allow access to bare areas of skin for skinfolds.

In the matter of dress as in other concerns, anthropometrists should always be sensitive to the cultural beliefs and traditions of the subject. Therefore, the measurement room should provide for privacy and be at a comfortable temperature for the subject. It should be appreciated that all people have an area around their body known as ‘personal space’ and that when this area is invaded they feel uncomfortable or threatened. This is particularly true for the front of a person and this is why most measurements are taken from the side or from behind. Anthropometrists should be mindful that some subjects may feel more comfortable being measured by people of the same gender.

There are some people for whom measures cannot be accurately taken. This may be due to factors such as extremely tight skin, large subcutaneous adiposity or injury. In these individuals it is recommended that no measurement is taken to avoid potentially very large errors and embarrassment. The anthropometrist should not take any measures which compromise the physical or emotional well-being of the subject.

1.3 Data collection

In general the measurer should be able to easily move around the subject and manipulate the equipment. This will be facilitated by setting aside adequate space for these measurement procedures.

Where possible, a recorder should be used to assist the measurer and enter data. The measurer and recorder work as a team and it is the responsibility of the recorder to help the measurer wherever possible. When used, a recorder should be trained in recording techniques. The recorder should be able to verify the accuracy of site location and ensure the correct sequence of measurement sites.

Despite careful attention to the standards, there is still the possibility that errors will occur in the recording of data. This may occur due to poor pronunciation by the measurer, inattention by the recorder or the recorder's failure to follow the steps which are designed to eliminate such errors. The recorder repeats the value as it is being recorded, thereby enabling the measurer to do an immediate check. Wherever possible, measurements should be repeated or even taken a third time. When two measures are taken, the mean value is used for data analysis. When three measures are taken the median value is used for data analysis.

1.4 Anthropometry equipment

Depending on the specific sites being measured, specific equipment items are necessary. General descriptions of equipment requirements are given below in the text. An appendix is included with details of suppliers of anthropometry equipment.

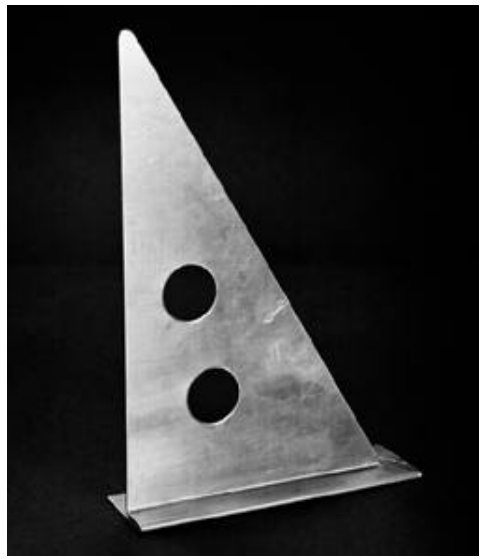


Figure 1. Headboard.

Stadiometer

This is the instrument used for measuring stature and sitting height. It is usually attached to a wall so that the subjects can be aligned vertically in the appropriate manner. The stadiometer should have a minimum range of measurement of 60 cm to 220 cm. The accuracy of measurement required is 0.1 cm. A sliding head board that is at least 6 cm wide is lowered to the vertex of the head. It is recommended that the head board be constructed with a locking device. The floor should be hard and level. The same equipment is often used for sitting height from a box as well as stature. Stadiometers range from simple and relatively inexpensive to complex and very expensive. The stadiometer should be checked periodically against a standard height. In the field, when a stadiometer is not available, a carpenter's tape fixed to a wall and checked for height and vertical position, may be used in conjunction with a 90° head board such as a large set square. As a 'last resort' method, a piece of paper taped to a wall may be used to identify the height, using a head board. Assessment of the height can then be completed using a steel tape. This method is not acceptable in the laboratory.

Weighing scales

The traditional instrument of choice has been the beam balance accurate to the nearest 100 g. However, the use of electronic scales is becoming more general and the accuracy of some of these scales is greater than that of the beam balance. For example, relatively inexpensive digital bathroom-type scales are now available which incorporate load cells as sensors. They are easily transported and can therefore be used in the laboratory and the field. The accuracy of these instruments is to within 50 g. Calibration of all scales is critical. This should be done using calibration weights, certified by a government department of weights and measures and totalling at least 150 kg.

Anthropometric tape

Figure 2A. Lufkin W606PM flexible steel tape.

A flexible steel tape of at least 1.5 m in length is recommended for girths. This should be calibrated in centimetres with millimetre gradations. If fibreglass tapes are used, regular calibration against a steel tape is required as these non-metal tapes may stretch over time. Any tape used should be non-extensible, flexible, no wider than 7 mm and have a stub (blank area) of at least 4 cm before the zero line. In addition to assessing girth measurements, an anthropometric tape is also required to accurately locate a number of skinfold sites and mark distances from bony landmarks. The tape needs to be enclosed in a case with automatic retraction.

Figure 2B. Reading the tape: align the zero mark with the top scale: here the reading is 48.9 cm.

Skinfold caliper

Skinfold calipers require a constant closing compression of 10 g.mm^{-2} throughout the range of measurements. They should ideally be calibrated to at least 40 mm in 0.2 mm divisions. Skinfold calipers require regular calibration. For details on skinfold caliper calibration, see Carlyon, et al. (2000), Gore, et al. (1995), and Schmidt and Carter (1990).

The application of skinfold data to any regression equation, or analysis of raw values, should be made with the same caliper that was used in the original paper. ISAK recommends the Harpenden skinfold caliper.

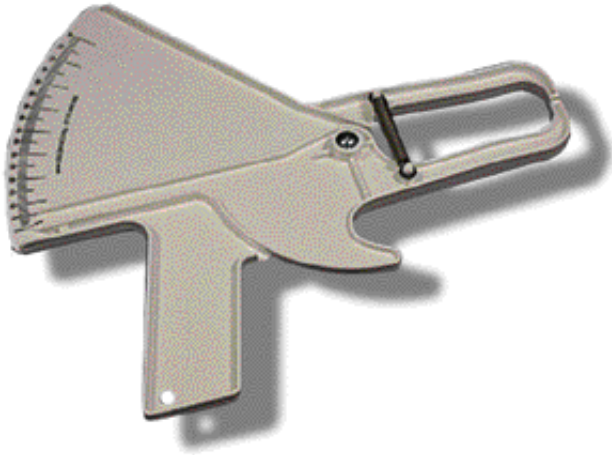


Figure 3A. Slim Guide skinfold caliper.

Figure 3B. Harpenden skinfold caliper.

Anthropometer

The anthropometer is used to measure heights and lengths either directly or indirectly. Also, the instrument can be used to measure segment lengths directly (e.g. Radiale-stylion), large bone breadths (e.g. Biacromial), non-bone breadths (e.g. Bideltoid) as well as stature and sitting height.

Estimates of segment lengths can be obtained indirectly using projected heights measured with an anthropometer. The projected heights method uses the difference between pairs of heights. For example, Acromiale-Radiale length can be obtained by subtraction: Acromiale® height minus Radiale® height. It is recommended that, where possible, direct measures of segment lengths be made using a segmometer or large sliding caliper.

Figure 4. Siber-Hegner anthropometer in a carry bag.

Large sliding caliper

This instrument may be the upper segment of the anthropometer or may be a specially made item. It has two straight branches that allow measurements of large bone breadths such as the Biiliocristal and Biacromial breadths. These branches are attached to a rigid scale since considerable pressure must be exerted when bony dimensions are measured. The distance between the branches should be verified to ensure it has been assembled correctly.

Figure 5. Siber-Hegner anthropometer set up as a large sliding caliper.

Figure 6. Custom-made segmometer.

Segmometer

The segmometer is designed to be used as an alternative to the anthropometer (Carr, Blade, Rempel & Ross, 1993) although it is not appropriate for measuring large bone breadths. This instrument is manufactured from a steel tape 100 cm long and at least 15 mm wide which has attached two straight branches, each approximately 7-8 cm in length. The instrument is used to measure segment lengths directly. It can also be used to measure selected heights (e.g. Iliospinale and Trochanterion heights).

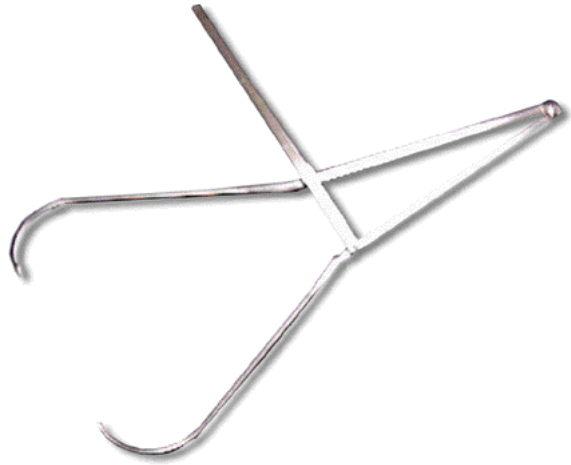


Figure 7A. Wide-spreading caliper (GPM)

Wide-spreading caliper

The wide-spreading caliper is a hinged instrument used mainly to measure anterior-posterior chest depth and other trunk depths. The instrument arms should be of sufficient length (approximately 25 cm beyond the measurement scale) to allow the caliper branches to be placed over the shoulder to the anatomical landmarks. In the absence of a wide-spreading caliper (e.g. Figure 7A) the measurement of anterior-posterior chest depth can be made using a large sliding caliper with recurved or L-shaped branches (Figure 7B).

Figure 7B. Large sliding caliper with L-shaped branches (Rosscraft).

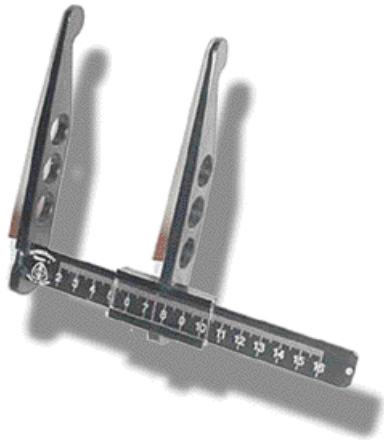


Figure 8A. Tommy 2 small sliding caliper (Rosscraft).

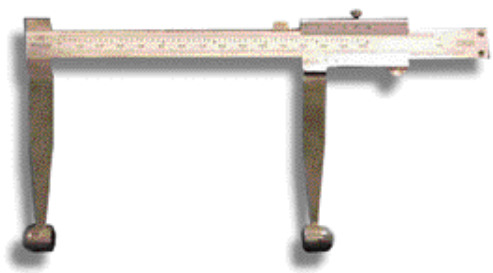


Figure 8B. Adapted Mitutoyo small sliding caliper.

Small sliding caliper

This caliper is used for Biepicondylar humerus and femur breadths, as well as other small bone breadths. It should have branch lengths of at least 10 cm, an application face width of 1.5 cm, and be accurate to within 0.05 cm. The longer branches allow sufficient depth to encompass the biepicondylar breadth of the femur and humerus. There are several commercial models available (e.g. Figure 8A). A small sliding caliper can also be a modified engineering vernier caliper (Figure 8B).

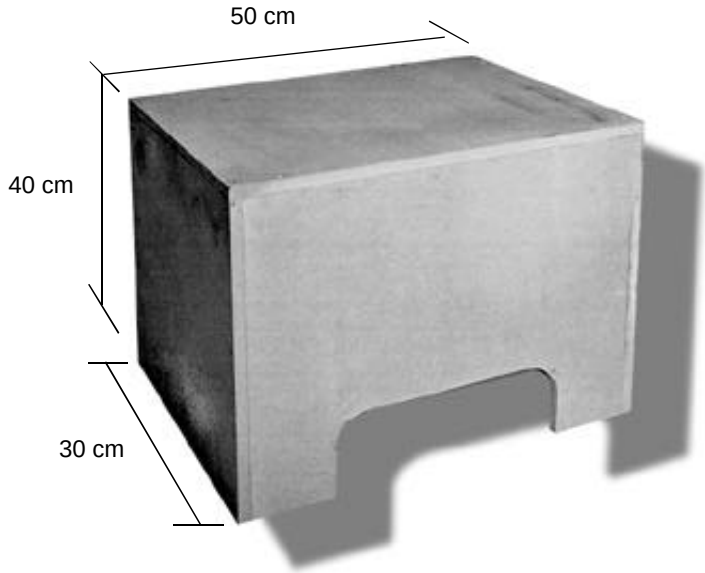


Figure 9. Anthropometric box with recommended dimensions.

Anthropometric box

This box should have dimensions approximately 40 cm (tall) x 50 cm (wide) x 30 cm (deep). The actual height of the box used in any laboratory should be known exactly and recorded on the box. It is necessary to have a cut-out section on one side of the box which enables the subject's feet to be positioned under the box during measurement of the Iliospinale height. It is also recommended to cut out slotted hand holes to enable the anthropometrist to carry and re-orient the box. The box is particularly useful for assisting in the measurement of heights such as Iliospinale and Trochanterion using a segmometer. In these cases the height of the box is added to the measured height of the landmark, and entered onto the proforma. This gives the true landmark height from the floor and is more efficient for the anthropometrist who need not bend to the floor but only to the top of the box. The box is also useful when measuring other lengths and breadths where the subject is required to be seated (on the box).

1.5 The anthropometric profile

There are two general 'profiles' commonly used for anthropometric assessment, the so-called Restricted and Full profiles. The Restricted Profile (17 measurements) is a sub-set of the Full profile (39 measurements) (Table 1). Both profiles can be entered onto the same proforma. Throughout this chapter the anthropometric sites are numbered in a way which corresponds to the site ID on the proforma. The measurements are divided into five broad categories: Basic, Skinfolds, Girths, Lengths and Breadths.

The Restricted Profile

For efficient profiling, sites which are part of the Restricted profile are identified in this chapter with an ® symbol. The anatomical landmarks required for exact location of these sites are also identified with this ® symbol. Measurement of these sites will enable computations to be made for somatotype, proportionality, relative body fat (using a restricted number of prediction equations), indices of body surface area, body mass index, waist to hip ratio, fat patterning, and skinfold-corrected girths. Other comparisons such as obesity estimates and proportional mass rankings relative to other populations of interest can also be performed for the sites measured.

The Full Profile

Measurement of the sites in the Full profile will enable additional computations to be made such as estimates of relative body fat (using a larger number of prediction equations), and calculation of bone, muscle, adipose and residual masses using fractionation of body mass techniques (Drinkwater & Ross, 1980; Kerr, 1988), as well as calculations of skeletal mass and skeletal muscle mass by various methods (Martin et al., 1990; Martin, 1991; Janssen et al., 2000; Lee et al., 2000).

Type	No.	Site	Restricted
Basic	1	Mass®	✓
	2	Stature®	✓
	3	Sitting height	
Skinfolds	4	Triceps®	✓
	5	Subscapular®	✓
	6	Biceps®	✓
	7	Iliac Crest®	✓
	8	Supraspinale®	✓
	9	Abdominal®	✓
	10	Front thigh®	✓
	11	Medial calf®	✓
Girths	12	Head	
	13	Neck	
	14	Arm (relaxed)®	✓
	15	Arm (flexed and tensed)®	✓
	16	Forearm (maximum)	
	17	Wrist (distal styloids)	
	18	Chest (mesosternale)	
	19	Waist (minimum)®	✓
	20	Gluteal (hips)®	✓
	21	Thigh (1 cm gluteal)	
	22	Thigh (mid-troch-tib. lat.)	
	23	Calf (maximum)®	✓
	24	Ankle (minimum)	
Lengths	25	Acromiale-radiale	
	26	Radiale-stylion	
	27	Midstylion-dactylion	
	28	Iliospinale height	
	29	Trochanterion height	
	30	Trochanterion-tibiale laterale	
	31	Tibiale laterale height	
	32	Tibiale laterale-sphyrion tibiale	
Breadths	33	Biacromial	
	34	Biilocristal	
	35	Foot length	
	36	Transverse chest	
	37	A-P chest depth	
	38	Humerus®	✓
	39	Femur®	✓

Table 1. Sites included in the anthropometric profile.
All 39 sites make up the Full profile.
The 17 checked sites make up the Restricted profile.
These sites are identified by the ® symbol.

2 Anatomical landmarks

2.1 Marked anatomical landmarks

Landmarks are identifiable skeletal points which generally lie close to the body's surface and are the 'markers' which identify the exact location of the measurement site, or from which a soft tissue site is located, for example, subscapular skinfold and arm girth. Llandmarks are found by palpation or measurement. For the comfort of the subject, the measurer's finger nails should be kept trimmed.

