

CHAPTER 10
ANTHROPOMETRY

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10.1 Introduction

The anthropometric measures included in the DISC clinical examination are critical: they are the primary means of assessing the effects of the DISC diet on the growth of the participants. The major source of error in anthropometry is variation in measurement technique of two kinds: inconsistent technique among several technicians, and inattention to technique on the part of a single technician -- in statistical jargon, inter- and intra-observer variation. The DISC training program for anthropometrists is designed to standardize measurement techniques and ensure that inter- and intra-observer errors are minimized. It is possible to make accurate, reproducible measurements. It requires that one be, in the words of an experienced auxological anthropometrist, "obsessional about acquiring and maintaining accuracy" (1).

Children in the dietary intervention program of DISC will be compared to children in the control group and both will be evaluated with reference to the NCHS growth standards based on the HES and NHANES surveys (2,3). The anthropometric techniques used by DISC will therefore conform to these used in the national surveys. These techniques may depart slightly from those you have used in the past and from techniques used in other studies. This does not imply any criticism of your previous training or of the methods of other investigators; rather it reflects the particular needs and goals of DISC. It is crucial that we share a standard methodology across all six Clinical Centers.

Most children take routine measurements of stature, weight and circumferences for granted. By 8 or 9 years of age, children are very cooperative. Some children perceive themselves to be too short or too

tall or overweight and may be embarrassed or reluctant to be measured. You can be sensitive to this and still make accurate measurements. Some children are ticklish or nervous or just plain silly about being measured. The firmer your touch the better, both for overcoming those reactions and for making accurate measurements. Anthropometry is not a delicate operation. You must be firm without being heavy-handed. Two common errors in technique among novice anthropometrists are hesitation and over-gentleness. The remedy is practice. Practice will also make you much more confident about locating measurements with reference to the bony landmarks, and more confident about handling the instruments.

10.2 General Aspects of Making Anthropometric Measurements

10.2.1 Order of Anthropometric Measurements

All measurements (i.e., height, weight, girths, and skinfolds) are to be done once before doing the second measurements, and all of the second measurements are to be done before doing any third measurements that may be necessary. The more popular approach of doing the two or three height measurements, then all the weight measurements, etc., is easier and gives smaller intra-individual variability, but greater overall variability in the measurements. The procedure proposed for DISC is designed to reduce the overall measurement error.

To facilitate standardization and reduce the potential in recording errors, the following order of anthropometric measurements, based on the order used in DISC Form 04 for recording anthropometric measurements, should be used for DISC: Height, weight, arm circumference, triceps skinfold, subscapular skinfold, suprailiac skinfold, waist circumference, hip (bitrochanter) circumference, maximum below waist circumference.

While marking the site for the upper arm circumference, you will also be marking the site for the triceps skinfolds. To mark this site, use a

cross mark (+) in order to get both the horizontal and vertical location of the skinfold. NCHS has recently begun using Maybelline eyeliner pencil (aqua blue--but any bright color should do), as it comes off very easily without scrubbing, especially with baby oil.

10.2.2 Number of Persons Doing Measurements

Each anthropometrist should work with a recorder. There are two reasons for this. First, the recorder helps position the subject and/or the instrument if necessary and helps assure that the tape is horizontal when measuring circumferences. In some cases it is nearly impossible to make a measurement correctly without assistance. Second, as a check on accuracy, the anthropometrist reports the measurement to the recorder, who repeats the measurement aloud before the anthropometrist removes the instrument; this catches transposed digits and misread scales.

During the feasibility study at least it is desired to assess the intra-versus inter-individual measurement variability. This will involve having one person doing both measurements (or all three when necessitated by too large a difference between the two measurements) on some children and two persons doing the two sets of measurements on other children. Specifically, on odd numbered days, one person should do both (or all three when necessary) sets of anthropometric measurements, while a second person records the measurements. On even-numbered days, one person should do the first set of measurements while another person records, and the roles should be reversed for the second set of measurements on a child. If any third measurements are required, the more senior (in experience) should do these; if both observers have roughly the same amount of experience, the first observer should do the third measurements. Also on even-numbered days, observers A and B should alternate in doing the first set of measurements. Thus:

	<u>First Measurement</u>	<u>Second</u>	<u>Third (if necessary)</u>
Child 1	Observer A	B	A
Child 2	Observer B	A	B

	<u>First Measurement</u>	<u>Second</u>	<u>Third (if necessary)</u>
Child 3	Observer A	B	A
etc.			

10.2.3 Acceptable Levels of Technical Error

The HES anthropometric consultants found that the intra- and inter-observer errors in the measurements of skeletal dimensions were low, in the range of 0.5 and 1.5 cm, respectively (1). Because of the importance of the height measurement in DISC, we will use 0.5 as target level for stature in DISC. In other words, if the two height measurements differ by more than 0.5 cm, a third measurement should be made. (See Section 10.3 for further details).

It is difficult to establish a target range of variation for weight since we will be using electronic scales at some Clinical Centers. However, weight is subject to less error than the other measures. Provided the scales are calibrated regularly, this should pose no quality control problem.

Soft tissue measurements are subject to substantial intra- and inter-observer variability. In the HES, hip and waist circumferences varied about 1.0 cm within and nearly 2.0 cm among observers (4). Skinfolts varied an average of 1.0 mm within and 1.5 mm among observers (1). While these are substantial degrees of variation considering the absolute magnitude of the dimensions involved, they nevertheless reflect excellent standardization and quality control in the HES examinations. We are not likely to achieve this level of consistency because we will be using many

more technicians. Therefore our target levels for hip and waist circumferences will be < 1.0 cm within technicians and < 2.5 cm among technicians. Our target level for arm circumference will be < 0.5 cm within and < 1.0 among technicians. Our target level for skinfolds will be < 1 mm and < 2 mm, respectively.

10.2.4 Rules for Recording Measurements

Each measurement is to be recorded to the last completed unit specified, rather than to the nearest unit, i.e., rounding down. In general the units specified (0.1 cm, 0.1 kg) are so small that there would be little room for distinguishing the nearest unit. The Tanner-Whitehouse (Holtain) skinfold calipers present an apparent contradiction to this, in that they are divided into units of 0.2 mm and we will be recording to the last completed whole mm. The markings of 0.2 mm give a false sense of the precision of the measurements involved.

10.3 Measurement of Height, Weight, and Circumferences

10.3.1 Height

10.3.1.1 Measurement Procedures

Height is measured in bare or stocking feet. The subject stands with feet flat on the floor, weight evenly distributed, heels almost together, arms at sides. Heels, buttocks, shoulder blades and head should touch against the stadiometer with the head aligned in the Frankfurt plane (see Illustration 1). Ask the subject to look straight ahead and stand up straight and tall. You will probably have to help position subject. The reading is made at the end of a normal expiration. Be sure to read the indicator at eye-level.

Diurnal variation in stature can amount to a centimeter in children in the DISC age group. The error introduced by measuring children at different times of the day over the course of a year or two can be

substantial. Therefore, we will modify the HES/NHANES stature technique slightly to include exerting gentle upward traction on the mastoid processes. Be sure that the subject does not lift his/her heels off the floor; it is easier to check this if the subject is barefoot. Also be sure that the subject does not adopt an unusually braced posture (i.e., not "at attention") since this alters the alignment of the spine and therefore stature.

You will occasionally encounter a subject with some sort of postural problem (e.g., kyphosis, scoliosis, traumatic injury) which interferes with the measurement of stature. Occasionally, also, a very obese child will be unable to make complete contact with the backboard of the stadiometer. In these circumstances you cannot make an accurate measurement of stature. It is kindest to proceed anyway, reporting the stature but making a note of the condition on the chart and flagging the measurement as inaccurate.

There is, finally, the problem of hair. Some hairstyles prevent the horizontal arm of the stadiometer from making proper contact with the participant's head, or prevent the back of the participant's head from making contact with the stadiometer. Ask that the hair be taken down or otherwise adjusted if possible; if not, make a note on the chart and flag the measurement.

Record stature to the last completed 0.1 centimeter. Acceptable difference between measurements: 0.5 cm (intra-observer), 0.5 cm (inter-observer). [Be sure to read the stadiometer at eye-level.]

10.3.1.2 Observer Blinding Procedures for Height Measurements

1. First measurement

Observer #1 will take the first measurement using the standard DISC procedures described above in 10.3.1.1. Observer #1 will record the

measurement on the appropriate DISC form without communicating the measurement to Observer #2.

2. Second measurement

Observer #2 will take the second measurement using the standard DISC procedures described above in 10.3.1.1. Observer #2 will tell Observer #1 the measurement and Observer #1 will record the measurement on the appropriate DISC form. Observer #2 should not look at the form. Observer #1 will determine if the difference between the two measurements is 0.5 cm or less. If the difference is greater than 0.5 cm, a third measurement will be required.