The landmark is identified with the thumb or index finger. The site is released to remove any distortion of the skin, then is relocated and marked using a fine tipped felt or dermographic pen. The site is marked directly over the landmark. The mark is then re-checked to ensure that there has been no displacement of skin relative to the underlying bone. When landmarks are made using an anthropometric tape, the mark should be made at the top edge of the tape while the tape is held at a right angle to the limb axis.

The landmarks described here are those required for the measurement sites included in this document. All landmarks are identified before any measurements are made. The order of their identification is as listed here. These sites represent only a small portion of the potentially infinite number of sites over the surface of the body. They are included since they are the sites typically referenced when profiling individuals. It should be pointed out, however, that other sites are often required for analyses in ergonomics, child growth and development and specific sporting populations.

Landmarks are identified by Latinised names. We urge anthropometrists to use the specific landmark terminology as presented here, regardless of language. That is, don't translate "Acromiale" into some other word in your language. To facilitate communication between anthropometrists from around the world, use "Acromiale" as the international term.

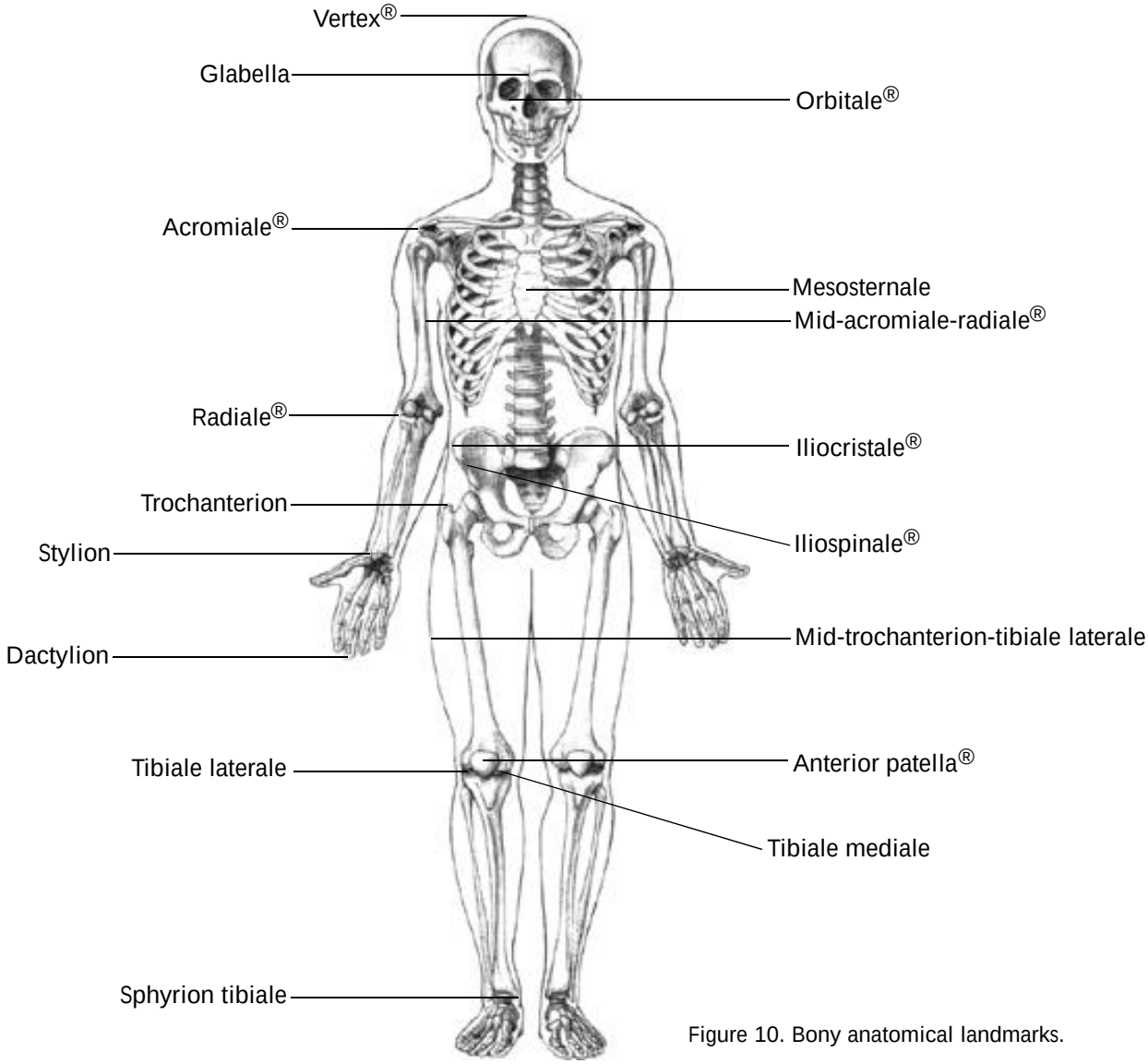


Figure 10. Bony anatomical landmarks.

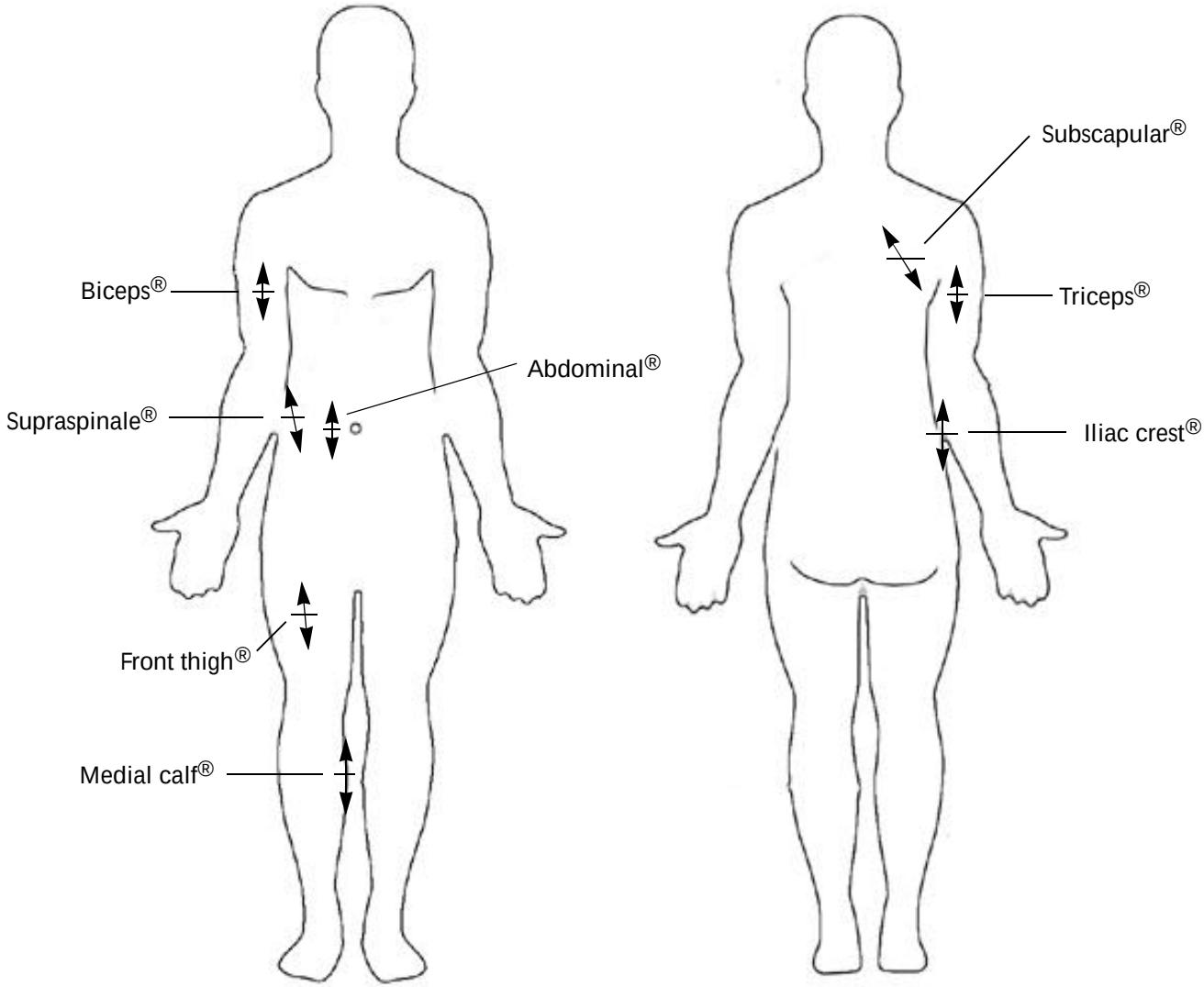


Figure 11. Location of skinfold sites: anterior view (left panel) and posterior view (right panel).

Acromiale®

Definition: The point on the superior part of the acromion border in line with the most lateral aspect.

Subject position: The subject assumes a relaxed position with the arms hanging by the sides. The shoulder girdle should be in a mid-position.

Location: Standing behind and on the right hand side of the subject, palpate along the spine of the scapula to the corner of the acromion. This represents the start of the lateral border which usually runs anteriorly, slightly superiorly and medially. Apply the straight edge of a pencil to the lateral aspect of the acromion to confirm the location of the most lateral part of the border. Mark this most lateral aspect. The acromion has an associated bone thickness. Palpate superiorly to the top margin of the acromion border in line with the most lateral aspect.

Figure 12. The Acromiale® landmark.

Radiale®

Definition: The point at the proximal and lateral border of the head of the radius.

Subject position: The subject assumes a relaxed position with the arms hanging by the sides.

Location: Palpate downward into the lateral dimple of the right elbow. It should be possible to feel the space between the capitulum of the humerus and the head of the radius. Then move the thumb distally onto the most lateral part of the proximal radial head. Correct location can be confirmed by slight rotation of the forearm which causes the head of the radius to rotate.

Figure 13. The Radiale® landmark.

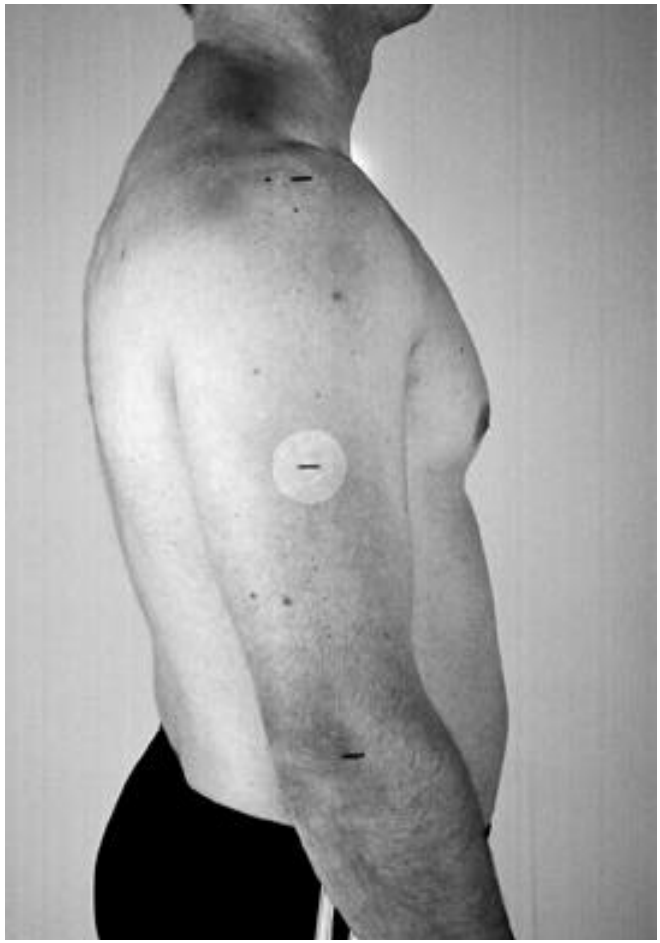


Figure 14. The Mid-acromiale-radiale® landmark. The other horizontal lines are the marked Acromiale® and Radiale® sites.

Mid-acromiale-radiale®

Definition: The point equidistant from Acromiale® and Radiale®.

Subject position: The subject assumes a relaxed position with the arms hanging by the sides.

Location: Measure the linear distance between the Acromiale® and Radiale® landmarks with the arm relaxed and extended by the side. The best way to measure this is with a segmometer or large sliding caliper. If a tape is used be sure to avoid following the curvature of the surface of the arm. Place a small horizontal mark at the level of the mid-point between these two landmarks. Project this mark around to the posterior and anterior surfaces of the arm as a horizontal line. This is required for locating the Triceps® and Biceps® skinfold sites.

Figure 15. The Triceps skinfold site®. The horizontal line to the right is the marked Mid-acromiale-radiale® site.

Triceps skinfold site®

Definition: The most posterior part of the Triceps when viewed from the side at the marked Mid-acromiale-radiale® level.

Subject position: When marking the sites for the Triceps® skinfold the subject assumes the anatomical position.

Location: The Triceps® skinfold site is marked over the most posterior part of the Triceps when viewed from the side at the marked Mid-acromiale-radiale® level.

Figure 16. The Biceps skinfold site®. Note the marked Mid-acromiale-radiale® site to the left.

Biceps skinfold site®

Definition: The most anterior part of the Biceps.

Subject position: When marking the sites for the Biceps® skinfold the subject assumes the anatomical position.

Location: The Biceps® skinfold site is marked over the most anterior part of the Biceps when viewed from the side at the marked Mid-acromiale-radiale® level.

Figure 17. The Stylion landmark.

Stylion

Definition: The most distal point on the lateral margin of the styloid process of the radius.

Subject position: The subject assumes a relaxed position with the arms hanging by the sides. The measurer lifts the wrist to locate the landmark.

Location: Using a thumb nail the anthropometrist palpates in the triangular space identified by the muscle tendons of the wrist immediately above the thumb. This area is also called the anatomical 'snuff box'. Once the snuff box has been identified, palpate in the space between the distal radius and the scaphoid in order to correctly identify the styloid process.

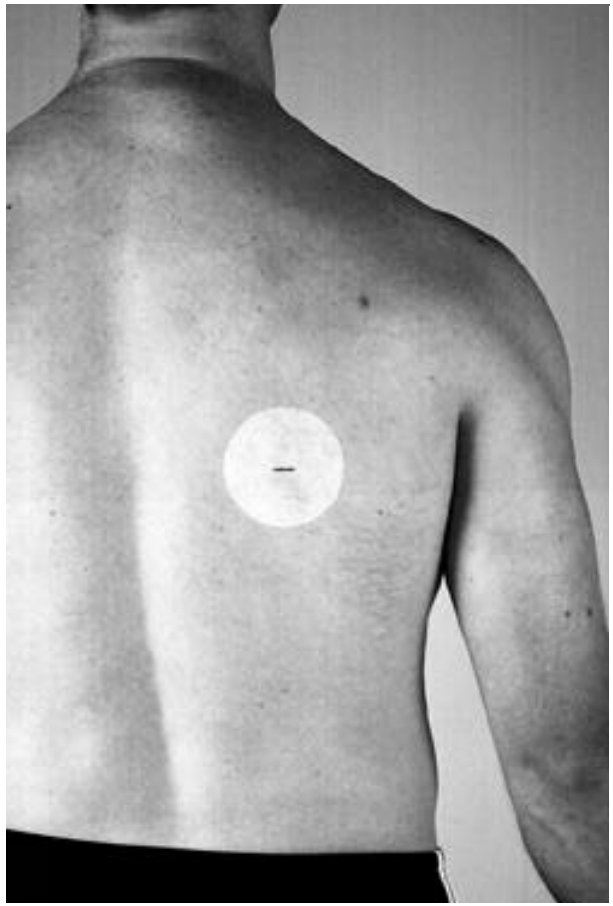
Figure 18. The Mid-stylion landmark.

Mid-stylion

Definition: The midpoint, on the anterior (palmar) surface of the wrist, of the horizontal line at the level of the stylion.

Subject position: The subject assumes a relaxed position with the arms hanging by the sides. The measurer lifts the wrist to locate the landmark.

Location: The tape is aligned with the stylion landmark and a line perpendicular to the long axis of the forearm is drawn close to the mid-point of the wrist. The mid-point is estimated between the medial and lateral edges of the wrist. A line is drawn at this position which intersects the perpendicular line.



Subscapulare®

*Definition:*The undermost tip of the inferior angle of the scapula.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Location: Palpate the inferior angle of the scapula with the left thumb. If there is difficulty locating the inferior angle of the scapula, the subject should slowly reach behind the back with the right arm. The inferior angle of the scapula should be felt continuously as the hand is again placed by the side of the body. A final check of this landmark should be made with the hand by the side in the relaxed position.

Figure 19. The Subscapulare® landmark.