3. Third measurement

When required, the third measurement will be taken by Observer #2. A mandatory wait of five minutes is required before the third measurement can be taken. When possible, Observer #2 should take height measurements on other participants before taking the required third measurement on the participant described in Item 2 above. Observer #1 will record the measurement. Additional measurements beyond three will not be taken.

4. Observer availability

The DISC Steering Committee has affirmed its support for having height measurements taken by two blinded observers to achieve independent measurements. It is required that, for in-clinic visits, two certified observers be available to take height measurements. For home visits, it is strongly urged that two certified observers be available during the visit. However, it is acceptable for a single observer to take the measures during home visits. The Coordinating Center will monitor the use of single observers for height measurements and report the level of usage to the Steering Committee.

5. Editing procedures

No additional editing will be required at the clinical centers. The routine within-form edits and across-visit edits will be performed at the Coordinating Center.

10.3.2 Weight

Check the zeroing of the scale before weighing each subject and adjust as needed. The subject should be wearing a hospital gown for this and all subsequent measurements for end point purposes.

Record weight to the last completed 0.1 kg.

Acceptable differences between measurements: 0.2 kg (intra-observer), 0.2 kg (inter-observer).

Note that at Screening Visit 01 height and weight will be measured only for eligibility -- not baseline for end point -- purposes. These measurements will be made with the children in indoor clothing and will be recorded on Form 02 rather than Form 04. At Screening Visit 02 weight will be measured for both eligibility and end point purposes. For eligibility, weight will be measured with the children in indoor clothing and recorded on Form 03. For the baseline measurement for end point purposes, weight will be measured with the children in hospital gowns and recorded on Form 04.

10.3.3 Mid-Arm Circumference

When making any circumference measurements, with the help of your recorder, always make sure the tape is horizontal all around the body (arm, waist, hip). Pull the spring-loaded pin of the tape out of the housing just until the red groove clears the housing. This exerts a constant 10 grams of tension on the tape. You will notice that this compresses the skin slightly. Use this technique for all of the circumference measurements.

The mid-arm circumference is measured on the right arm half way between the inferior border of the acromion and the olecranon processes (see Illustration 5). Ask the subject to bend his/her right arm at a 90-degree angle with his/her hand resting gently on the abdomen. Then determine the length of the upper arm by applying the zero point of the tape to the lower edge of the acromion process and the other to the tip of the olecranon process. The tape will be aligned behind the lateral portion of the arm, not quite in the midline in back. While maintaining tension on the tape, make a mark (a long dash) at the midpoint of the arm. Some people find that this requires three hands, so you may have to enlist the aid of the recorder to make the mark.

To mark the location where the tricep skinfold will be taken later, have the subject stand with the arm hanging relaxed at the side, palm facing the thigh. Determine the midline of the back of the arm by visual inspection and place a vertical mark to cross the horizontal mark just taken (see paragraph above). This cross mark (+) will be the location for the tricep skinfold.

To take the arm circumference measurement, make sure the arm is hanging relaxed at the side, palm facing the thigh. With the help of the recorder, make sure the tape is horizontal to the long axis of the arm and is at the level of the midpoint mark.

Record mid-arm circumference to the last completed 0.1 cm.

Acceptable difference between measurements: 0.5 cm (intra-observer), 1.0 cm (inter-observer).

Do not wipe off the mark at the midpoint of the arm until you have measured the triceps skinfold at the same level.

10.3.4 Waist Circumference

Measure waist circumference midway between the lower edge of the ribs and the iliac crest (see Illustrations 2, 3 and 4). Note that this may not be at the apparent minimum waist circumference because the site is located with reference to the bony landmarks (see Illustration 4). Make a mark at this midway point along the midaxillary line.

Be sure the child is breathing normally, not holding in or pushing out his/her abdomen. Take the measurement at the end of a normal expiration.

Make sure the tape is horizontal.

Record waist circumference to the last completed 0.1 cm.

Acceptable difference between measurements: 1.0 cm (intra-observer), 2.5 cm (inter-observer).

10.3.5 Hip Circumference -- Bitrochanteric

Ask the child to stand with feet together with weight evenly distributed on both feet. Be sure that the child is not tensing his/her buttocks, as this will alter the measurement.

Measure hip circumference at the level of the greater trochanters (see Illustrations 2, 3 and 4). It is almost mandatory that this measurement be made by two people, one to palpate the maximum lateral width of the greater trochanters and the other to apply the tape. Make sure the tape is horizontal.

Record bitrochanteric hip circumference to the last completed 0.1 cm.

Acceptable difference between measurements: 1.0 cm (intra-observer), 2.5 cm (inter-observer).

10.3.6 Hip Circumference -- Maximum Below Waist Circumference

Ask the child to stand with feet together, weight evenly distributed. The object is to measure the maximum circumference below the waist. There

are no bony landmarks underlying this measurement since the maximum circumference will be located at different levels on different children, depending on individual fat patterning. Typically this measurement is located slightly above the bitrochanteric circumference, but it may well not be. The measurement may also coincide closely to the bitrochanteric level.

Be sure the tape is horizontal; enlist the aid of your recorder to check this.

Record maximum hip circumference to the last completed 0.1 cm.

Acceptable difference between measurements: 1.0 cm (intra-observer), 2.5 cm (inter-observer).

10.4 Measurement of Skinfololds

10.4.1 Introduction

Most children have not encountered skinfold measurements before and many find the calipers frightening. Since skinfololds are the hardest of the measurements to make accurately, it is worthwhile to spend some time reassuring the children and giving them a clear idea of what to expect.

Explain that you will be picking up a fold of skin (avoid the word "pinch") and measuring its thickness. Demonstrate picking up a fold of skin on the back of your own hand. You may occasionally encounter a child who thinks the calipers are scissors of a sort, and that you are going to remove skin or flesh with them. Demonstrating the calipers on yourself usually dispels this illusion. You might also apply the calipers to the child's finger so he/she can see exactly how they work. (A child may ask to handle the calipers and perhaps apply them to you. This is fine for patient relations but can be hard on the instrument so emphasize the need to handle the calipers very carefully.) Explain that you will be poking and prodding to find just the right spot to take each skinfold measure-

ment, and explain that picking up the skinfold and applying the calipers does not hurt but that it does feel strange. You will be out of the child's sight most of the time you are making skinfold measurements. It is helpful to keep up a running commentary about what you are doing: "Now I am going to run my finger along your shoulder blade to find the spot .. now I am going to pick up a skinfold ... now you will feel the calipers squeeze your skin ..."

10.4.2 Technique of Skinfold Measurements

From Cameron (1):

The technique of picking up the fold of subcutaneous tissue measured by the skinfold caliper is often referred to as a "pinch" ... but the action to obtain the fold is to sweep the index of middle finger and thumb together over the surface of the skin from about 6 to 8 cm apart ... To "pinch" suggests a small and painful pincer movement of the fingers, and this is not the movement made. The measurement of skinfolds should not cause undue pain to the subject, who may be apprehensive from the appearance of the calipers and will tend to pull away from the observer, and, in addition, a pinching action will not collect the quantity of subcutaneous tissue required for the measurement.

The measurement of skinfold is prone to many sources of error. Location of the correct site is critical ... but greater errors may arise from the consistency of the subcutaneous tissue and the way in which each observer collects the fold of tissue (p. 87).

From Brozek as cited in (5):

The skin should be lifted by grasping firmly the fold between the thumb and the forefinger. A firm grip, not exceeding the pain threshold, eliminates or at least substantially reduced the variations in the

apparent thickness of skinfold that would result from wide differences in the pulling force of the fingers.

The width of the skin that is enclosed between the fingers is an important factor. It cannot be standardized, in its absolute size, for all the sites of the body. With a thick subcutaneous layer a wider segment of the skin must be "pinched" in order to form a fold than when the adipose tissue is poorly developed, as it is on the dorsum of the hand. For a given site the width of the skin should be minimal, still yielding a well defined fold.

The depth of the skinfold at which the calipers are placed on the fold also requires comment. The two sides of the fold are not likely to be parallel, when the skin is lifted by one hand, being narrower near the crest and larger toward the base. When the calipers are placed at the base, the resulting measurement is too large. Here, again, the correct distance from the crest is defined as the minimal distance from the crest at which a true fold, with surfaces approximately parallel to each other and to the contact surfaces of the calipers, is obtained upon application of the calipers to the skin (p. 51).

Skinfolds are composed of fat cells, connective tissue, blood vessels and intracellular fluid. The needle of the calipers may creep a little when applied to the skinfold, as the pressure of the instrument compresses the tissue. Take the reading 3 seconds after applying the caliper (count "1-thousand, 2-thousand, 3-thousand"). Pick the skinfold up with your fingers 1 cm from the site where you will apply the calipers. The jaws of the calipers should be placed perpendicular to the skinfold. Do not let go of the skinfold with your fingers while applying the caliper and taking the reading. While holding the skinfold gently with your left hand, apply the calipers with your right, count 3 seconds, make the reading and report it to the recorder. Release the calipers from the skinfold before you let

go with your left hand to avoid scratching the participant with the calipers. Occasionally, for example in subjects with edema, the needle of the calipers may continue to creep downward for more than 3 seconds. Take your reading at the end of 3 seconds; do not wait for the needle to stop moving.

Do not handle the skinfolds any more than is necessary to make the measurements, both because it may cause discomfort and because repeated manipulation may alter the local fluid content of the tissue and yield progressively lower measurements.

Record all skinfolds to the last completed mm. Please note that the Tanner-Whitehouse (Holtain) calipers are a little confusing to read at first glance because the needle travels counter-clockwise around the dial. Thus, if you are not careful, you may read a measurement of 14 and several tenths as 15 and several tenths, rounding to 15 rather than to the correct 14. Also note that the caliper scale is divided into units of 0.2 mm, but this gives a false sense of the precision of the instrument. Readings should be recorded to the last completed whole mm.

In some subjects, at some sites, it is simply impossible to raise a discrete fold of subcutaneous tissue. The underlying fat feels slablike and resistant. Work out a code with the recorder, to tactfully indicate that a skinfold could not be measured. A value of "98" should be recorded on Form 04, indicating "measurement not available." A value of "98" should be recorded on Form 04 if the skinfold is ≥ 50 mm and cannot be measured.

Acceptable difference between measurements: 1 mm (intra-observer), 2 mm (inter-observer).

10.4.3 Triceps Skinfold

The triceps skinfold is measured on the back of the right arm halfway between the acromion and olecranon process (see Illustrations 5 and 6). The mid-arm circumference is measured at the same level -- use the mark you made earlier.

With the arm hanging relaxed at the side and palm facing thigh, sweep up a skinfold in the mid-line of the back of the arm with the fingers 1 cm above the mid-point mark (+). Apply the calipers at the level of the mark. The skinfold should be taken at the midline of the back of the arm parallel to the long axis of the arm and the jaws of the calipers are placed at the marked level perpendicular to the length of the fold.

10.4.4 Subscapular Skinfold

The subscapular skinfold is measured 1 cm below the inferior angle of the right scapula, along the natural cleavage lines of the skin (see Illustrations 5 and 6). Make sure the subject is relaxed, with arms hanging loosely at the sides, palms facing the thigh, when you locate the site and when you take the measurement. On some obese children, you may have difficulty finding the angle of the scapula, and you can ask the child to rotate his/her right arm to move the scapula so you can palpate the point of the angle. However, once you have located the bone, have the subject relax the arm again before you mark the site to measure the skinfold. Variations in posture such as folding the arms or clasping the hands move the scapula.

There is a lot of variation in the natural cleavage of the skin at the subscapular site. Most subscapular skinfolds will run at a 45 degree angle (see Illustration 6), but some may not. Take the subscapular skinfold along the natural cleavage line of the skin.

Pick up the skinfold 1 cm above and toward the spine from the mark. Place the jaws of the caliper at the mark perpendicular to the skinfold.

10.4.5 Suprailiac Skinfold

The suprailiac skinfold is taken in the midline (sometimes called the midaxillary line) of the body 1 cm above the right iliac crest (see Illustrations 2, 3, and 6). The midline or midaxillary line is an imaginary line from the midaxilla (the middle of the armpit) down the side of the body, in the imaginary center of the body when viewed from the side (see Illustration 4). The iliac crest falls on or just slightly ahead of the midline. Note that the iliac crest is the highest extension of the pelvic bone, and you must palpate forward and backward to find the highest point. When you find the site make a mark.

In obese children, the iliac crest may be difficult to palpate. In all children, the right arm is in the way. Ask the child to hold the arm slightly away from the body, and if absolutely necessary, slightly back from the midline. Ask the child to keep the arm as relaxed as possible. Do not ask the child to put the right hand on the left shoulder, on the abdomen, or to move the arm forward or up. All of these arm movements move the skin, skinfolds and underlying musculature of the trunk. If you have the child perform these movements when you locate the iliac crest, you will have made a mark on the skin that is actually behind and/or below the site that you want when the arm is relaxed.

The suprailiac skinfold is taken on the midaxillary line as nearly horizontal to the trunk as possible. In some children, again especially in obese children, it is not possible to lift the skinfold in the horizontal plane. Follow the natural cleavage of the skin. This may place the skinfold on an angle. Finally, in some children, you just can't lift a suprailiac skinfold because the underlying tissue is slablike and

resistant. Use your code (98) with your recorder to indicate that the measurement couldn't be made.

10.5 Anthropometry Calibration Procedures

10.5.1 Calibration Logs

The Coordinating Center will provide calibration log forms for scales, skinfold calipers and tapes. Please fill them out weekly.

10.5.2 Stadiometer

The IOWA Anthropometric Plane requires little in the way of calibration. It is a sturdy and self-contained device. After transporting, be sure that the base and the backboard are still perpendicular. This is most easily accomplished with a small carpenter's level. Generally you will find that the surface on which the stadiometer rests is not level; level the base of the stadiometer with small shims or something similar. Once the base is level, the backboard should be perpendicular. Be sure, also, that the headboard is level in the track.

10.5.3 Scales

The Steering Committee left the choice of scales to the Clinical Centers. A preference was expressed for digital electronic scales but beam balance scales are also acceptable. Centers opting for the electronic scales should have a beam balance or other scale as backup.

All scales should be inspected by a local certification agency at the beginning of each examination cycle; in Chicago we use the city's Consumer Services Office division of weights and measures, which certifies scales for commercial purposes. If your center routinely has scales certified, you need only report the date of the most recent inspection (within 60 days of the beginning of the exam cycle). Once the scales have been certified, they should be checked weekly with standard weights. The

Chicago center has arranged for the city's inspector to calibrate our scales weekly, this proved far less expensive than purchasing our own standard weights.

The NCHS 5th centile of weight for 8-year-old girls is 21 kg; the 95th centile for 15-year-old boys (assuming we run for five years) is 84 kg. We may also be weighing parents. In view of this range of weights, I suggest a calibration protocol that includes 6 weights for kilogram scales: one 5-kg, two 10-kg, one 20-kg and two 25-kg weights.

As calibration weights are expensive and inconvenient to transport, protocols and weights already in use at your center may also be acceptable. The main requirement is that you take readings between, as well as precisely at, the major increments on the beam balance scales. For electronic scales, you need simply make six or eight readings from something less than 25 kg up to about 100 kg. One source of standard weights is Troemner, Inc., 6825 Greenway Avenue, Philadelphia, Pennsylvania 19142, (215) 724-0800. The local certification agency may be able to suggest a more convenient source.

10.5.4 Tanner-Whitehouse (Holtain) Skinfold Calipers

The Coordinating Center will supply small step-blocks for calibrating the skinfold calipers. These are custom made devices as the manufacturer of the calipers does not provide one. Please note that the sides of the steps on the calibration block are not supposed to be exactly parallel. Calipers should be checked at least once a week. Those of us who are compulsive check them daily. Apply the calipers to the steps on the block in succession and record the readings to the last completed 0.2 mm. (Note that the actual reading of skin-folds are to be recorded to the last completed whole mm.) The calipers should read precisely 10 mm, 20 mm and so on.

Occasionally a pair of calipers will consistently read 10.2 mm, 20.2 mm, etc. Check that the calipers are precisely zeroed, and adjust as needed with the small black knob on the upper right above the face of the calipers. Loosening the knob allows you to adjust the dial so that the zero is directly under the needle. (Do not remove the knob entirely, as it is annoyingly difficult to replace.) If this does not result in precise readings, note the discrepancies at each step of the calibration block. IF the discrepancies are only 0.2 mm and if they are the same at each step, e.g., the calipers read 10.2, 20.2, 30.2 and 40.2, you may readjust the zeroing so that the needle begins 0.2 mm to the right (recall that the needle of the caliper moves counter-clockwise) of zero. (Reverse this process if the calipers consistently read 0.2 mm low). Apply the calipers to the calibration block again, and determine whether the readings are now exact across the entire range. If so, you may use the calipers. If not, the calipers must be returned to the vendor for repair. Also, if the discrepancies are greater than 0.2 mm, even though consistent, you must send the calipers for repair.

If the calipers give only one discrepant reading, e.g., they read 10.0 mm, 20.0 mm, 30.2 mm, 40.0 mm, it indicates an inconsistent fault in the tension of the spring mechanism. This results in readings of unpredictable error across the range of the calipers. In this case the calipers must be returned for repair. The same is true if the calipers give increasing or decreasing error readings, e.g., 10.0 mm, 20.2 mm, 30.4 mm, 40.6 mm. Again, the calipers cannot be adjusted locally and must be sent back for repair.