Figure 20. The Subscapular skinfold site®. The horizontal line is the marked Subscapulare® site.

Subscapular skinfold site®

Definition: The site 2 cm along a line running laterally and obliquely downward from the Subscapulare® landmark at a 45° angle.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Location: Use a tape measure to locate the point 2 cm from the Subscapulare® in a line 45° laterally downward.

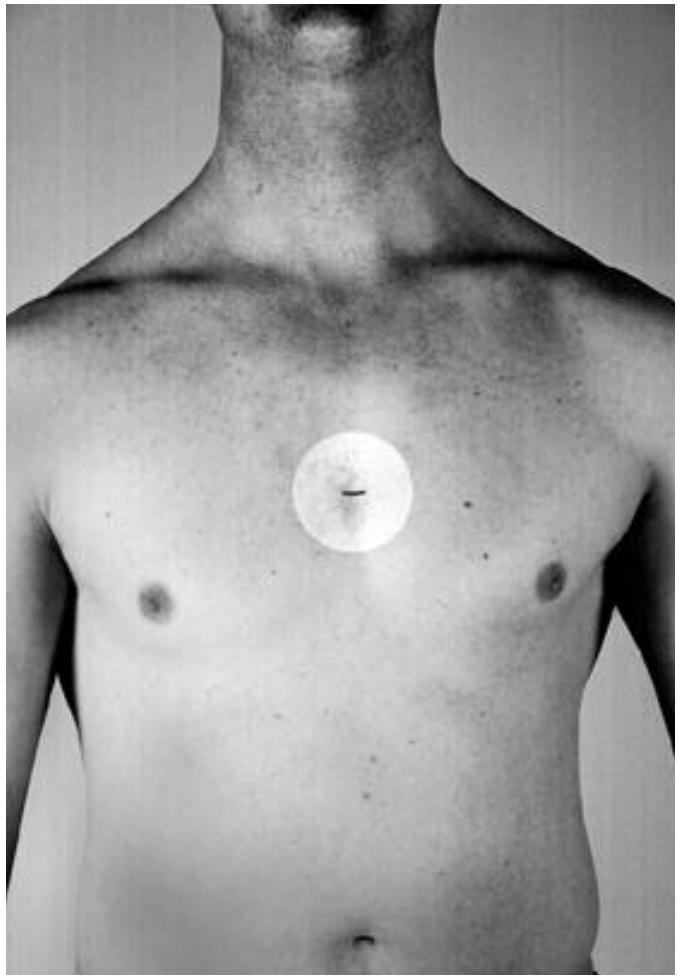


Figure 21. The Mesosternale landmark.

Mesosternale

Definition: The midpoint of the corpus sterni at the level of the centre of the articulation of the fourth rib with the sternum (chondrosternal articulation).

Subject position: The subject assumes either a seated or standing position with the arms hanging by the sides.

Location: This landmark is located by palpation beginning from the top of the clavicles. Using the thumb the anthropometrist should roll down from the clavicle to the first intercostal space (i.e. between the first and second ribs). The thumb is then replaced by the index finger and the procedure is then repeated down to the second, third and fourth intercostal spaces. The fourth rib is between the last two spaces. An extra check of rib identification is that the second rib is at the level of the sternal angle which can be felt as a ridge on the sternum.

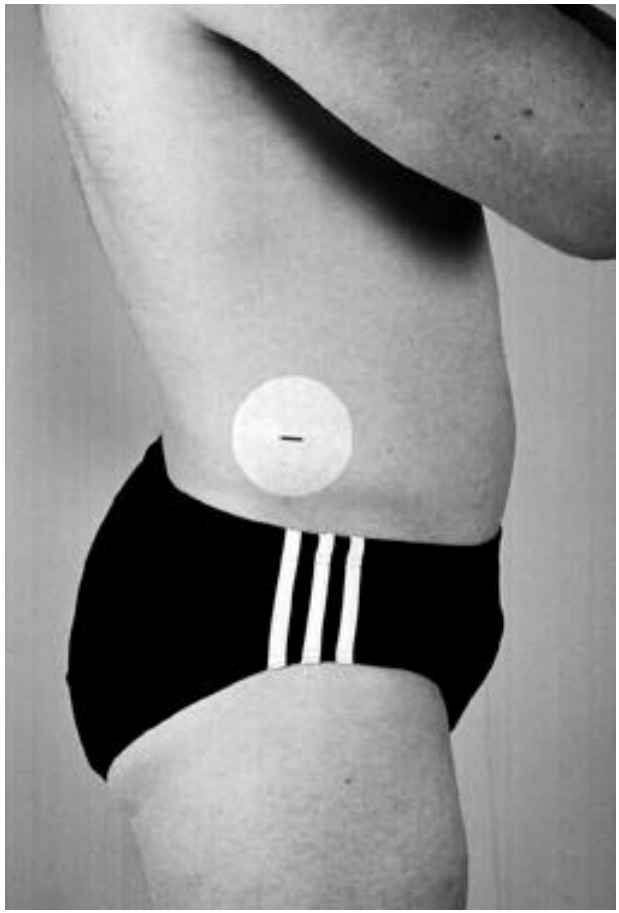


Figure 22. The Iliocristale® landmark.

Iliocristale®

Definition: The point on the most lateral aspect of the iliac tubercle, which is on the iliac crest.

Subject position: The subject assumes a relaxed position with the left arm hanging by the side and the right arm abducted to the horizontal.

Location: From behind the subject, locate the most lateral edge of the iliac crest on the ilium using using the right hand. The left hand is used to stabilise the body by providing resistance on the left side of the pelvis. The landmark is the most lateral point made at the identified edge of the ilium.

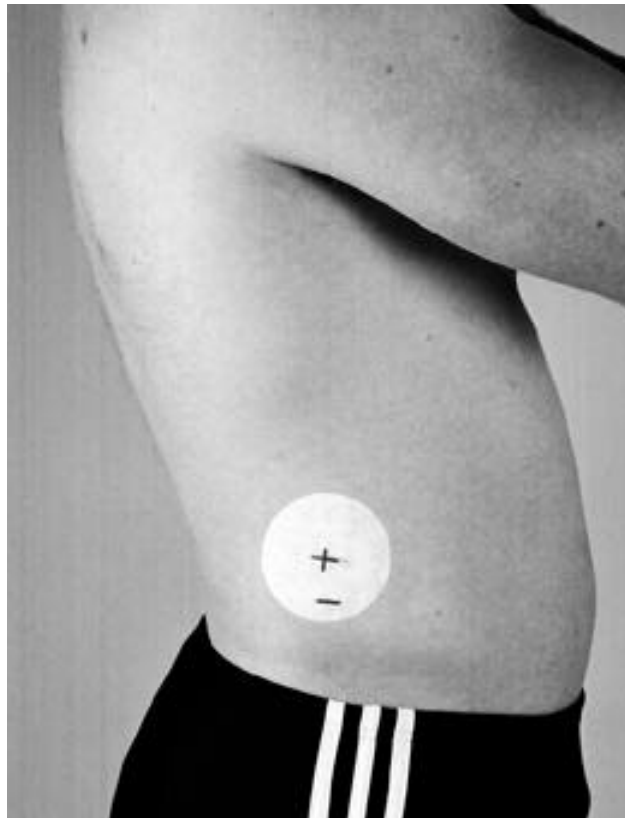


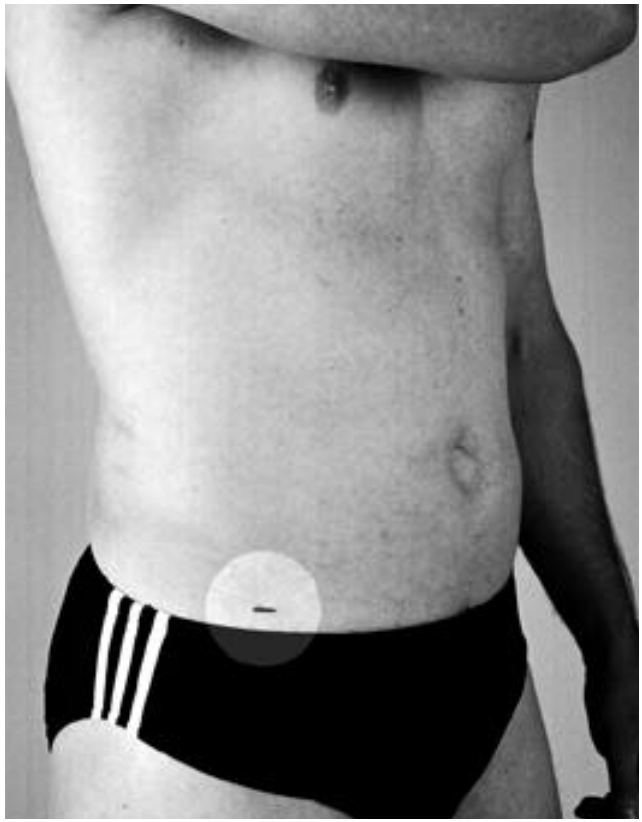
Figure 23. The Iliac crest skinfold site®. The horizontal line is the marked Iliocristale® site.

Iliac crest skinfold site®

Definition: The site at the centre of the skinfold raised immediately above the marked Iliocristale®.

Subject position: The subject assumes a relaxed position with the left arm hanging by the side and the right arm abducted to the horizontal.

Location: This skinfold is raised immediately superior to the Iliocristale. Align the fingers of the left hand on the Iliocristale landmark and exert pressure inwards so that the fingers roll over the iliac crest. Substitute the left thumb for these fingers and relocate the index finger a sufficient distance superior to the thumb so that this grasp becomes the skinfold to be measured. Mark the centre of the raised skinfold. The fold runs slightly downwards anteriorly as determined by the natural fold of the skin.



Iliospinale®

Definition: The most inferior or undermost part of the tip of the anterior superior iliac spine.

Subject position: The subject assumes a standing position with the arms hanging by the sides.

Location: Palpate the superior aspect of the ilium and follow anteriorly and inferiorly along the crest to the anterior superior iliac spine and downward until it runs posteriorly. The landmark is the lower margin or edge where the bone can just be felt. Difficulty in appraising the landmark can be assisted by the subject lifting the heel of the right foot and rotating the femur outward. Because the Sartorius muscle originates at the Iliospinale®, this movement of the femur enables palpation of the muscle and tracing to its origin.

Figure 24. The Iliospinale® landmark.

Supraspinale skinfold site®

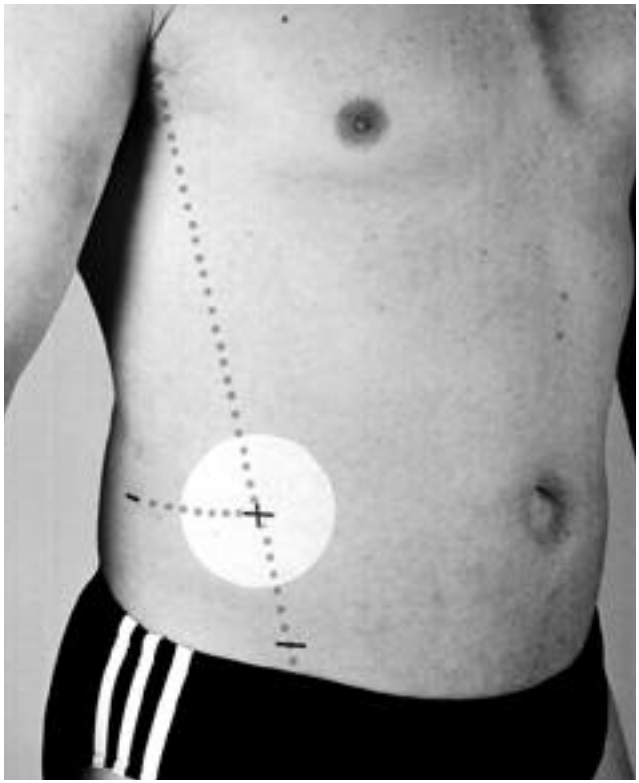


Figure 25. The Supraspinale skinfold site®. Note the dotted lines from the marked Iliospinale® to the anterior axillary border, and the horizontal line at the level of the marked Iliocristale®.

Definition: The site at the intersection of two lines:
(1) the line from the marked Iliospinale® to the anterior axillary border, and
(2) the horizontal line at the level of the marked Iliocristale®.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides. The right arm may be abducted to the horizontal after the anterior axillary border has been identified.

Location: The fold runs slightly downwards and anteriorly as determined by the natural fold of the skin. [This skinfold was originally named "suprailiac" by Parnell (1958) and Heath and Carter (1967), but since 1982 it has been known as the "supraspinale" (Ross and Marfell-Jones, 1982; Carter and Heath, 1990).]

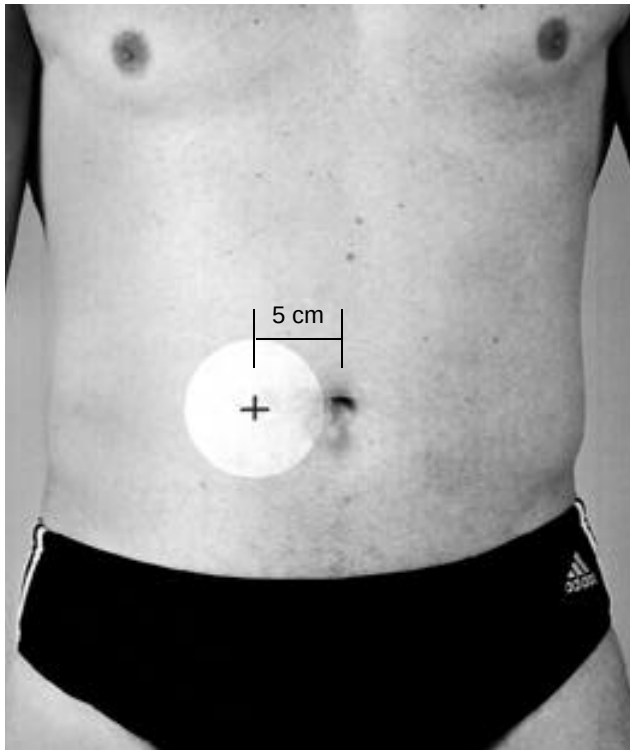


Figure 26. The Abdominal skinfold site®.

Abdominal skinfold site®

Definition: The site 5 cm to the right hand side of the omphalion (midpoint of the navel).

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Location: This is a vertical fold raised 5 cm from the right hand side of the omphalion.

Figure 27. The Trochanterion landmark.

Trochanterion

Definition: The most superior point on the greater trochanter of the femur, not the most lateral point.

Subject position: The subject assumes a relaxed standing position with the right arm across the trunk.

Location: This site is identified while standing behind the subject by palpating the lateral aspect of the gluteal muscle with the heel of the hand while standing behind the subject. It is advisable to support the left side of the subject's pelvis with the left hand while applying pressure with the right hand. Once the greater trochanter has been identified, the measurer should palpate upward to locate the highest point of the trochanter where the bone can still be felt when strong downward pressure is applied. [Note: This site is difficult to locate in persons with thick adipose tissue over the greater trochanter.]

Figure 28. The Tibiale laterale landmark. The upper mark is the Trochanterion.

Tibiale laterale

Definition: The most superior point on the lateral border of the head of the tibia.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Location: This is often a difficult landmark to correctly locate due to thick lateral ligaments that run across the knee joint. Palpate the site using a thumb nail and the following guidelines. Locate the joint space bounded by the lateral condyle of the femur and the antero-lateral portion of the lateral tibial condyle. Press inwards firmly in order to locate the superior and lateral border of the head of the tibia. It is often useful to have the subject flex and extend the knee several times to ensure that the correct position has been located. The mark should be made approximately one-third of the distance along the border moving in an anterior-posterior direction.