Having said all of this, let me assure you that the Tanner-Whitehouse (Holtain) calipers don't usually develop errors. Treat them kindly: remember to release the handle gently -- don't snap the spring mechanism. Also don't pick the calipers up by the jaws.

10.5.5 Tapes

The Greulich tapes are accompanied by a calibration stand and a weight. Insert the housing of the spring mechanism in the stand and lock it in place. Gently attach the weight to the metal ring between the tape and the pin in the spring housing. The pin should emerge from the housing just far enough to expose the red notch. This indicates a tension of 10 grams on the spring. Check the tapes at least once a week. If the spring does not respond properly you may replace it; spare springs can be obtained from John Dyson in the Medical Instruments Lab at the University of Iowa.

10.6 Training and Certification

10.6.1 Training

- A. The DISC master trainer will be Carol Ballew (Northwestern University), who is responsible for central training and assessment of quality assurance during the trial.
- B. Each center will designate a master trainer who will have attended a DISC central training session, or have fulfilled criteria equivalent to the training provided at the central training session as defined below.
- C. Additional anthropometrists at a given center should be trained by the center's own master trainer.
- D. All center anthropometrists must measure five children between initial training and initiation of certification in conjunction with the master trainer at a given center. This training can include children seen at a screening visit, but for these children the recorded data should be those of the master trainer.

- E. Repeat measurements must be performed in one child by each anthropometrist to assess intraobserver variability weekly.

10.6.2 Practice Before DISC Screening Exam

Each anthropometrist to be certified will be required to measure a minimum of five children per week during each week between the training session and the beginning of the screening exams. All anthropometrists at a given center will be required to measure the same children, independently. With the exception of the replicate measurements required of each anthropometrist (see below), anthropometrists should not measure a given child more than once. (It is tempting to measure your own children over and over again because they are readily available. Unfortunately this introduces bias as you begin to remember their dimensions.)

Every week each anthropometrist should measure one child twice, ideally at a three or four day interval to minimize recall bias. The second measurement is to be made without reference to the record of the first. To facilitate the replicate measurements, it may be most practical to measure the children of colleagues or neighbors for this exercise.

All practice measurements are to be recorded on copies of the form to be used for the DISC examinations. Copies of the forms are to be sent to the trainer for evaluation. The supervising anthropometrist at each center is invited to carry out the precision and accuracy computations used in the training session with the staff at each center. In addition, an overall summary report will be prepared from the materials received from all the centers.

The source of children to be measured during the interim training period will be left to the discretion of the local centers. I recognize that this is a logistic problem, but it is vital to developing accurate anthropometric techniques. Anthropometry is deceptive. It is con-

ceptually very simple. In fact it is very difficult to attain acceptable accuracy. Frequent practice is essential.

10.6.3 Certification of Anthropometrists

Certification will be based on the weekly anthropometric records sent to the trainer by each anthropometrist, and on a final site visit by the trainer if possible. The master trainer should complete the Anthropometric Measurements Checklist Form (Exhibit 10.1) as each anthropometrist is certified.

10.6.4 Skill Maintenance (During the Trial)

- A. A percentage of all study children should be reexamined by DISC anthropometrists to reaffirm accuracy. Each center anthropometrist should remeasure, in conjunction with the master trainer, 3% of all children evaluated for anthropometry. The master trainer should reexamine approximately 10% of all study children. Thus, if a given center has 5 anthropometrists and each perform a repeat measurement on 3%, then the master trainer will also have reexamined a total of 15% of study children and will have met the criteria. If the study center has only 2 anthropometrists, including the master trainer, then the master trainer will have to examine an additional number of patients to meet the 10% criteria for skill maintenance as a master trainer. Results of these measurements should be forwarded to the DISC master trainer.
- B. For scale calibration, it is suggested that the scale be recalibrated at least monthly. If the scale is moved from place to place, it should be recalibrated more frequently.
- C. Acceptable intra- and interobserver differences for various anthropometric measurements follow:

For hip and waist measurements, intraobserver variability should be less than 1.0 cm and interobserver variability less than 2.5 cm; for skinfolds, intraobserver variability should be less than 1.0 mm, and interobserver variability less than 2.0 mm; for height, intraobserver variability should be less than 0.5 cm, and interobserver variability less than 1.5 cm.

10.6.5 Retraining and Recertification

Before each subsequent exam cycle, anthropometrists, both new and returning will be retrained and recertified. This is necessary because it is unlikely that anthropometrists will keep up a schedule of regular measuring between cycles. Recertification will also be necessary if a period of time greater than 3 months has elapsed since the anthropometrist has rigorously performed anthropometric measurements. Even experienced anthropometrists develop technical drift. For recertification, the initial certification process should be followed.

Assemble ALL prospective anthropometrists to be certified-please note that all previously certified staff are due for recertification. Assemble a minimum of 5 subjects and a recorder. The recorder should not be a candidate for certification. Each prospective anthropometrist is to independently measure each subject. You do not need to measure all subjects in a single session, but ALL prospective anthropometrists must measure any particular subject at same session. Certification is based on consideration of all candidates' measurements simultaneously.

10.6.6 Certification of New Trainees

- A. New trainees should be trained by the master trainer at a given center and meet the criteria as outline in Section 10.6.1 (B-E), for training and certification.

- B. If a new master trainer is required at a given center, this person should be trained by the DISC master trainer, or by a master trainer at a DISC center. This training should replicate the training provided at the DISC central training session.

10.7 Quality Assessment

For a 10% sample of children at each visit, all of the anthropometric measurements will be made independently by a person not involved in either measuring or recording the original two (or three) sets of measurements. If such a person, trained and certified as an anthropometrist for DISC, is not available, the second choice is a person who only recorded but did not make any measurements the first time around. If such a person is not available either, then the person who did the second set of measurements originally should do the set of quality assessment measurements at a later time in the examination. The following children will be selected for the quality assessment: at Screening Visit 02, children with final digit of the middle part of the ID number ending in "1." At 6, 12, 24, 36, 48 months, Year 05, Year 06, Year 07, Year 08, Year 09, and FV01 visits, children with final digit of ID numbers ending in "2," "3," "4," "5," "6," "7," "8," "9," "0," "1," and "2," respectively.

The repeat measurements for quality assessment will be recorded on the anthropometry form, with the words "Quality Assessment" written on top of the front page of the form, and the form will be sent to the Coordinating Center for analysis. The Coordinating Center will also send the pairs of the anthropometry form to the master trainer for evaluation.

10.8 Equipment

10.8.1 Equipment Sources

Stadiometer, University of Iowa, Medical Instruments,
Room 8, Medical laboratories,
Iowa City, Iowa 52242
(319) 335-9840
Attn: John Dyson

Scales, at the discretion of the center

Skinfold calipers, Tanner-Whitehouse model 610,
Seritex, Inc. (Pfister Import/Export)
450 Barell Ave.
Carlstadt, NJ 07072
(201) 939-4606

Calibration block for skinfold caliper, provided by
Coordinating Center.

Tape measure and calibration stand, University of Iowa, as
above.

10.8.2 Equipment Checklist

A. Stadiometer

Does not need calibration. Check level if moved.

B. Scales

All scales are to be inspected by a local certification agency
within 60 days of the beginning of each examination cycle.

Scales should be checked weekly against a range of standard
weights between 20 and 100 kg. Record on DISC Scale Calibration
Form (Exhibit 10.2)

C. Skinfold calipers

Check weekly against the calibration block. Record on DISC
Caliper Calibration Form (Exhibit 10.3)

D. Tape measure

Check spring tension weekly with the calibration stand and
weight. Record on DISC Greulich Tape Calibration Form (Exhibit
10.4)

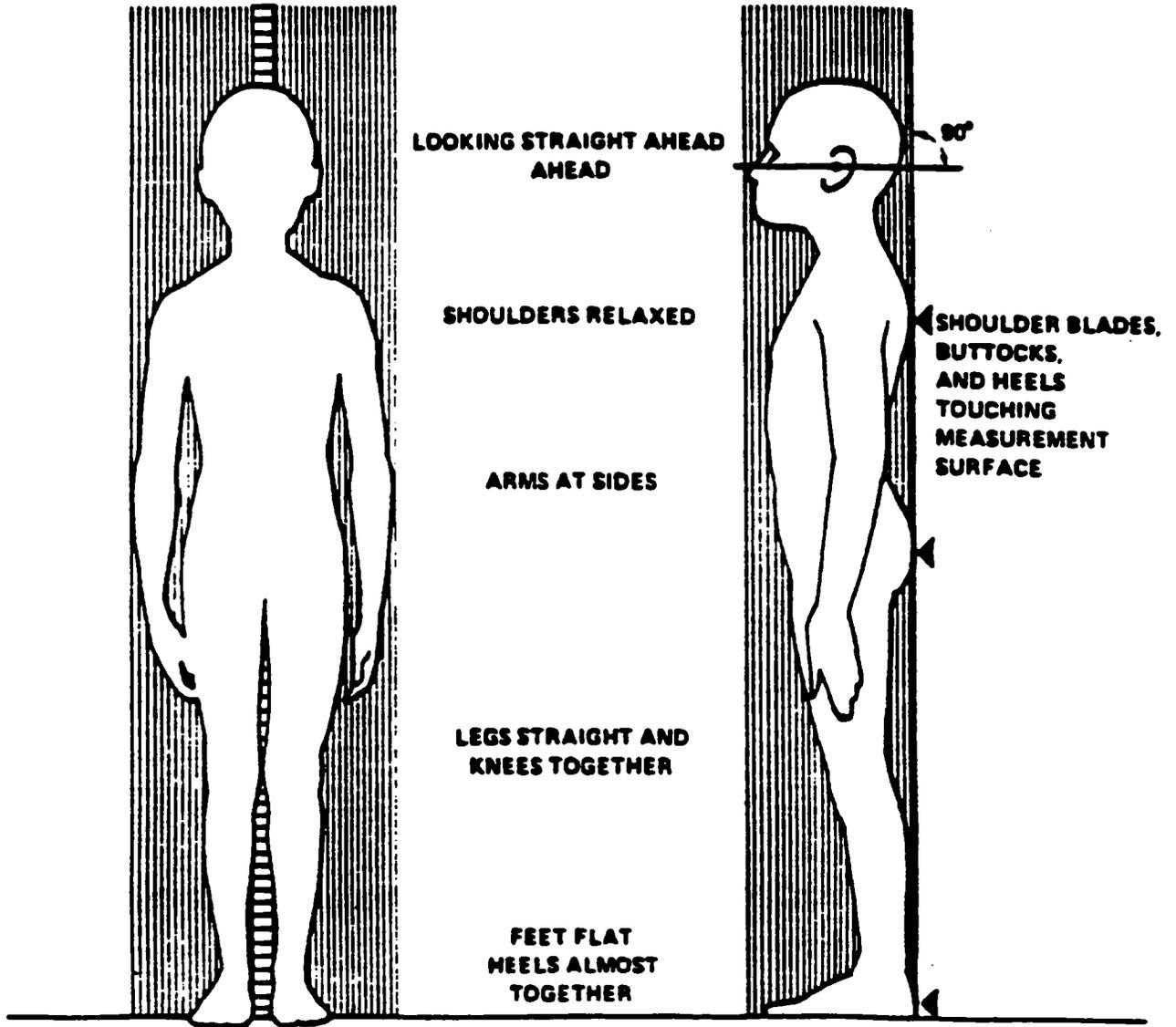
10.9 References

1. Cameron N. The Measurement of Human Growth. Croom Helm, London, 1984.
2. NCHS. Height and Weight of Children. USDHEW, Series 11, number 104, 1970.
3. NCHS. Skinfold Thickness of Children 6-11 Years, United States. NCHS Series 11, number 120, 1972.
4. NCHS. Selected Body Measurements of Children 6-11 Years, United States. NCHS Series 11, number 123, 1973.
5. USDHHS/PHS. Guide to Pediatric Weighing and Measuring. CDC/Nutritional Division. 1981.

10.10 Acknowledgements

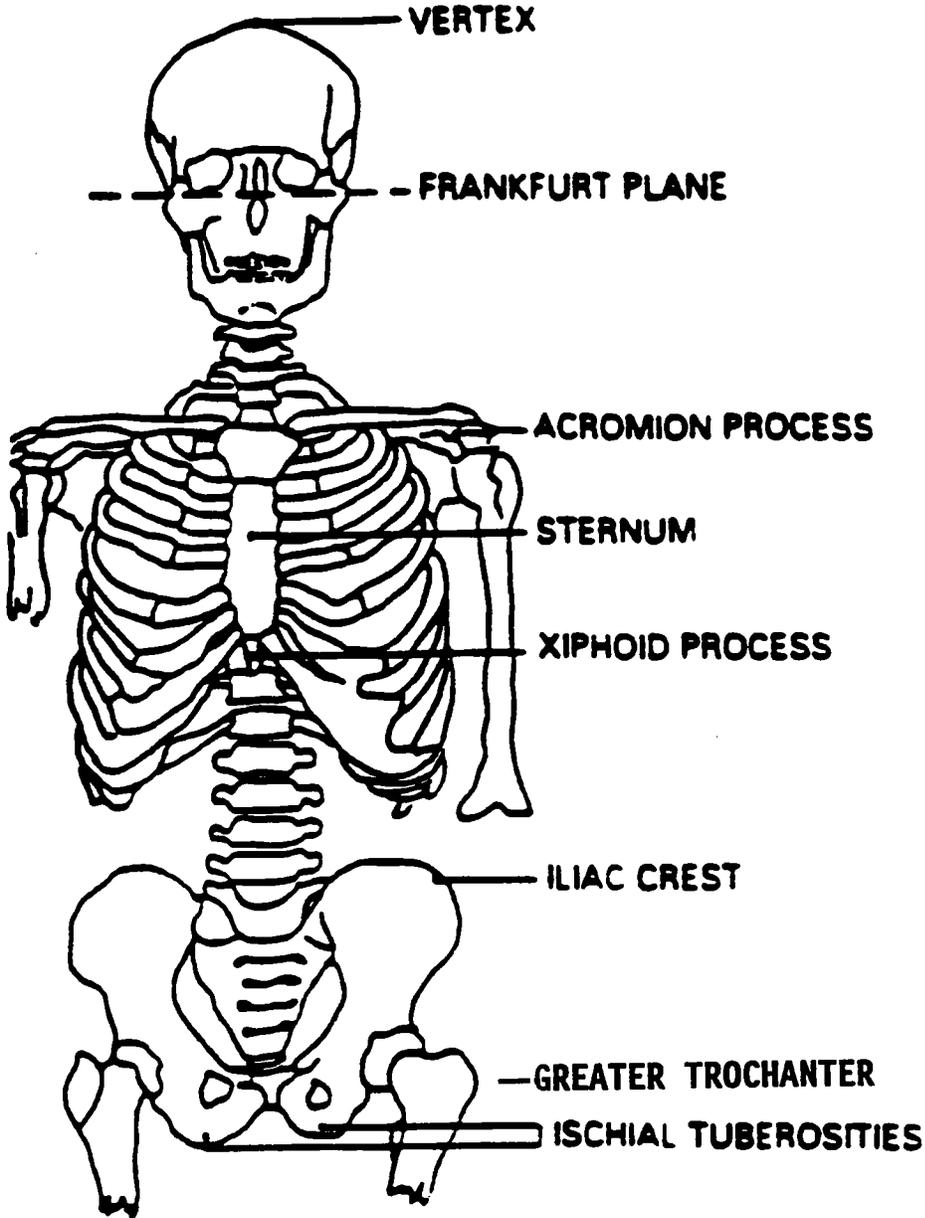
This protocol was prepared with reference to the above-cited sources and in consultation with Dr. W. Cameron Chumlea of the Fels Institute and Dr. Francis Johnston of the University of Pennsylvania.