Mid-trochanterion-tibiale laterale

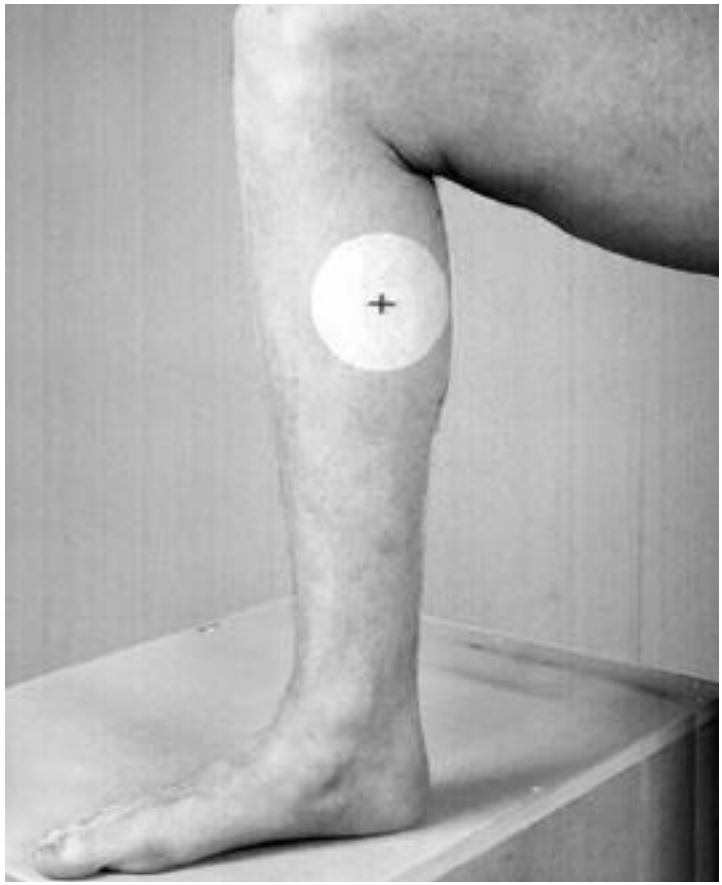
Figure 29. The Mid-trochanterion-tibiale laterale landmark. Note also the marks for the Trochanterion (above) and Tibiale laterale (below).

Definition: The point equidistant from trochanterion and tibiale laterale.

Subject position: The subject assumes a relaxed position with the left arm hanging by the side and the right forearm across the trunk.

Location: Measure the linear distance between the Trochanterion and Tibiale laterale landmarks. The best way to measure this is with a segmometer or large sliding caliper. If a tape is used be sure to avoid following the curvature of the surface of the thigh. Place a small horizontal mark at the level of the mid-point between these two landmarks.

Medial calf skinfold site®



Definition: The site on the most medial aspect of the calf at the level of the maximal girth.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.The subject's feet should be separated with the weight evenly distributed.

Location: The level of the maximum girth is determined and marked with a small horizontal line on the medial aspect of the calf. The maximal girth is found by using the middle fingers to manipulate the position of the tape in a series of up or down measurements to determine the maximum girth. View the marked site from the front to locate the most medial point and mark this with an intersecting vertical line.

Figure 30. The Medial calf skinfold site®.

Figure 31. The Front thigh skinfold site®.

Front thigh skinfold site®

Definition: The site at the mid-point of the distance between the Inguinal fold® and the anterior surface of the patella (Anterior patalla®) on the midline of the thigh.

Subject position: The subject assumes a seated position with the torso erect and the arms hanging by the sides. The knee of the right leg should be bent at a right angle.

Location: The measurer stands facing the right side of the seated subject on the lateral side of the thigh. The site is marked parallel to the long axis of the thigh at the mid-point of the distance between the Inguinal fold® and the superior margin of the anterior surface of the patella (while the leg is bent). The Inguinal fold® is the crease at the angle of the trunk and the thigh. If there is difficulty locating the fold the subject should flex the hip to make a fold. Place a small horizontal mark at the level of the mid-point between the two landmarks. Now draw a perpendicular line to intersect the horizontal line. This perpendicular line is located in the midline of the thigh. If a tape is used be sure to avoid following the curvature of the surface of the skin.

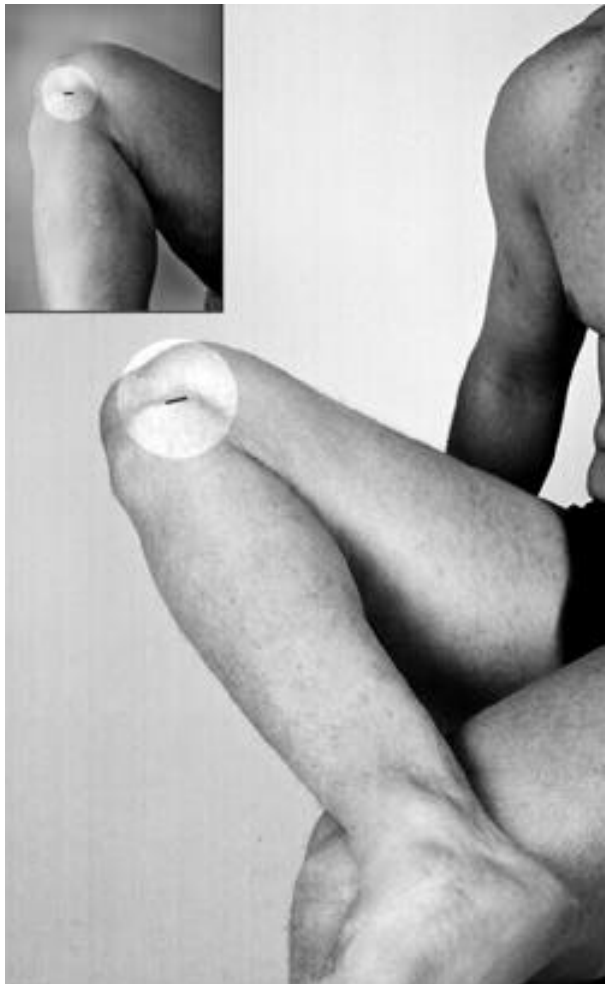


Figure 32. The Tibiale mediale landmark.

Tibiale mediale

Definition: The most superior point on the medial border of the head of the tibia.

Subject position: The subject is seated with the right leg resting over the left knee so that the medial aspect of the leg is able to be marked.

Location: The Tibiale mediale is approximately in the same transverse plane as the Tibiale laterale. Palpate the joint space bounded by the medial femoral condyle and the medial tibial condyle. The most superior point should be marked on the proximal medial border while the leg is held in this position.

Sphyrion tibiale

Definition: The most distal tip of the medial malleolus.

Subject position: The subject is seated with the right leg resting over the left knee so that the medial aspect of the leg is able to be marked.

Location: This landmark may be located most easily by palpation with the thumb nail from beneath and dorsally. It is the distal tip, not the most medial aspect, of the medial malleolus.

Figure 33. The Sphyrion tibiale landmark.

2.2 Other reference landmarks

Akropodion

Definition: The most anterior point on the toe of the foot when the subject is standing. This may be the first or second phalanx.

Anterior patella®

Definition: The most anterior and superior margin of the anterior surface of the patella when the subject is seated and the knee bent at a right angle.

Dactylion

Definition: The tip of the middle (third) finger. Finger nails should not be used as landmarks for the end of fingers.

Glabella

Definition: The mid-point between the brow ridges.

Gluteal fold

Definition: The crease at the junction of the gluteal region and posterior thigh.

Inguinal fold®

Definition: The crease at the angle of the trunk and the anterior thigh.

Orbitale®

Definition: The lower bony margin of the eye socket.

Pternion

Definition: The most posterior point on the calcaneus of the foot when the subject is standing.

Tragion®

Definition: The notch superior to the tragus of the ear.

Vertex®

Definition: The most superior point on the skull when the head is positioned in the Frankfort plane.

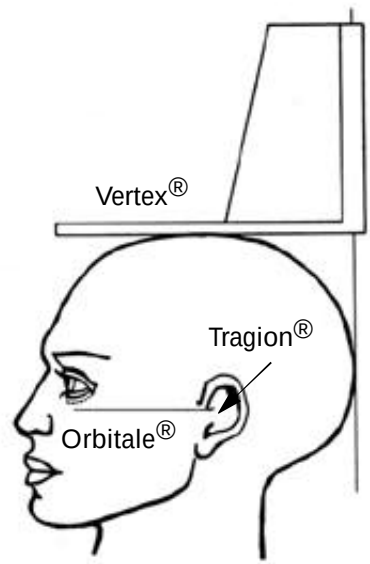
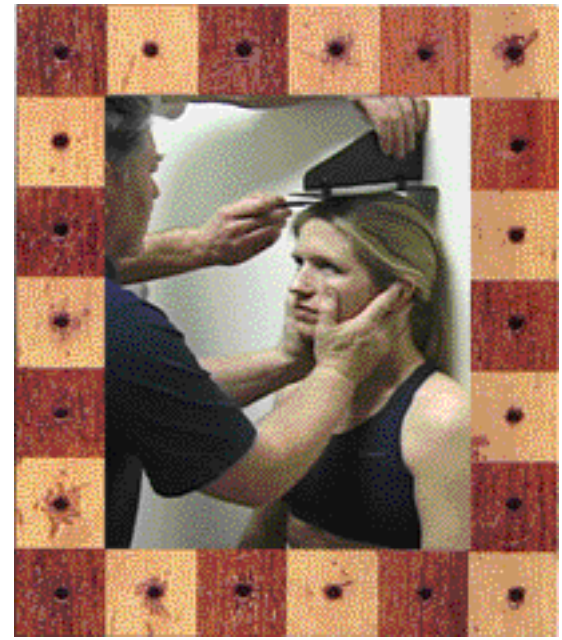


Figure 34. The head in the Frankfort plane



3 Basic measurements

3.1 General instructions

The precise assessment of anthropometric measurements can be difficult and therefore extreme care is required. In general there is not enough attention paid to an accurate measurement technique and, consequently, reproducibility cannot be obtained. The description of the measurement procedures seems quite simple, but a high degree of technical skill is essential for consistent results, especially when applied under field test conditions.

Anthropometrists wishing to become criterion measurers (i.e. those who do not make systematic errors and who can demonstrate reproducibility), must be able to routinely make accurate measurements. It is essential, therefore, that the standard protocols outlined in these guidelines are strictly adhered to:

• Prior to measuring, the tester should develop the appropriate technique. This has been shown to reduce the level of error in repeated measurements and among investigators (Jackson, Pollock & Gettman, 1978; Lohman & Pollock, 1981). Repeated measures on at least twenty subjects should be made in order to establish reproducibility, and comparison of measurements with an experienced anthropometrist will help to establish accuracy, and to expose any weaknesses in technique.

• The right side of the body is always used for measurements irrespective of the preferred side of the subject. It is sometimes impracticable to use the right side due to injury (swelling, casts, etc.) and at other times it is desirable to compare the two sides of the body following injury and/or rehabilitation, in which case the left side may be used. Comparisons between the left and right sides of the body have indicated that there is either no significant difference in skinfold thickness (Womersley & Durnin, 1973) or that the differences, although statistically significant, are of no practical significance (Martorell, Mendoza, Mueller & Pawson, 1988) even when the subject's musculature and bone have hypertrophied on one side such as in

tennis players (Gwinup, Chelvam & Steinberg, 1971; Jokl, 1976; Montoye, Smith, Fardon & Howley, 1980). However, there can be significant differences in girths and occasionally bone breadths. Variations from standard procedures should be recorded on the proforma sheet. For example, if time permits, left-dominant subjects may be measured on their dominant side for somatotype analysis as originally described by Heath and Carter (1967).

• If possible, 2-3 measurements should be taken at each site with the mean value being used in any further calculations if two measurements are taken, and the median value used if three measurements are taken. It is especially important for the beginner to repeat measurements so that confidence and reproducibility can be established. Where possible, an assistant should be used to record values and help standardise measurement techniques.

• Sites should be measured in succession to avoid experimenter bias. That is, a complete data set is obtained before repeating the measurements for the second and then third time.

• Normally, measurements should not be taken after training or competition, sauna, swimming or showering, since exercise, warm water and heat can produce dehydration and/or hyperæmia (increased blood flow). These may affect body mass, skinfold and girth measurements.

3.2 Basic measurement items

Figure 35. Measurement of Body mass®.

1 Body mass®

Body mass exhibits diurnal variation of about 1 kg in children and 2 kg in adults (Sumner & Whitacre, 1931). The most stable values are those obtained routinely in the morning twelve hours after food and after voiding. Since it is not always possible to standardise the measurement time it is important to record the time of day when measurements are made.

Equipment required: weighing scale

Method: Nude mass is the recorded measure. This can be estimated (or calculated) by first weighing the same or similar clothing to that which will be worn during measurement and subtracting this from the measured scale mass. Generally the mass in minimal clothing is of sufficient accuracy. Check that the scale is reading zero, then the subject stands on the centre of the scales without support and with the weight distributed evenly on both feet.

Figure 36. Measuring stretch Stature®.

2 Stature®

There are four general techniques for measuring stature: free standing, stature against the wall, recumbent length, and stretch stature. The recumbent length method may be used for infants up to 2–3 years or adults unable to stand and will not be considered here. The other three methods give slightly different values. It must also be remembered that there will be diurnal variation in stature. Generally, subjects are taller in the morning and shorter in the evening. A loss of about 1% in stature is common over the course of the day (Reilly, Tyrrell & Troup, 1984; Wilby, Linge, Reilly & Troup, 1985). The effect of this diurnal variation can be reduced using the stretch stature method. Therefore, the preferred technique is the stretch stature method described below. Repeated measures should be taken as near as possible to the same time of day as the original measurement. The time of measurement should be recorded on the proforma.

Equipment: Stadiometer

Method: The stretch stature method requires the subject to stand with the feet together and the heels, buttocks and upper part of the back touching the scale. The head when placed in the Frankfort plane need not be touching the scale. The Frankfort plane is achieved when the Orbitale® (lower edge of the eye socket) is in the same horizontal plane as the Tragion® (the notch superior to the tragus of the ear). When aligned, the Vertex® is the highest point on the skull as illustrated in Figure 34.

The measurer places the hands far enough along the line of the jaw of the subject to ensure that upward pressure is transferred through the mastoid processes. The subject is instructed to take and hold a deep breath and while keeping the head in the Frankfort plane the measurer applies gentle upward lift through the mastoid processes. The recorder places the head board firmly down on the vertex, crushing the hair as much as possible. The recorder further assists by watching that the feet do not come off the floor and that the position of the head is maintained in the Frankfort plane. Measurement is taken at the end of a deep inward breath.

Figure 37. Measurement of Sitting height.

3 Sitting height

The height from the sitting platform to the Vertex® when the head is held in the Frankfort plane. The preferred technique is the stretch stature method. Repeated measures should be taken as near as possible to the same time of day as the original measurement. The time of measurement should be recorded on the proforma.

Equipment: Stadiometer

Method: The subject is seated on a measuring box or level platform. The hands should be resting on their thighs. The subject is instructed to take and hold a deep breath and while keeping the head in the Frankfort plane the measurer applies gentle upward lift through the mastoid processes. The recorder places the head board firmly down on the Vertex®, crushing the hair as much as possible. Care must be taken to ensure the subject does not contract the gluteal muscles nor push with the legs.

4 Skinfolds

4.1 Techniques for measuring skinfolds

Of all surface anthropometry measurements, skinfolds have the lowest accuracy and precision. Therefore great care is needed.

• Prior to measuring, ensure that the skinfold caliper is accurately measuring the distance between the centre of its contact faces by using the short blades of an engineer's vernier caliper. If possible, the tester should check that the tension of the jaws remains constant throughout the range of measurement. A full sweep of the needle is 20 mm and this is reflected on the small scale on the Harpenden caliper face. Before using the caliper make sure that the needle is on zero. After unlocking the small screw, rotate the outer ring of the caliper to adjust the position of the caliper dial directly under the needle.

• The skinfold site should be carefully located using the correct anatomical landmarks. Marking the skin with a fine tipped felt or dermographic pen for all skinfold landmarks minimises location errors for repeat measures. Skinfold thicknesses have been shown to vary by an average of 2-3 mm when the caliper was placed 2.5 cm from the correct site. Inaccurate location of skinfold sites was also found to be the greatest source of error among investigators (Ruiz, Colley & Hamilton, 1971).

• The skinfold is picked up at the marked line. It should be grasped and lifted (raised) so that a double fold of skin plus the underlying subcutaneous adipose tissue is held between the thumb and index finger of the left hand. The near edge of the thumb and finger are in line with the marked site. The back of the hand should be facing the measurer. Care must be taken not to incorporate underlying muscle tissue in the grasp. In order to eliminate muscle, the finger and thumb roll the fold slightly thereby also ensuring that there is a sufficiently large grasp of the fold. If difficulty is encountered the subject should tense then relax the muscle until the tester is confident that only skin and subcutaneous tissue are in the grasp. Since a dou-

ble fold of skin (dermis) is also being measured, some variability may be attributed to variations in skin thicknesses at different sites over the body and among different people (Martin, Ross, Drinkwater & Clarys, 1985). Despite skin thickness decreasing with age (due to changes in collagen structure), this should not normally be considered an important variable since it is outside the resolution for detection with skinfold calipers.

• The nearest edge of the contact faces of the caliper are applied 1 cm away from the edge of the thumb and finger. If the caliper is placed too deep or too shallow incorrect values may be recorded. As a guide, the caliper should be placed at a depth of approximately mid-fingernail. Practice is also necessary to ensure the same size of skinfold is grasped at the same location for repeat measures.