ILLUSTRATION 1: MEASUREMENT OF STATURE



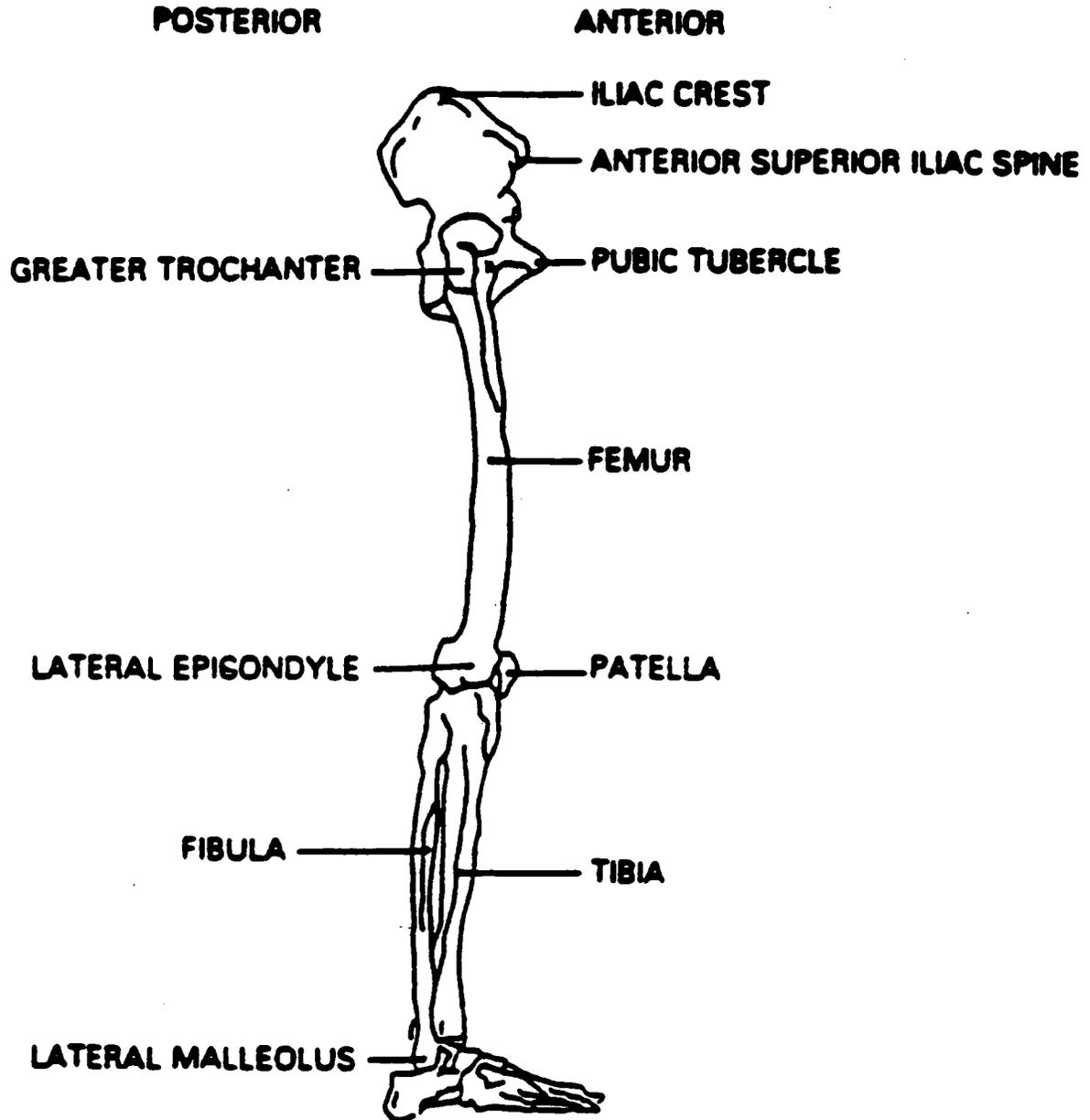
SOURCE: USDHHS/PHS. 1981. A Guide to Pediatric Weighing and Measuring. CDC/Nutritional Division.

ILLUSTRATION 2: SKELETAL LANDMARKS OF THE SKULL, THORAX AND PELVIC GIRDLE



SOURCE: Cameron, N. 1984. The Measurement of Human Growth. Croom Helm, London.

ILLUSTRATION 3: SKELETAL LANDMARKS FROM LATERAL VIEW OF PELVIC GIRDLE AND LEG



SOURCE: Cameron, N. 1984. *The Measurement of Human Growth*. Croom Helm, London.

ILLUSTRATION 4: CIRCUMFERENCE SITES

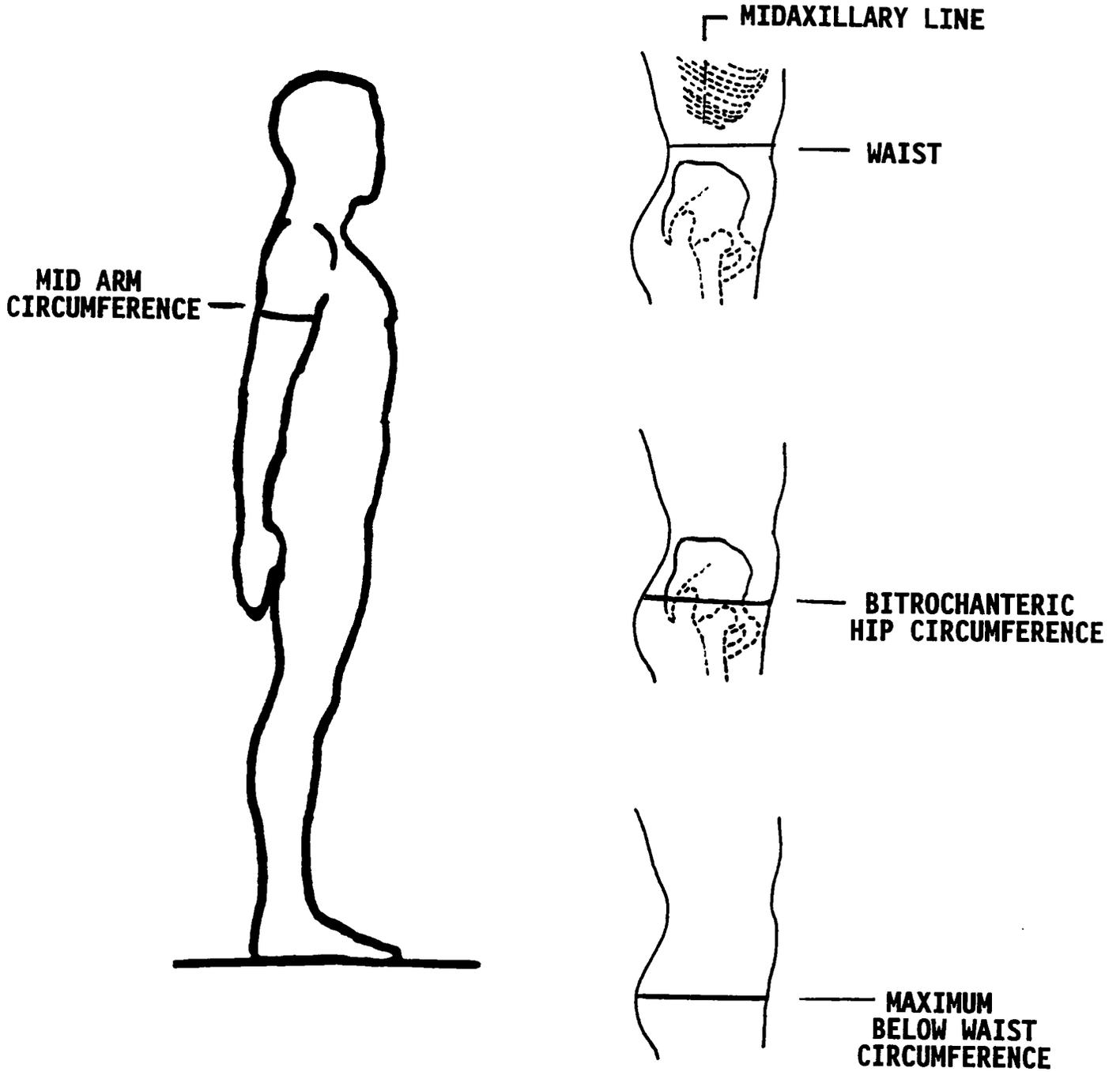
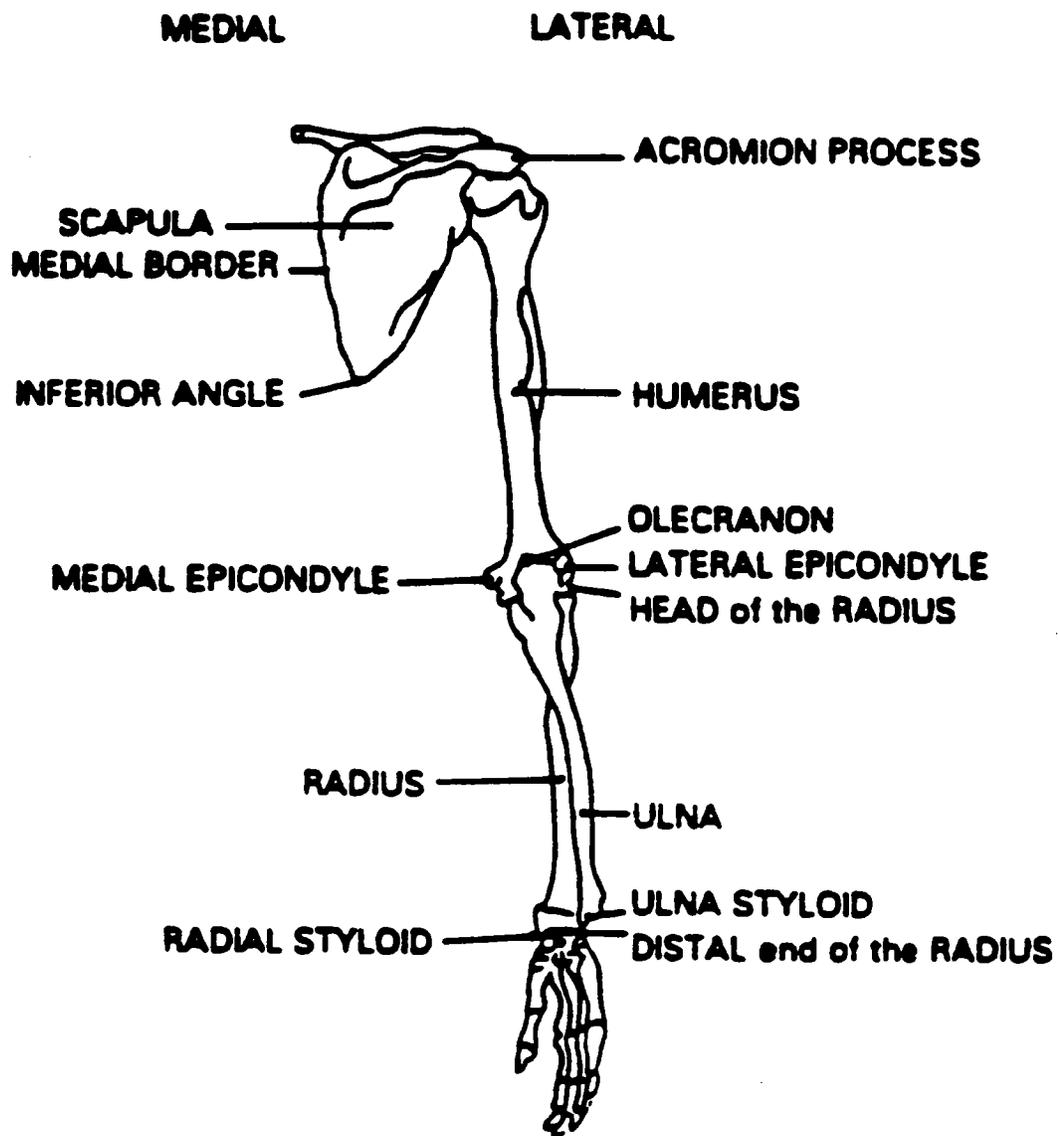
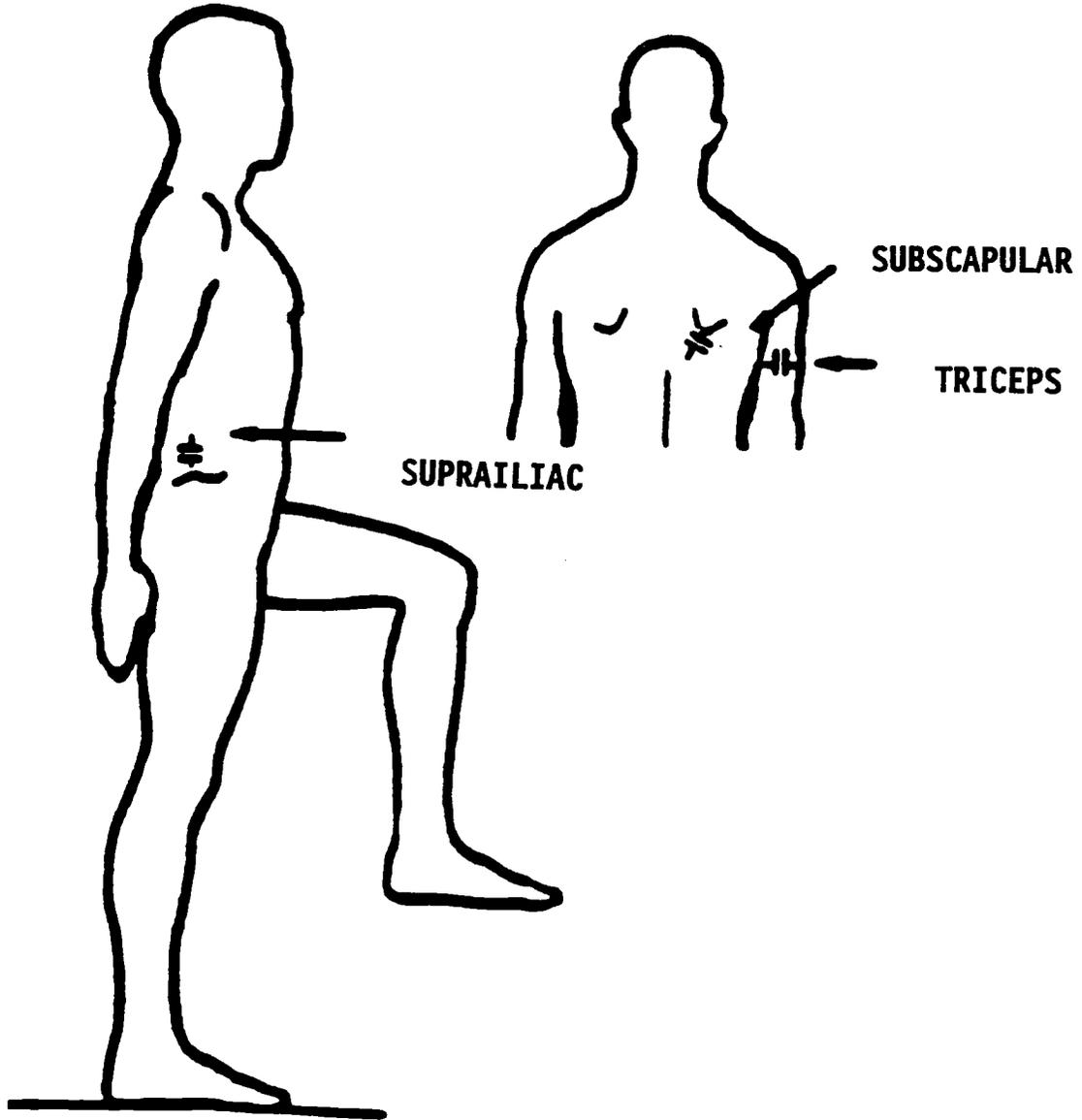


ILLUSTRATION 5: SKELETAL LANDMARKS FROM POSTERIOR VIEW OF SCAPULA AND ARM



SOURCE: Cameron, N. 1984. *The Measurement of Human Growth*. Croom Helm, London.

ILLUSTRATION 6: SKINFOLD SITES



SOURCE: NCHS. 1974. Skinfold Thickness of Youths 12-17 Years. United States. USDHEW, Series 11, number 132.

DISC ANTHROPOMETRY MEASUREMENTS

Certification and Quality Control Checklist

1. DISC Center: _____
2. Site Visit Trainer/Master Trainer: _____
3. Individual or Trainer Observed: _____

A. <u>HEIGHT</u>	<u>YES</u>	<u>NO</u>	<u>COMMENTS</u>
1. Is stadiometer on a firm (uncarpeted) level surface?	1	2	_____
2. Is bottom of stadiometer at a 90° angle to the vertical section?	1	2	_____
3. Was participant told to remove shoes?	1	2	_____
4. Was participant told to remove head gear/adjust hair?	1	2	_____
5. Was participant told to stand with heels almost together?	1	2	_____
6. Was participant told to stand with feet flat on the floor, weight evenly distributed?	1	2	_____
7. Is participant asked to stand erect with his/her buttocks, shoulder blades and head against the stadiometer?	1	2	_____
8. Is participant asked to look straight ahead with his/her head in the Frankfort horizontal plane?	1	2	_____
9. Is the head of the person taking height measurement in the same horizontal plane as head of participant?	1	2	_____
10. Is the height board brought down snugly (as opposed to tightly) on top of participant's head?	1	2	_____
11. Is anthropometrist exerting gentle upward traction on subject's mastoid processes?	1	2	_____
12. Are observers rounding appropriately? (last completed 0.1 cm)	1	2	_____

EXHIBIT 10.1 (CONTINUED)

B. <u>WEIGHT</u>	YES	NO	<u>COMMENTS</u>
1. Does anthropometrist check zeroing of scale before weighing each participant?	1	2	_____
2. Is the scale on a firm, level surface (if floor is carpeted, is there a sheet of wood or hard plastic beneath the scale)?	1	2	_____
3. Was participant weighed in examination gown?	1	2	_____
4. Was participant asked to remove shoes?	1	2	_____
5. Was participant told to stand in the center of the scale platform?	1	2	_____
6. Are observers rounding appropriately? (last completed 0.1 kg)	1	2	_____
C. <u>BODY CIRCUMFERENCE MEASUREMENTS</u>			
1. Did observer use a flexible metal anthropometric cm measuring tape? (i.e., tape which will not stretch)	1	2	_____
D. <u>UPPER ARM CIRCUMFERENCE</u>			
2. Did observer locate midpoint of arm by measuring from tip of acromion process on shoulder to tip of olecranon process on the elbow, with the arm flexed at a 90° angle?	1	2	_____
3. Did observer place a (+) at the midpoint between the shoulder and elbow in the middle of back of upper arm?	1	2	_____
4. Did the observer make measurement with participant's arm hanging relaxed at his/her side, palm facing thigh?	1	2	_____
5. Was tape placed at mark made for tricep skinfold (midpoint of upper arm)?	1	2	_____
6. Was tape kept horizontal while taking measurements?	1	2	_____
7. Was tension on tape sufficient to draw pin out of housing to reference line?	1	2	_____
8. Did observer take two measurements?	1	2	_____