• The caliper is held at 90° to the surface of the skinfold site at all times. If the caliper jaws are allowed to slip or are incorrectly aligned the distance recorded may be inaccurate. The tester must make sure the hand grasping the skin remains holding the fold while the caliper is in contact with the skin.

• Measurement is recorded two seconds after the full pressure of the caliper is applied (Kramer & Ulmer, 1981). It is important that the measurer makes sure that fingers resting on the caliper trigger do not prevent the full caliper pressure from being exerted. In the case of large skinfolds, the needle may still be moving at this point. The measurement is nevertheless recorded at this time. This standardisation is necessary since adipose tissue is compressible (Martin et al., 1985). A constant recording time enables test/retest comparisons to be made while controlling for skinfold compressibility.

• As with other measurements, skinfold sites should be measured in succession to avoid experimenter bias. That is, a complete data set is obtained before repeating the measurements for the second and then third time. This may also help to reduce the effects of skinfold compressibility. They should be measured in the same order as listed on the proforma so that the assistant is familiar with the routine and errors are min-

imised. (Note: If consecutive skinfold measurements become smaller, the adipose tissue is likely being compressed where the intra- and extracellular fluid content is gradually being reduced. This most often occurs in the fatter subjects. In this instance the tester should move to the next site and return to the original site after several minutes.)

• Skinfold measurements should not be taken after training or competition, sauna, swimming or showering, since exercise, warm water and heat produce hyperæmia (increased blood flow) in the skin with a concomitant increase in skinfold thickness. Additionally, it has been suggested that dehydration causes the skinfold thickness to increase due to changes in skin turgidity or tenseness (Consolazio, Johnson & Pecora, 1963). However, a more recent study (Norton, Hayward, Charles & Rees, 2000) failed to find differences between skinfolds taken before and after moderate dehydration induced by heat and/or exercise.

4.2 Measurement sites — skinfolds

Figure 38. Triceps® skinfold.

4 Triceps®

Subject position: The subject assumes a relaxed standing position with the left arm hanging by the side. The right arm should be relaxed with the shoulder joint slightly externally rotated and elbow extended by the side of the body.

Method: The fold is parallel to the long axis of the arm.

Figure 39. Subscapular® skinfold.

5 Subscapular®

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Method: The line of the skinfold is determined by the natural fold lines of the skin.

Figure 40. Biceps® skinfold.

6 Biceps®

Subject position: The subject assumes a relaxed standing position with the left arm hanging by the side. The right arm should be relaxed with the shoulder joint slightly externally rotated and elbow extended by the side of the body.

Method: This skinfold is parallel to the long axis of the arm.

Figure 41. Iliac crest® skinfold.

7 Iliac crest®

Subject position: The subject assumes a relaxed standing position with the left arm hanging by the side. The right arm should be either abducted or placed across the trunk.

Method: The line of the skinfold generally runs slightly downward posterior-anterior, as determined by the natural fold lines of the skin.

Note: Over the years there has been a lot of confusion about the nomenclature of skinfold sites over the ilioabdominal region. Sites have variously been called the iliac crest, iliocristale, suprailium, suprailiac and supraspinale. ISAK identifies the **Iliac crest®** and **Supraspinale®** skinfold sites. ISAK's Iliac crest site is very similar to the site that Durnin & Womersley (1974) called the suprailiac skinfold.

8 Supraspinale®

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Method: The fold runs medially downward at about a 45° angle as determined by the natural fold of the skin.

Note: ISAK's Supraspinale site was termed the suprailiac by Parnell (1958) and Tanner (1964). ISAK's Supraspinale skinfold site is a site used in the Heath-Carter somatotype system (Carter & Heath, 1990)

Figure 42. Supraspinale® skinfold.

Figure 43. Abdominal® skinfold.

9 Abdominal®

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Method: This is a vertical fold. It is particularly important at this site that the measurer is sure the initial grasp is firm and broad since often the underlying musculature is poorly developed. This may result in an underestimation of the thickness of the subcutaneous layer of tissue. (Note: Do not place the fingers or caliper inside the navel.)

10 Front thigh®

Figure 44A.

Figure 44B.

Subject position: The subject assumes a seated position at the front edge of the box with the torso erect and the arms hanging by the sides. The knee of the right leg is usually bent at a right angle. In some subjects, this skinfold may be easier to take with the knee extended.

Method: Method: Because of difficulties with this skinfold, three methods are recommended. These are illustrated in Figures 44A-44C.Be sure to record on the proforma the method used as A, B or C.

Method A (Figure 44a)
The measurer stands facing the right side of the subject on the lateral side of the thigh. The skinfold is raised at the marked site. The skinfold measurement is taken while the knee is bent. This is the standard and preferred method.

Method B (Figure 44b)
If the fold is difficult to raise the subject is asked to assist by lifting with both hands the underside of the thigh to relieve the tension of the skin.

Figure 44C.

Method C (Figure 44c)

• For subjects with particularly tight skinfolds, the subject is asked to assist by lifting the underside of the thigh as in (b). The recorder (standing on the medial aspect of the subject's thigh) assists by raising a fold with both hands at about 6 cm either side of the landmark. The measurer then raises the skinfold at the marked site).

Figure 44D.

If the skinfold is difficult to take with the knee flexed, ask the subject to extend the knee (Figure 44 D). Any of the three methods (A, B and C) may be used with the knee extended if necessary.

11 Medial calf®

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides and the right foot placed on the box. The right knee is bent at about 90°.

Method: The subject's right foot is placed on a box with the calf relaxed. The fold is parallel to the long axis of the leg.

Figure 45. Medial calf® skinfold.

5 Girths

5.1 Techniques for measuring girths

Equipment: Anthropometry tape, box

Method: The cross-hand technique is used for measuring all girths and the reading is taken from the tape where, for easier viewing, the zero is located more lateral than medial on the subject. In measuring girths, the tape is held at right angles to the limb or body segment which is being measured and the tension of the tape must be constant. Constant tension is achieved by ensuring that there is no indentation of the skin, but the tape holds its place at the designated landmark. While constant-tension tapes may be available, non-tension tapes are preferred since they allow the anthropometrist to control the tension. The objective is to minimise the gaps between the tape and the skin, and to minimise indentations of the skin wherever possible. Anthropometrists should realise that this is not always achievable. Where the contour of the surface of the skin becomes concave, for example, across the spinal column, continuous contact with the skin is neither achievable nor desirable.

To position the tape, hold the case in the right hand and the stub in the left. Facing the body part to be measured, pass the stub end around the back of the limb and take hold of the stub with the right hand which then holds both the stub and the casing. At this point the left hand is free to manipulate the tape to the correct level. Apply sufficient tension to the tape with the right hand to hold it at that position while the left hand reaches underneath the casing to take hold of the stub again. The tape is now around the part to be measured. The middle fingers of both hands are free to exactly locate the tape at the landmark for measurement and to orientate the tape so that the zero is easily read. The juxtaposition of the tape ensures that there is contiguity of the two parts of the tape from which the girth is determined. When reading the tape the measurer's eyes must be at the same level as the tape to avoid any error of parallax.

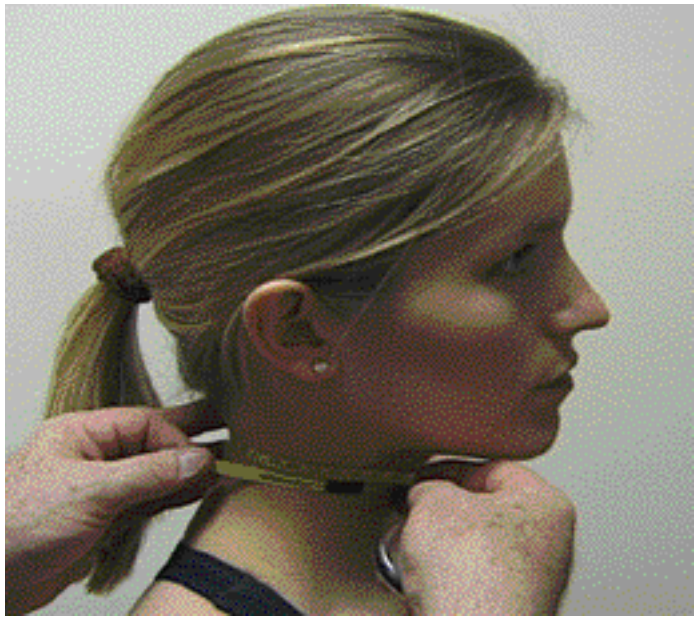
5.2 Measurement sites — girths

Figure 46. Head girth.

12 Head

Subject position: The subject assumes a relaxed seated or standing position with the arms hanging by the sides and the head in the Frankfort plane.

Method: The girth of the head is obtained in the Frankfort plane at the level immediately above the Glabella with the tape perpendicular to the long axis of the head. The tape needs to be pulled tight to compress the hair. Use of the middle fingers at the sides of the head is often necessary to prevent the tape from slipping over the head. Do not include the ears and ensure that there are no hair pins, clips or similar items in the hair during the measurement.



47. Neck girth.

13 Neck

Subject position: The subject assumes a relaxed seated or standing position with the arms hanging by the sides and the head in the Frankfort plane.

Method: The girth around the neck is measured immediately superior to the thyroid cartilage (Adam's apple). The subject should maintain the head in the Frankfort plane. It is important not to pull the tape tight in this region since the tissues are compressible. The tape is held perpendicular to the long axis of the neck which may not necessarily be in the horizontal plane.

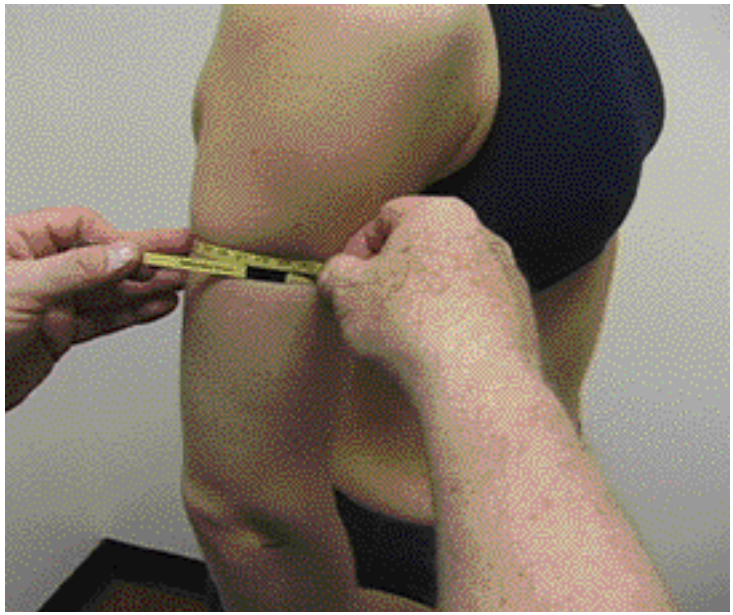


Figure 48. Arm girth — relaxed®.

14 Arm relaxed®

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides. The subject's right arm is abducted slightly to allow the tape to be passed around the arm.

Method: The girth of the arm is measured at the marked level of the Mid-acromiale-radiale®. The tape should be positioned perpendicular to the long axis of the arm.

15 Arm flexed and tensed®

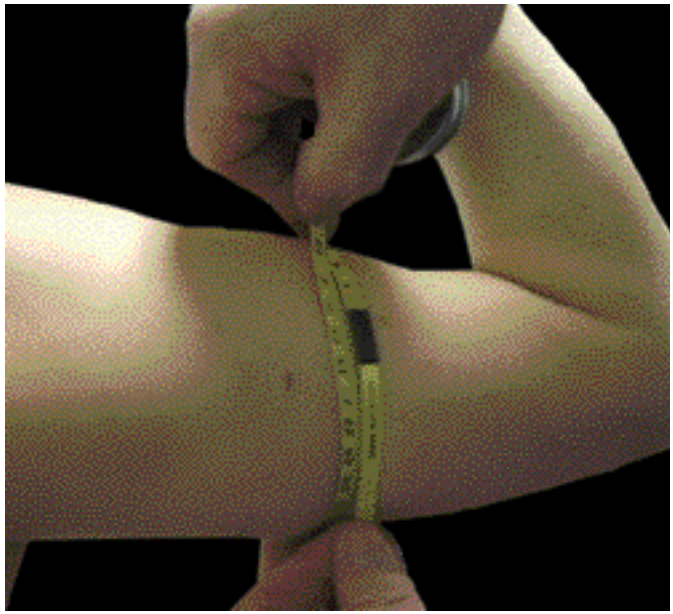


Figure 49. Arm girth — flexed and tensed®.

Subject position: The subject assumes a relaxed standing position with the left arm hanging by the side. The subject's right arm is raised anteriorly to the horizontal with the forearm supinated and flexed at about 45-90° to the arm.

Method: The flexed and tensed arm girth is measured at the level of the peak of the contracted Biceps. The measurer stands to the side of the subject and with the tape loosely in position. The subject is asked to partially tense the elbow flexors to identify the probable peak of the contracted muscles. The subject is encouraged to contract the arm muscles as strongly as possible and hold it while the measurement is made at the peak of the Biceps. If there is no obvious peak of the Biceps this girth should be measured at the level of the Mid-acromiale-radiale® landmark.

16 Forearm

Subject position: The subject assumes a relaxed standing position with the left arm hanging by the side. The subject's right arm is slightly flexed at the shoulder and the elbow is extended.

Method: The measurement is taken at the maximum girth of the forearm distal to the humeral epicondyles. The subject holds the palm up (ie forearm supinated) while relaxing the muscles of the forearm. Using the cross-hand technique move the tape measure up and down the forearm and make serial measurements in order to correctly locate the level of the maximum girth. It usually occurs just distal to the elbow.

Figure 50. Forearm girth.

Figure 51. Wrist girth.

17 Wrist

Subject position: The subject assumes a relaxed standing position with the left arm hanging by the side. The subject's right arm is slightly flexed at the shoulder, the elbow is extended, the forearm supinated and the hand relaxed.

Method: This girth measurement is taken distal to the styloid processes. It is the minimum girth in this region. Manipulation of the tape measure is required to be sure the minimal girth is obtained. The tissues should not be compressed by excessive tension.

18 Chest

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides and slightly abducted.

Method: This girth is taken at the level of the Mesosternale. The anthropometrist stands to the right of the subject who abducts the arms to the horizontal position allowing the tape to be passed around the thorax. The stub of the tape and the housing are then both held in the right hand while the anthropometrist uses the left hand to adjust the level of the tape at the back to the adjudged level of the marked Mesosternale. The anthropometrist resumes control of the stub with the left hand and using the cross-hand technique positions the tape in front at the level of the marked Mesosternale. The subject is instructed to lower their arms to the relaxed position with the arms slightly abducted. The tape is then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin. The subject should breathe normally and the measurement is taken at the end of a normal expiration (end tidal).

Figure 52. Chest girth.

Figure 53. Waist girth.

19 Waist®

Subject position: The subject assumes a relaxed standing position with the arms folded across the thorax.

Method: This girth is taken at the level of the narrowest point between the lower costal (10th rib) border and the iliac crest. The anthropometrist stands in front of the subject who abducts the arms slightly allowing the tape to be passed around the abdomen. The stub of the tape and the housing are then both held in the right hand while the anthropometrist uses the left hand to adjust the level of the tape at the back to the adjudged level of the narrowest point. The anthropometrist resumes control of the stub with the left hand and using the cross-hand technique positions the tape in front at the target level. The subject is instructed to lower their arms to the relaxed position. The tape is then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin. The subject should breathe normally and the measurement is taken at the end of a normal expiration (end tidal). If there is no obvious narrowing the measurement is taken at the mid-point between the lower costal (10th rib) border and the iliac crest.

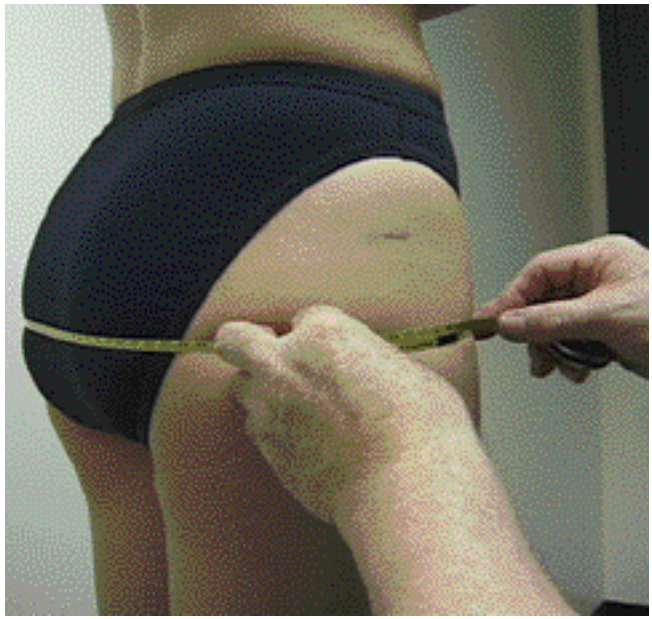


Figure 54. Gluteal (hip) girth.

20 Gluteal (hip)®

Subject position: The subject assumes a relaxed standing position with the arms folded across the thorax. The subject's feet should be together and the gluteal muscles relaxed.

Method: The girth is taken at the level of the greatest posterior protuberance of the buttocks which usually corresponds anteriorly to about the level of the symphysis pubis. The anthropometrist passes the tape around the hips from the side. The stub of the tape and the housing are then both held in the right hand while the anthropometrist uses the left hand to adjust the level of the tape at the back to the adjudged level of the greatest posterior protuberance of the buttocks. The anthropometrist resumes control of the stub with the left hand, and using the cross-hand technique, positions the tape in front and the sides so that the tape is held in a horizontal plane at the target level. The tape is then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin.

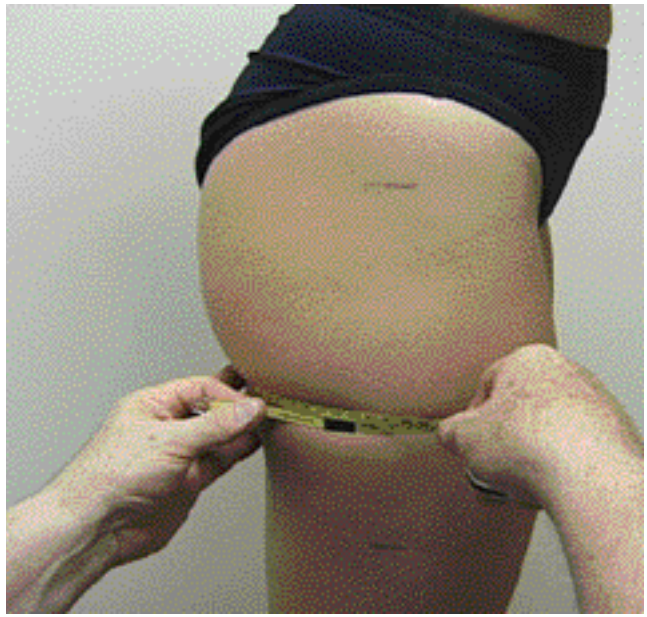


Figure 55. Thigh girth.

21 Thigh

Subject position: The subject assumes a relaxed standing position with the arms folded across the thorax. The subject stands with the feet slightly apart and mass equally distributed on both feet.

Method: The girth of the thigh is taken 1 cm below the level of the Gluteal fold, perpendicular to the long axis of the thigh. It is usually helpful to have the subject stand on a box or stool for this measure. The anthropometrist passes the tape between the lower thighs and then slides the tape up to the correct plane. The stub of the tape and the housing are both held in the right hand while the anthropometrist uses the left hand to adjust the level of the tape to the target level. The anthropometrist resumes control of the stub with the left hand and using the cross-hand technique positions the tape so that it is held in a perpendicular plane. The tape is then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin.

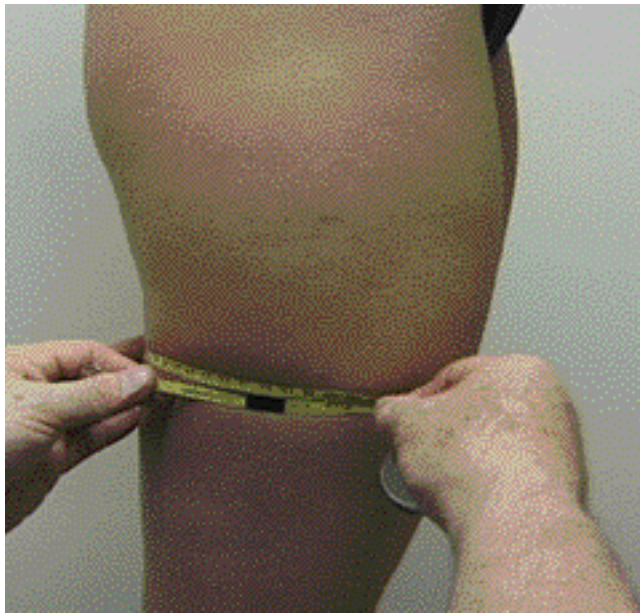


Figure 56. Mid-thigh girth.

22 Mid-thigh

Subject position: The subject assumes a relaxed standing position with the arms folded across the thorax. The subject's feet should be separated with the weight evenly distributed.

Method: This is the right mid-thigh girth at the marked Mid-trochanterion-tibiale-laterale site. It is usually helpful to have the subject stand on a box or stool for this measure. The anthropometrist passes the tape between the lower thighs and then slides the tape up to the correct plane. The stub of the tape and the housing are both held in the right hand while the anthropometrist uses the left hand to adjust the level of the tape to the target level. The anthropometrist resumes control of the stub with the left hand and using the cross-hand technique positions the tape so that it is held in a perpendicular plane. The tape is then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin.

Figure 57. Calf® girth.

23 Calf®

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides. The subject's feet should be separated with the weight evenly distributed.

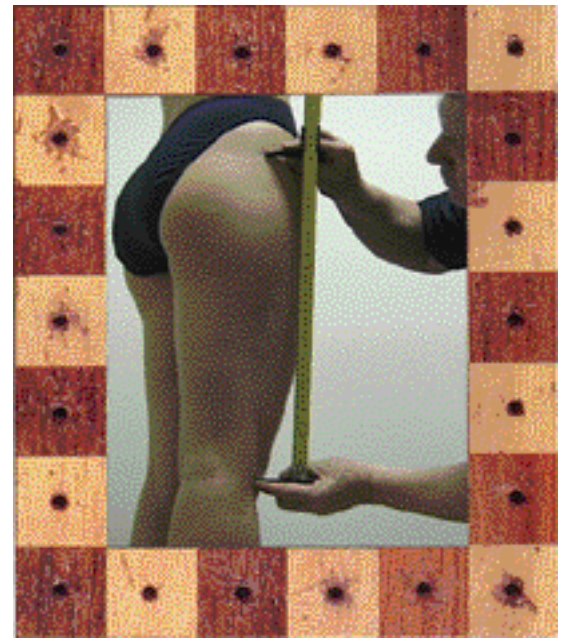
Method: The maximum girth of the calf at the marked Medial calf® skinfold site. The subject stands in an elevated position. The elevated position will make it easier for the measurer to align the eyes with the tape. The anthropometrist passes the tape around the calf and then slides the tape to the correct plane. The stub of the tape and the housing are both held in the right hand while the anthropometrist uses the left hand to adjust the level of the tape to the marked level. The anthropometrist resumes control of the stub with the left hand and using the cross-hand technique positions the tape so that it is held in a plane perpendicular to the axis of the leg. The tape is then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin.

Figure 58. Ankle girth.

24 Ankle

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides. The subject's feet should be separated with the weight evenly distributed.

Method: The minimum girth of the ankle is taken at the narrowest point superior to the Sphyrion tibiale. The subject stands in an elevated position. The elevated position will make it easier for the measurer to align the eyes with the tape. The anthropometrist passes the tape around the ankle. and manipulates it up and down this region to ensure that the minimum girth is obtained. The stub of the tape and the housing are both held in the right hand while the anthropometrist uses the left hand to adjust the level of the tape to the marked level. The anthropometrist resumes control of the stub with the left hand and using the cross-hand technique positions the tape so that it is held in a plane perpendicular to the axis of the leg. The tape is then readjusted as necessary to ensure it has not slipped and does not excessively indent the skin.



6 Lengths

6.1 Techniques for measuring lengths

Equipment: Anthropometer with foot plate, large sliding caliper, segmometer, box

Method: There are two methods for measuring body segment lengths:

• **Derived lengths**: This involves first measuring projected heights which are the vertical distances from the floor to a series of marked landmarks with a full-length anthropometer. For these measurements the bare-foot subject assumes the erect standing position with the feet together with arms against the sides with fore-arms pronated and fingers of the right hand extended. Following these measurements, the lengths of indi-vidual segments are determined by subtraction. For example, Acromiale® height minus Radiale® height, gives upper arm length (Acromiale-Radiale). Note that projected heights rather than segment lengths may be the variable of interest and they can be used as such.

• **Direct lengths**: In this method direct measurements are taken of the segment lengths from landmark to landmark. In this case either a large sliding caliper or a segmometer are the instruments used. Previous research (Day, 1986) has shown errors are more common when the projected segment lengths method is used. Therefore, it is recommended that segment lengths be measured directly. The following guidelines are based on the use of either a large sliding caliper or a segmometer. Before reading any measurement inspect each caliper branch to make sure that neither has moved away from its respective landmark. It is preferable that the caliper end where measurements are to be read is located closest to the measurer's eye level.

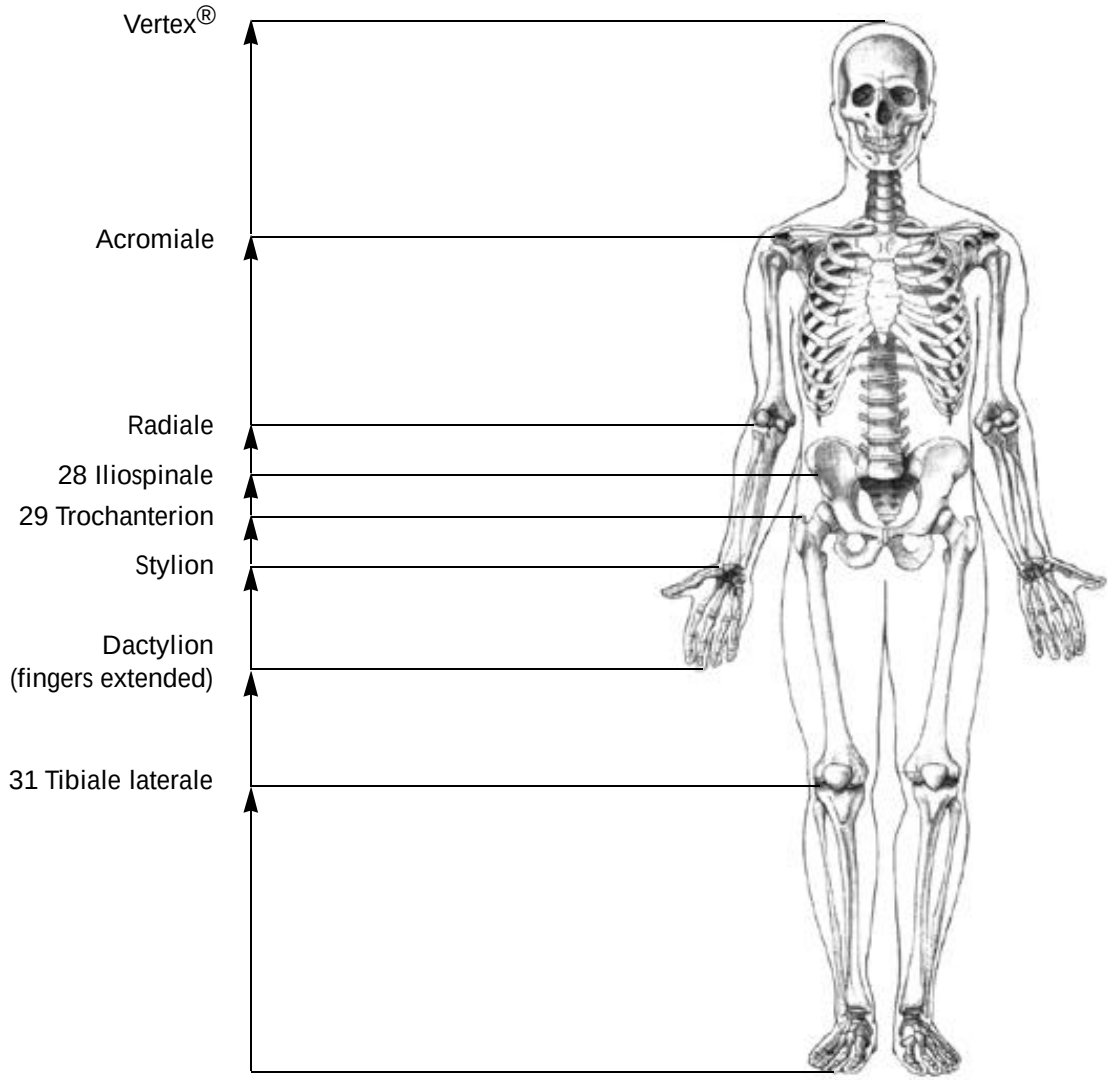


Figure 59. Projected heights. These are also used to determine derived segment lengths.

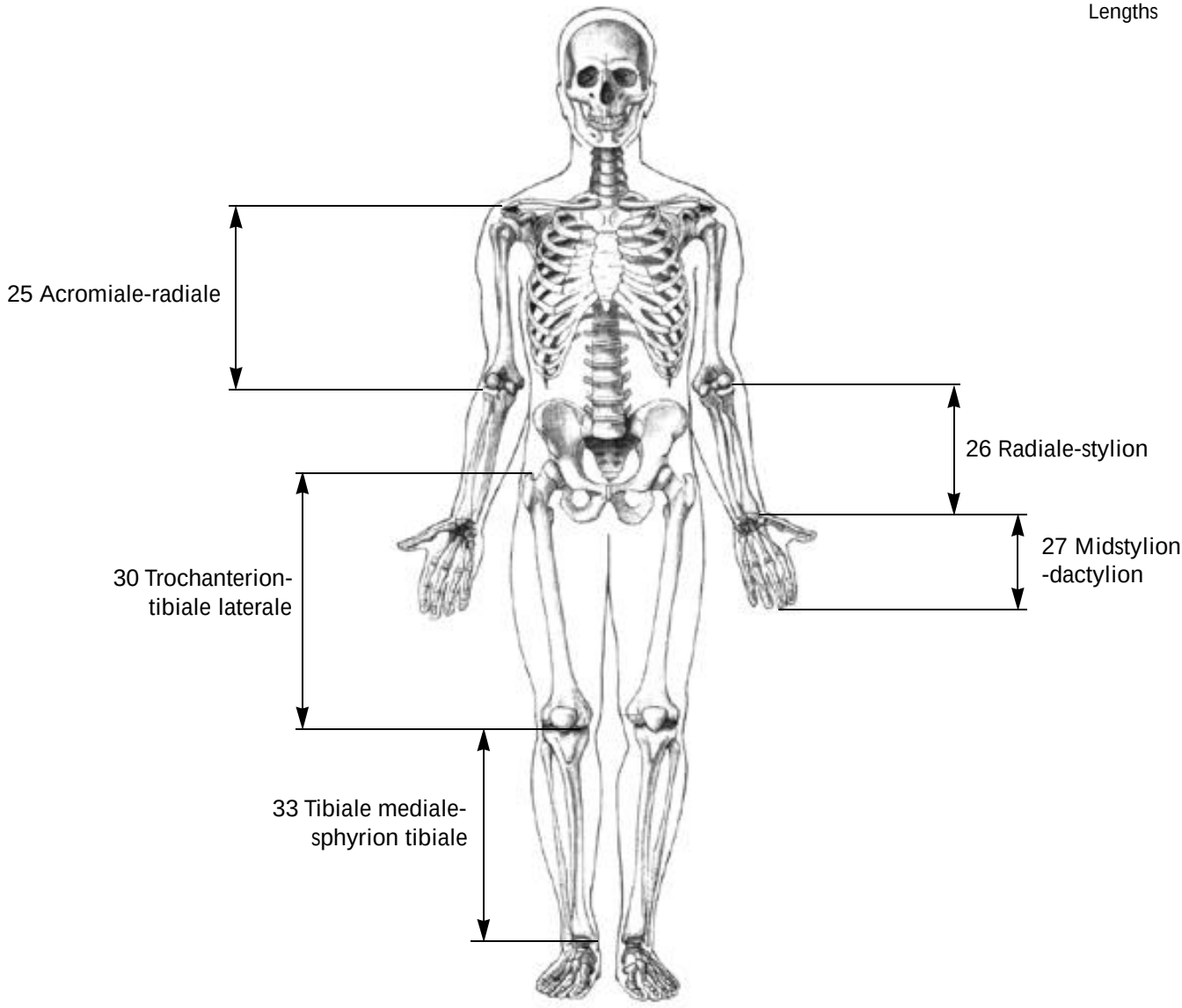


Figure 60. Direct lengths. Note that all measurements are normally taken on the right-hand side of the body.