EXHIBIT 10.1 (CONTINUED)

D. <u>UPPER ARM CIRCUMFERENCE</u> (Continued)	<u>YES</u>	<u>NO</u>	<u>COMMENTS</u>
9. Did observer remove tape after first and before second measurement?	1	2	_____
10. Was rounding appropriate? (last completed 0.1 cm)	1	2	_____
E. <u>WAIST</u>			
11. To find correct location, did observer palpate lower rib and iliac crest in axillary line and take measurement midway between them?	1	2	_____
12. Did observer make a mark at appropriate location?	1	2	_____
13. Did tape remain horizontal during measurement?	1	2	_____
14. Was tension on tape sufficient to draw pin out of housing to reference line?	1	2	_____
15. Did observer take two measurements?	1	2	_____
16. Did observer remove tape between 2 measurements?	1	2	_____
17. Was rounding appropriate? (last completed 0.1 cm)	1	2	_____
F. <u>HIP GIRTH - BITROCHANTERIC</u>			
18. Did observer place tape at the level of greater trochanters, while participant stood with feet together, weight evenly distributed, and buttocks relaxed?	1	2	_____
19. Did tape remain horizontal during measurement?	1	2	_____
20. Was tension on tape sufficient to draw pin out of housing to reference line?	1	2	_____
21. Did observer take two measurements?	1	2	_____
22. Did observer remove tape between two measurements?	1	2	_____
23. Was rounding appropriate? (last completed 0.1 cm)	1	2	_____

EXHIBIT 10.1 (CONTINUED)

G.	<u>HIP GIRTH - MAXIMUM</u>	<u>YES</u>	<u>NO</u>	<u>COMMENTS</u>
24.	Did the observer place tape at maximum below waist girth, while participant stood with feet together, weight evenly distributed, and buttocks relaxed?	1	2	_____
25.	Did tape remain horizontal during measurement?	1	2	_____
26.	Was tension on tape sufficient to draw pin out of housing to reference line?	1	2	_____
27.	Did observer take two measurements?	1	2	_____
28.	Did observer remove tape between measurements?	1	2	_____
29.	Was rounding appropriate? (last completed 0.1 cm)	1	2	_____
H.	<u>SKINFOLD MEASUREMENTS</u>			
1.	Was the procedure explained to the participant?	1	2	_____
2.	Was participant measured in examination gown?	1	2	_____
3.	Did observer measure participant's right side, or attempt to measure right side?	1	2	_____
	If not, was (were) left side measurement(s) indicated?	1	2	_____
4.	Were proper Tanner-Whitehouse (Holtain) skinfold calipers used?	1	2	_____
I.	<u>TRICEPS SKINFOLD</u>			
5.	Did observer grab skinfold parallel to long axis of arm?	1	2	_____
6.	Did observer grab skinfold over triceps area on back of arm?	1	2	_____
7.	Did observer use his/her thumb and forefinger?	1	2	_____

EXHIBIT 10.1 (CONTINUED)

I. <u>TRICEPS MEASUREMENTS</u> (Continued)	<u>YES</u>	<u>NO</u>	<u>COMMENTS</u>
8. Did observer grasp skin approximately 1 cm. above (+)?	1	2	_____
If not, was it	()	too high	_____
	()	too low?	_____
a. Did observer lift skinfold away from body?	1	2	_____
b. Were calipers placed at (+)?	1	2	_____
c. Were calipers placed at approximately half total depth of the skinfold?	1	2	_____
d. Were calipers placed perpendicular to the fold?	1	2	_____
e. Did observer wait approximately three seconds before taking reading off dial?	1	2	_____
f. Did observer keep hold of the skinfold while taking a reading?	1	2	_____
g. If second measurement was > 1 mm different from first, was a third measurement taken?	1	2	_____
J. <u>SUBSCAPULAR SKINFOLD</u>			
9. Did observer palpate bottom of right scapula with the right arm hanging relaxed?	1	2	_____
10. Did observer take a skinfold approximately 45° from the horizontal?	1	2	_____
If not, was it more or less than 45°?	()	more	_____
	()	less	_____
a. Did observer lift skinfold away from body?	1	2	_____
b. Were calipers placed at (+)?	1	2	_____
c. Were calipers placed at approximately half the total depth of the skinfold?	1	2	_____
d. Did observer wait approximately three seconds before taking reading off dial?	1	2	_____
e. Did observer keep hold of skinfold while taking a reading?	1	2	_____
f. If second measurement was > 1 mm different from first, was a third measurement taken?	1	2	_____

EXHIBIT 10.1 (CONTINUED)

K. <u>SUPRAILIAC SKINFOLD</u>	<u>YES</u>	<u>NO</u>	<u>COMMENTS</u>
11. Did observer locate skinfold properly: was it 1 cm above the crest of the right ilium, i.e., at the highest peak on the side of the pelvic girdle on the mid-axillary line?	1	2	_____
12. Did observer mark the point with an (+)?	1	2	_____
13. Did observer take a horizontal fold?	1	2	_____
a. Did observer lift skinfold away from body?	1	2	_____
b. Were calipers placed at (+)?	1	2	_____
c. Were calipers placed at approximately half the total depth of the skinfold?	1	2	_____
d. Did observer wait approximately three seconds before taking reading off dial?	1	2	_____
e. Did observer keep hold of skinfold while taking a reading?	1	2	_____
f. If second measurement was > 1 mm different from first, was a third measurement taken?	1	2	_____

Certification/Recertification Form for Evaluating Anthropometrists

Subject _____

	Anthrop	Anthrop	Anthrop	Anthrop	Anthrop	Mean	Range
Stature	_____	_____	_____	_____	_____	_____	+/-0.5 cm of mean
Weight	_____	_____	_____	_____	_____	_____	+/-0.5 kg of mean
Waist	_____	_____	_____	_____	_____	_____	+/-2.5 cm of mean
Hip (bitroch)	_____	_____	_____	_____	_____	_____	+/-2.5 cm of mean
Hip (max)	_____	_____	_____	_____	_____	_____	+/-2.5 cm of mean
Mid-arm	_____	_____	_____	_____	_____	_____	+/-1.0 cm of mean
Triceps	_____	_____	_____	_____	_____	_____	+/-2.0 cm of mean
Subscap	_____	_____	_____	_____	_____	_____	+/-2.0 cm of mean
Suprail	_____	_____	_____	_____	_____	_____	+/-2.0 cm of mean

ASSESSMENT

1. Overall assessment of performance (check one)

- Excellent ()
- Good ()
- Fair ()
- Poor ()

2. Trainer's comments:

3. Results reviewed with individual observed:

- a. Signature of Trainer _____
- b. Signature of Trainee _____

Today's date ___ ___/___ ___/___ ___

EXHIBIT 10.2

DISC SCALE CALIBRATION

SCALE LOCATION _____

ELECTRONIC _____ BALANCE _____

MONTH _____

total	67.7	47.7	37.7	27.7	15	Tech.
WEIGHTS	22.7 20,10,10,5	22.7,20,5	22.7,10,5	22.7,5	10,5	
Kg.						
Date						
Date						
Date						
Date						
Date						
Date						
Date						
Date						
Date						
Date						
Date						
Date						

Check scales once each week or within 24 hours of use. Record date and weight obtained. If weights are not as expected check scale for being square on the plexiglass platform, the wire straight out of the scale platform and no edge of the scale touching the wall. Once adjustment is made re-zero and read again. If unable to verify accuracy check the balance scale and use it as an alternate. Highlight any out of control results.

Reviewed by:

Date:

Position:

11-02-88

EXHIBIT 10.3

DISC CALIPER CALIBRATION

CALIPER # _____

MONTH _____

EXPECTED M.M.	10	20	30	40	COMMENTS	Tech.
OBTAINED M.M.						
DATE						
DATE						
DATE						
DATE						
DATE						

Check CALIPERS with the provided step block once each week within 24 hours of use.

Record date and M.M. obtained.

If millimeters are not as expected check the other set of calipers.

Use the set that is the most accurate and report inaccuracies to the clinic coordinator.

Highlight any out of control results.

See DISC Manual of Operations under anthropometry for more complete procedure.

Reviewed by:

Date:

Position:

Reviewed by:

Date:

Position:

11-02-88