6.2 Measurement sites — lengths

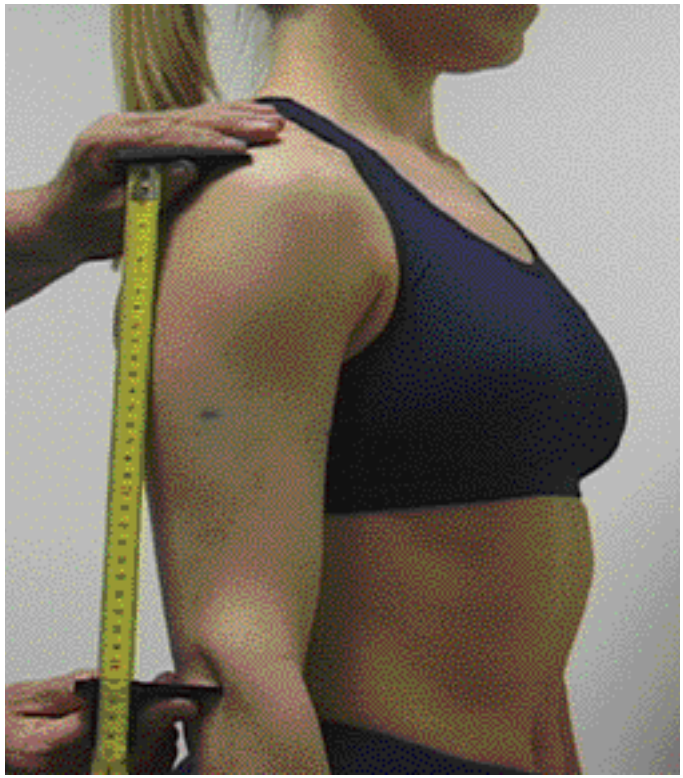
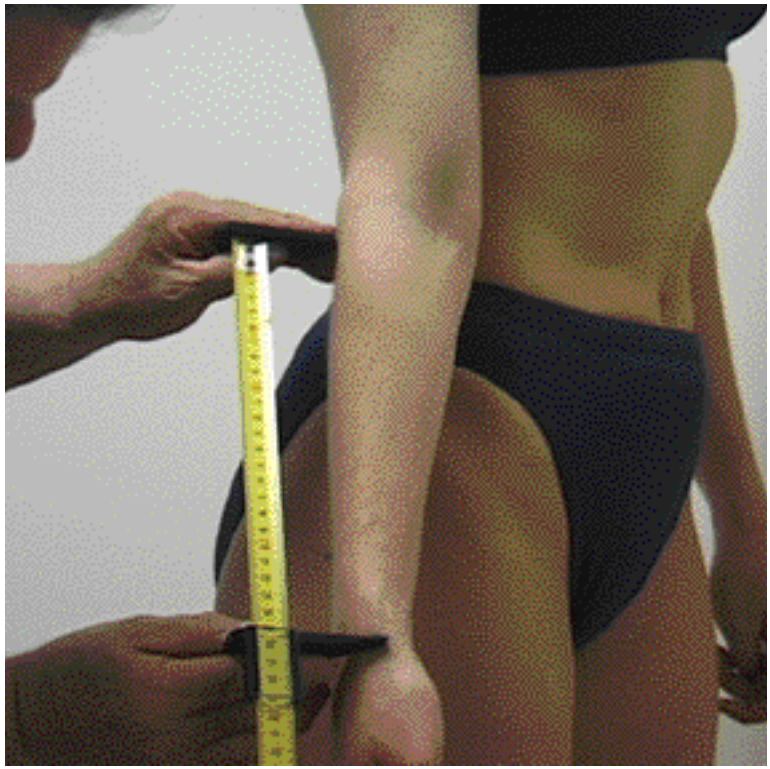


Figure 61. Acromiale-radiale length.

25 Acromiale-radiale

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.The right forearm should be pronated.

Method: This represents the arm length. It is the distance between the previously marked Acromiale® and Radiale® landmarks. One branch of the caliper or segmometer is held on the Acromiale® while the other branch is placed on the Radiale®. If the branches of the segmometer are too short to allow clearance of the Deltoids, a large sliding caliper should be used.



26 Radiale-stylion

Subject position: The subject assumes a relaxed position with the arms hanging by the sides. The right forearm should be slightly externally rotated to a mid-pronated position.

Method: This represents the length of the forearm. It is the distance between the previously marked Radial® and Stylion landmarks. One caliper (or segmometer) branch is held against the Radiale® and the other branch is placed on the Stylion landmark.

Figure 62. Radiale-stylion length.

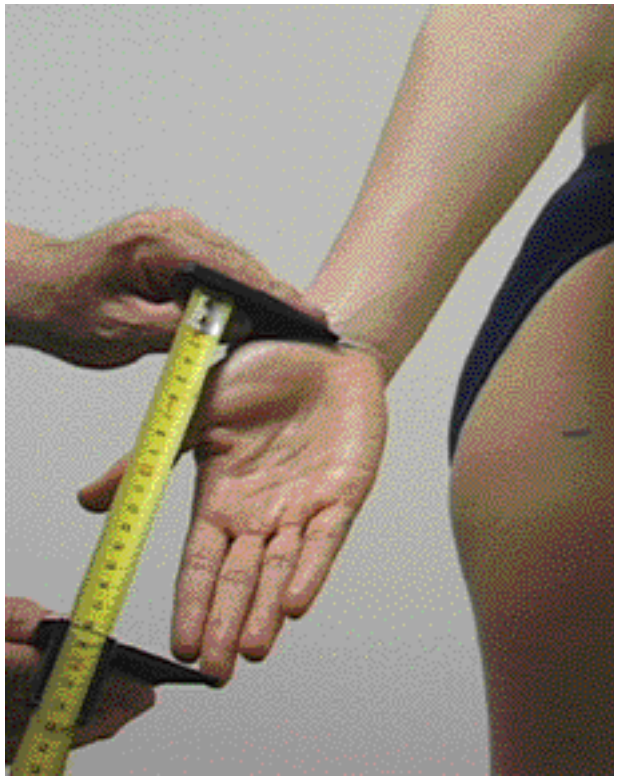


Figure 63. Midstylion-dactylion length.

27 Midstylion-dactylion

Subject position: The subject assumes a relaxed standing position with the left arm hanging by the side. The right elbow is partially flexed, forearm supinated, and the fingers extended (but not hyper-extended).

Method: This represents the length of the hand. The measurement is taken as the shortest distance from the marked Midstylion line to the Dactylion. One branch of the caliper or segmometer is placed on the marked Midstylion line while the other branch is positioned on the Dactylion (most distal point of the third digit).

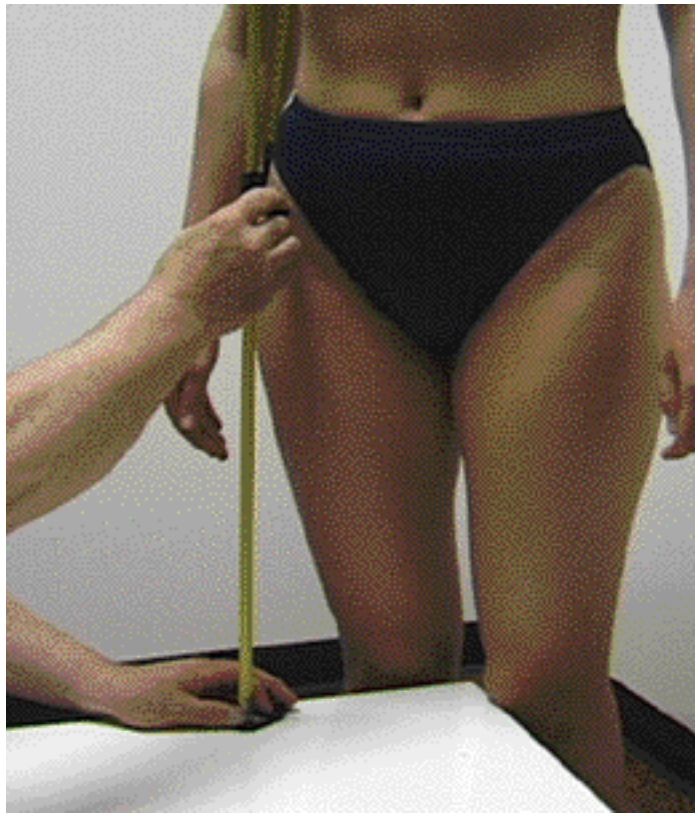


Figure 64. Iliospinale height.

28 Iliospinale height

Subject position: The subject assumes a standing position with the feet together and the arms hanging by the sides.

Method: The height from the top of the box or the floor to the Iliospinale® is measured. If a box is used, the subject stands with feet together facing the box so that the toes are placed in the cut-out portion of the box. The base of the anthropometer or fixed branch of the segmometer is placed on the floor or on top of the box. The anthropometer or segmometer is oriented vertically with the moving branch positioned at the marked iliospinale® site. (Note: The height of interest is the height from the floor to the Iliospinale® landmark, and this should be entered onto the proforma. If a box is used, the height of interest is obtained by adding the box height to the height from the top of the box to the Iliospinale®.)

Figure 65. Trochanterion height.

29 Trochanterion height

Subject position: The subject assumes a standing position with the feet together and the arms hanging by the sides.

Method: The height from the top of the box to the Trochanterion is measured. If a box is used, the subject stands with feet together and the lateral aspect of their right leg against the box. The base of the anthropometer or fixed branch of the segmometer is placed on top of the box. The anthropometer or segmometer is oriented vertically with the moving branch positioned at the marked Trochanterion site. (Note: The height of interest is the height from the floor to the Trochanterion landmark, and this should be entered onto the proforma. If a box is used, the height of interest is obtained by adding the box height to the height from the top of the box to the Trochanterion.)

30 Trochanterion-tibiale laterale

Figure 66. Trochanterion-tibiale laterale.

Subject position: The subject assumes a standing position with the feet together and the arms folded across the thorax.

Method: This represents the length of the thigh. The distance between the marked Trochanterion and Tibiale laterale landmarks is measured. One branch of the anthropometer or segmometer is placed on the marked Trochanterion and the other branch is placed on the marked Tibiale laterale site.

Figure 67. Tibiale laterale height.

31 Tibiale laterale

Subject position: The subject assumes a standing position with the feet together and the arms hanging by the sides.

Method: This represents the length of the leg. It is usual practice to have the subject stand on the box while the base of the anthropometer or fixed branch of the segmometer is on the top of the box and the moving branch is placed on the marked Tibiale laterale site. The anthropometer or segmometer should be held in the vertical plane. A spirit level may be used to verify this. The height from the Tibiale laterale to the top of the box is then measured.

32 Foot length

Subject position: The subject assumes a relaxed standing position with the feet comfortably apart and weight evenly distributed. The arms are hanging by the sides.

Method: This is the distance from the Akropodion (the tip of the longest toe — which may be the first or second phalanx) to the Pternion (most posterior point on the calcaneus of the foot). Minimal pressure is applied to the large sliding caliper. It is more convenient for the measurer if the subject stands on the box during this measurement.

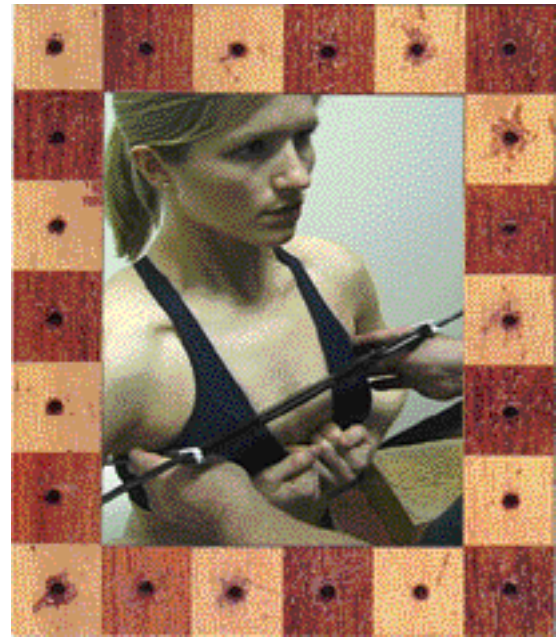
Figure 68. Foot length.

33 Tibiale mediale-sphyrion tibiale

Subject position: The subject is seated with the right ankle resting over the left knee so that the medial aspect of the leg is able to be measured.

Method: This represent the length of the tibia. It is the measured length between the Tibiale mediale and the Sphyrion tibiale. One branch of the anthropometer or segmometer is placed on the marked Tibiale mediale site and the other branch is positioned on the marked Sphyrion site.

Figure 69. Tibiale mediale-sphyrion tibiale.



7 Breadths

7.1 Techniques for measuring breadths

Equipment: Large sliding caliper, wide-spreading caliper, small sliding caliper, box

Method: Both the small sliding caliper and the large sliding caliper are held in the same way. The caliper lies on the backs of the hands while the thumbs rest against the inside edge of the caliper branches, and the extended index fingers lie along the outside edges of the branches. In this position the fingers are able to exert considerable pressure to reduce the thickness of any underlying soft tissue and the middle fingers are free to palpate the bony landmarks on which the caliper faces are to be placed.

The measurements are made when the caliper is in place, with the pressure maintained along the index fingers. However, for transverse chest breadth and anterior-posterior chest depth only light pressure is applied to avoid any injury or pain to the subject.

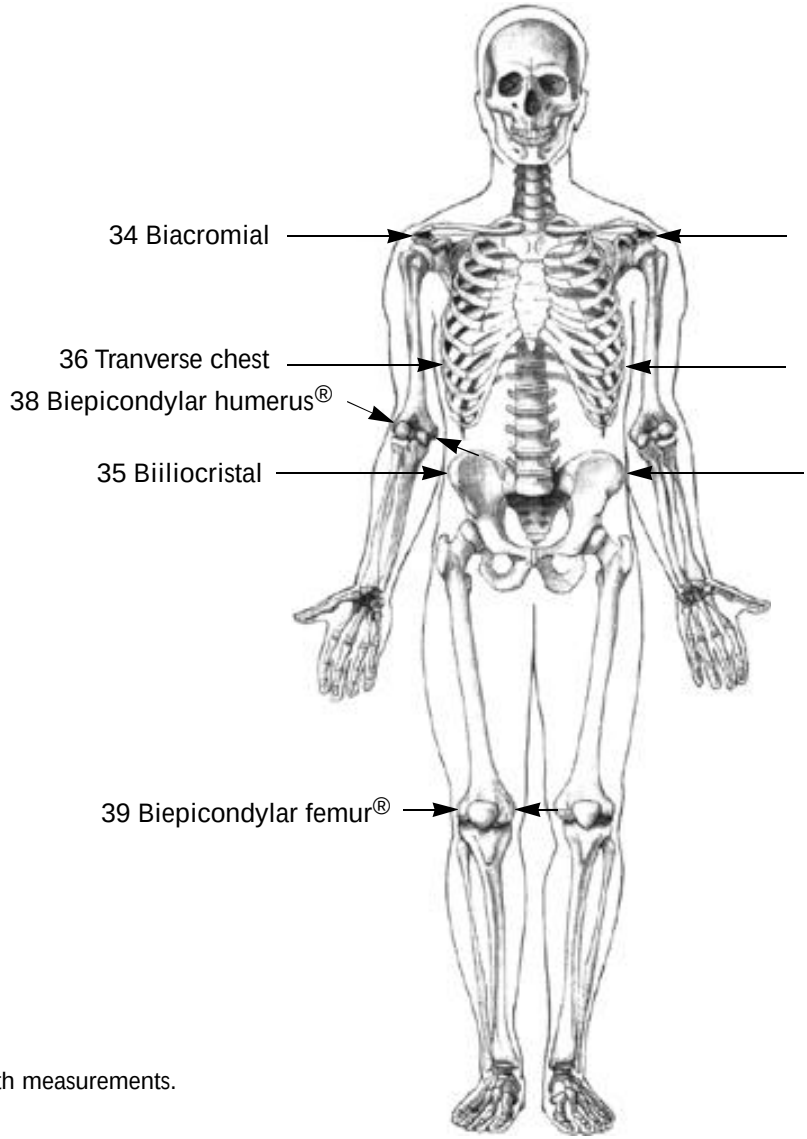


Figure 70. Location of breadth measurements.

7.2 Measurement sites — breadths

34 Biacromial

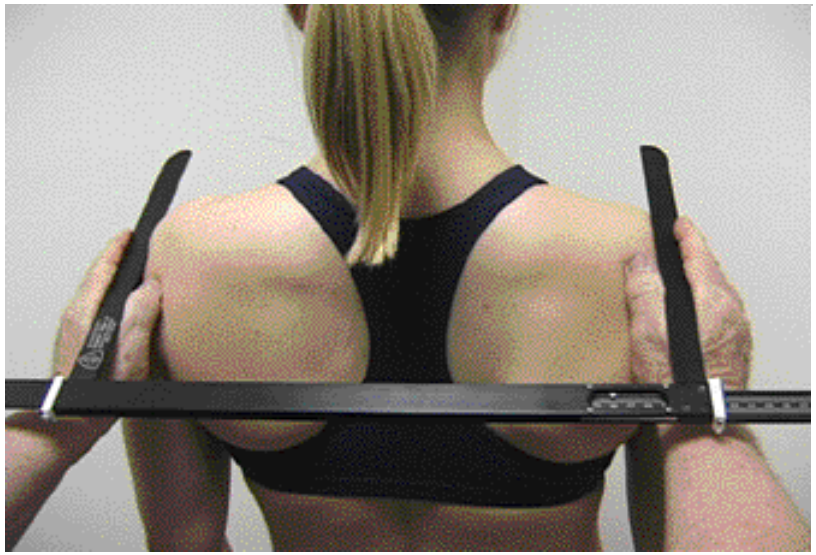


Figure 71. Biacromial breadth.

Subject position: The subject assumes a relaxed standing position with the arms hanging by the sides.

Method: This is the distance between the most lateral points on the acromion processes. This distance is measured with the branches of the large sliding caliper placed on the most lateral points of the acromion processes (below the marked Acromiale® landmark). The subject stands with the arms hanging at the sides, and the measurer, standing behind the subject, should bring the caliper branches in to the acromion processes at an angle of about 30° pointing upwards. Pressure should be applied to compress the overlying tissues, but should not move the shoulders.

Figure 72. Biiliocristal breadth.

35 Biiliocristal

Subject position: The subject assumes a relaxed standing position with the arms across the chest.

Method: The distance between the most lateral points on the iliac crests (Iliocristale®) is measured. The measurer stands in front of the subject and the branches of the anthropometer are kept at about 45° pointing upwards. Firm pressure is applied by the anthropometrist to reduce the effect of overlying tissues.

36 Transverse chest

Figure 73. Transverse chest.

Subject position: The subject assumes a relaxed standing or seated position with the arms abducted sufficiently to allow the caliper branches to be positioned at the lateral borders of the ribs.

Method: The distance is measured between the most lateral aspect of the thorax when the superior aspect of the caliper scale is positioned at the level of the Mesosternale (at the front) and the blades are positioned at an angle of 30° downward from the horizontal. This will prevent the caliper from slipping between the ribs. The measurer stands in front of the subject who may be either seated or standing. Care must be taken to avoid inclusion of the Pectoralis Major or Latissimus Dorsi muscles. The measurement is taken at the end of a tidal expiration.

37 Anterior-posterior chest depth

Subject position: The subject assumes a seated position with the torso erect and the palms resting on the thighs.

Method: This is the distance measured between the recurved or L-shaped branches of the caliper when positioned at the level of the Mesosternale. Hold the rounded tips of the caliper branches between the thumb and digits 2-3 so that the tips are placed on the landmarks with very light pressure. The measurer applies the caliper over the right shoulder of the subject who is instructed to breathe normally. The rear branch of the caliper should be positioned on the spinous process of the vertebra at the horizontal level of the Mesosternale. Measurement is taken at end-tidal expiration.

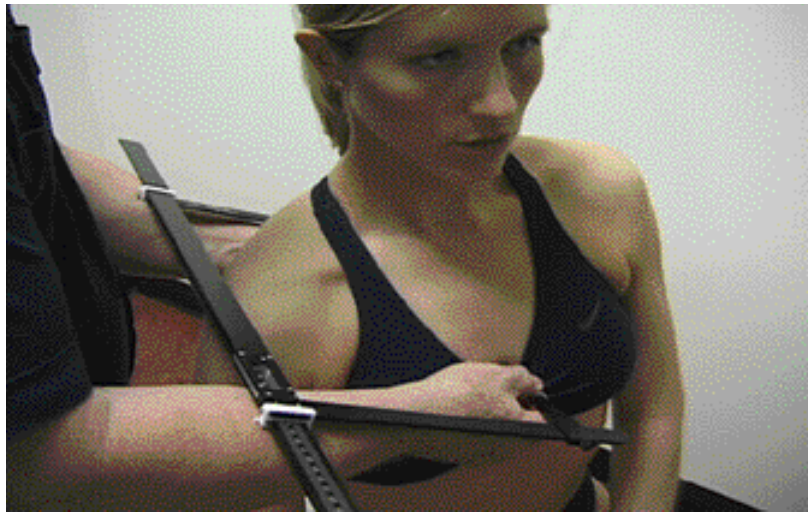


Figure 74. Anterior-posterior chest depth.

38 Biepicondylar humerus®

Subject position: The subject assumes a relaxed standing or seated position. The right arm is raised anteriorly to the horizontal and the forearm is flexed at right angles to the arm.

Method: The distance is measured between the medial and lateral epicondyles of the humerus. With the small sliding caliper gripped correctly, use the middle fingers to palpate the epicondyles of the humerus, starting proximal to the sites. The bony points first felt are the epicondyles. Place the caliper faces on the epicondyles and maintain strong pressure with the index fingers until the value is read. Because the medial epicondyle is normally lower than the lateral epicondyle the measured distance may be somewhat oblique.

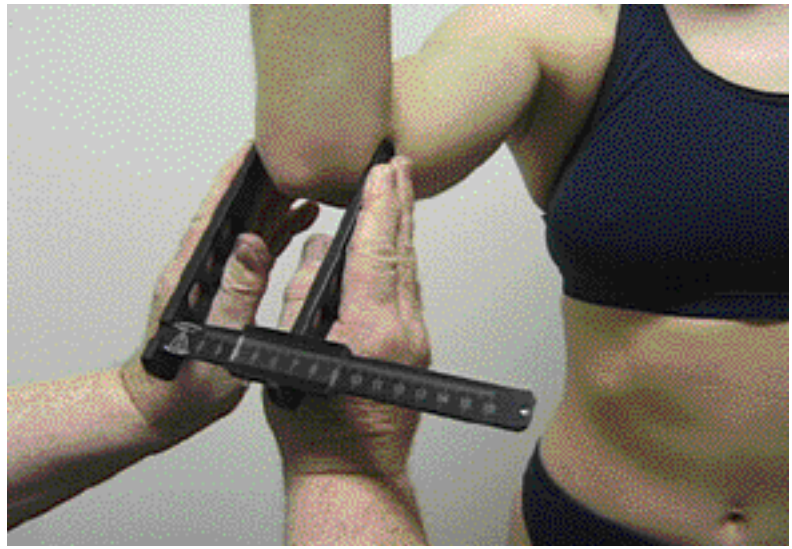


Figure 75. Biepidocondylar humerus®.

39 Biepicondylar femur®

Subject position: The subject assumes a relaxed seated position with the palms resting on the thighs. The right leg is flexed at the knee to form a right angle with the thigh.

Method: The distance is measured between the medial and lateral epicondyles of the femur. With the subject seated and the caliper in place, use the middle fingers to palpate the epicondyles of the femur beginning proximal to the sites. The bony points first felt are the epicondyles. Place the caliper faces on the epicondyles and maintain strong pressure with the index fingers until the value is read.

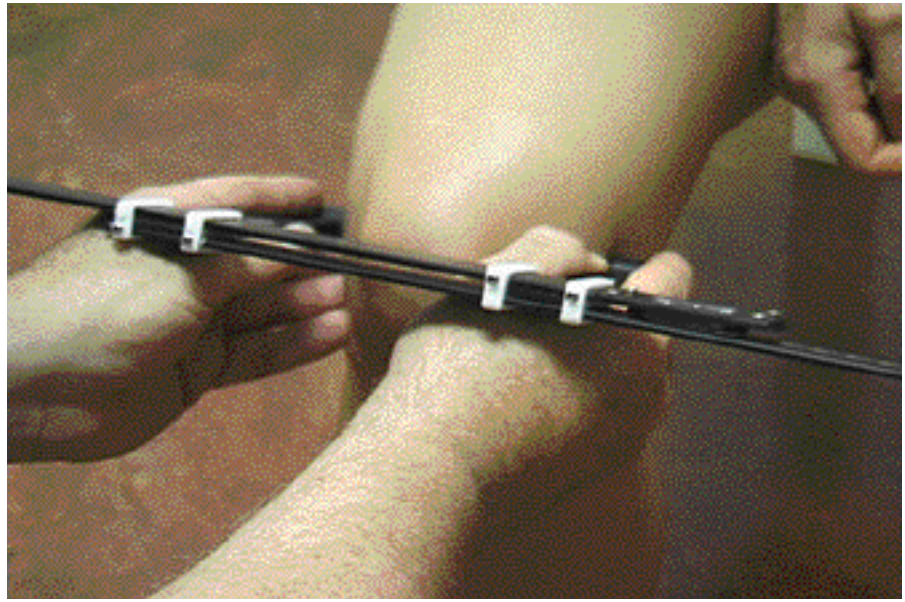


Figure 76. Biepidocondylar femur®.

8 Equipment suppliers

8.1 Equipment requirements

Anthropometry equipment can be purchased as a kit (i.e. with multiple items) or separately. In the ISAK Anthropometry Accreditation Scheme there are different equipment requirements for Levels 1 and 2-3:

- Level 1: wall stadiometer, weighing scale, tape, skinfold caliper, and small sliding caliper
- Levels 2-3: same as Level 1 plus large sliding caliper, segmometer, large spreading caliper (or sliding caliper with recurved or L-shaped branches), anthropometer and footplate.

Some kits do not have all the required items so they must be supplemented with separate items.

A wide selection of equipment is available, and although much is excellent, not all pieces have acceptable characteristics. There are three main brands of equipment that have excellent quality and have been used internationally for many years:

- Rosscraft, Canada
- Siber-Hegner GPM, Switzerland
- Holtain Ltd., Wales.

Additional equipment will be referred to in the following pages.

8.2 Anthropometry kits

- **Rosscraft Kits**

Centurion Kit: 1 Campbell 20 (54 cm) large sliding caliper with AP branches, 1 Campbell 10 (18 cm) small sliding caliper, 1 segmometer, 1 head square with 110 tape, 2 Slim Guide skinfold calipers, 2 steel anthropometry tapes adapted with a zero indicator patch and filed notch, 1 O-Scale System, 1 Anthropometry Illustrated (a CD interactive digital learning system). All in a cordura carrying case: (70 x 35 x 10 cm, weight 3.5 kg). This kit constitutes a complete kit for Level 1 and 2-3 measures, except for weighing scale.

Tom Kit: 1 Tommy 2 (15 cm) small bone caliper, 1 Slim Guide skinfold caliper, 1 steel girth tape, 1 O-Scale System, 1 Anthropometry Illustrated (a CD interactive digital learning system), in cordura carrying case (weight 1 kg). This kit is suitable for Level 1 when weighing scale and stature equipment are available.

- **Siber-Hegner GPM Kit.**

The kit contains a four-segment anthropometer (2.0 m) with straight and recurved branches, all stored in a canvas bag. A baseplate, small sliding caliper with flat branches, tape and a skinfold caliper are separate items. These items, plus a weighing scale and stadiometer are needed for Level 2.

- **Harpenden Kit**

The Harpenden Survey Set includes a case, anthropometer with straight and recurved branches, two 1 m tapes, and skinfold caliper. A small sliding caliper, stadiometer, weighing scale and Holtain skinfold caliper are additional, and these alone are suitable for Level 1 if a tape is available. For Level 2 all items are needed.

8.3 Contact details

✉ British Indicators
Victoria Road, Burgess Hill
West Sussex, RH15 9LB
UK
☎ +44 (0) 1444 235621
Fax +44 (0) 1444 246985
• Harpenden skinfold caliper and replacement springs.

✉ Creative Health Products
5148 Saddle Ridge Road, Plymouth
MI 48170
USA
☎ (313) 996-5900; 1-800-742-4478
Fax (313) 996-4650.
• Harpenden and Slim Guide skinfold calipers, tapes, weighing scales, other items.

✉ Holtain Ltd., Crosswell, Crymmych
Dyfed, SA41 3UF
Wales, UK
☎ (0) 1239 891453.
🖳 www.fullbore.co.uk/holtain/
• Harpenden Survey Set, Harpenden anthropometer, Holtain Tanner/Whitehouse skinfold caliper, small sliding caliper, stadiometers, other items.

✉ Mentone Educational Centre, 24 Woorayl Street, Carnegie
Victoria 2163
Australia

• Harpenden skinfold caliper springs.

✉ QuickMedical, 43811 SE 143rd Street, North Bend
WA 98045
USA

☎ (425) 831-5963; toll free: 1-888-345-4858

🌐 http://measurmentconcepts.com

• A wide variety of stadiometers.

✉ Rosscraft, 14732 16-A Avenue, Surrey
BC, V4A 5M7
Canada; or

✉ PO Box 2043 Blaine
WA, 98230
USA

☎ (604) 531-5049

Fax (604) 538-3362

Email rosscraft@home.com

🌐 www.tep2000.com

• Centurion Kit, Tom Kit, Harpenden skinfold caliper, Slim Guide skinfold caliper, Tommy 2 small sliding caliper, large and small sliding calipers, tapes, scales, segmometer, software, other items.

✉ Seritex, Inc. One Madison Street, East Rutherford
NJ 07073
USA
☎ (973) 472-4200
Fax (973) 472-0222.
🌐 www.seritex.com/anthro.html/
• GPM anthropometer, base plate, small sliding caliper, wide spreading caliper, tape
• Harpenden and Holtain equipment including anthropometer, stadiometer, small sliding caliper, Tanner/Whitehouse skinfold caliper; other items.

✉ Attn: Ursula Schmidli, Product Manager Anthropology
Siber-Hegner & Co. Ltd., Wiesenstrasse 8, P.O. Box 888, CH-8034
Zurich
Switzerland
☎ +41-1-286 73 51
Fax +41-1-386 77 51
🌐 http://www.SiberHegner.com
• GPM equipment.

8.4 Recommended sources

The following list contains recommended sources for equipment. The choice will depend on such factors as cost, mail accessibility, whether buying separate items or kits, and what equipment is already in hand.

Stadiometers

• Rosscraft; QuickMedical; Holtain; Seritex

Weighing scales

• Rosscraft; Creative Health Products; local supplier

Anthropometry tapes

• The Lufkin (W606PM) is the preferred metal tape

• A fibreglass tape may be substituted, especially for laboratory practice. Rosscraft; Creative Health Products

Skinfold calipers

• The Harpenden caliper has been used as the criterion instrument by ISAK. Harpenden may be accurately interpolated to the nearest 0.1 mm.

• As an alternative, the Slim Guide caliper may be used. It is highly reliable, has the same jaw compression as the Harpenden and produces almost identical readings (Anderson & Ross, 1986; Schmidt & Carter, 1990). British Indicators Ltd.; Rosscraft; Creative Health Products

Small sliding calipers

• Rosscraft Campbell 10 (18 cm) small bone caliper or the Tommy 2 (15 cm) small bone caliper

• The Holtain-Harpenden small bone caliper is easy to use but the measurement scale may be less reliable

than the Mitutoyo adapted caliper, especially if the branches become loose: Holtain; Seritex
• The Siber-Hegner caliper is more cumbersome to handle over relatively small breadths such as the biepicondylar breadths and lacks the necessary resolution for these bony measurements: Seritex; Siber-Hegner

Anthropometers
• Two anthropometers, the Holtain and GPM, have four sections that must be assembled to measure up to 2 m. Holtain; Seritex; Siber-Hegner

Segmometer
• Only available from Rosscraft; or custom made locally to your own design

Large sliding calipers
• Campbell 20 (54 cm) large sliding caliper: Rosscraft.
• The upper segment of the Siber-Hegner GPM anthropometer with straight branches: Seritex; Siber-Hegner.
• The upper segment of the Harpenden anthropometer with straight branches: Holtain; Seritex

Wide-spreading calipers
• Campbell 20 (54 cm) large sliding caliper with L-shaped branches for A-P chest and other depth measures,: Rosscraft
• The upper segment of the Siber-Hegner GPM anthropometer with recurved branches; or separate GPM wide spreading caliper with round tips, 0-60 cm, No. 108: Seritex; Siber-Hegner.
• The upper segment of the Harpenden anthropometer with recurved branches: Holtain; Seritex

Anthropometry boxes
Custom made locally to your own design

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