

HEIGHT

1. Background and Rationale

The measurement of stature (standing height) has been correlated with vertebral osteoporosis, and can be used to address various other questions as well. For example, is height loss associated with a decline in physical function? Is height loss related to the risk of weight-related disease, disability or mortality? Measurement of height will also enable us to calculate body mass index (weight/stature²), an approximation of total body fatness in the elderly. Standing height is measured in millimeters with a wall-mounted Harpenden stadiometer.

2. Equipment and Supplies

- Harpenden stadiometer
- 0.5 kg weight
- Clear plastic right angle or T-square

The stadiometer produced by Holtain Ltd. - known as the "Harpenden" stadiometer because of its development during the Harpenden Longitudinal Growth Study - is a counter recording instrument. The counter gives a reading in millimeters over a range of 600 mm to 2,100 mm. It is a wall-mounted instrument made of light alloy with a wooden headboard fixed to a metal carriage that moves freely on ball bearing rollers.

A weight of about 0.5 kg should be placed on the headboard during measurements to standardize pressure on the head and improve measurement performance. A soft weight, such as a beanbag, should be used to avoid injury to the participant if it should fall off.

2.1 Stadiometer Use and Maintenance

- The counter may break if the headboard is 'raced' up or down the backboard. The headboard should therefore be moved to its topmost position when not in use.
- The stadiometer contains a direct reading counter mounted on a counter-balanced carriage riding on ball bearings. The counter is a self-contained unit and requires no maintenance. A spare counter is provided if replacement should be required.
- The bearings and counter weight pulleys should be lubricated semiannually with one drop of light machine or instrument oil.
- The "formica" covering may be washed with soap and water as required.

2.2 Stadiometer Calibration

Daily. A metal rod of 600 mm length is placed between the headboard and the floor so that it stands vertically. If the counter does not record the correct length of the rod, loosen it by undoing the two metal retaining screws, and pull the counter away from the main fiber cog of the

carriage. In this position, turn the small metal cog of the counter until the counter records the true length of the metal rod. Press the counter against the backplate so that the teeth of the counter cog and the carriage cog engage, and tighten the retaining screws. Move the headboard up and down the backboard a number of times to ensure that the counter continues to give an accurate reading. If not, replace the counter.

3. Safety Issues and Exclusions

The measurement of standing height with the wall-mounted stadiometer should not pose any safety problems to the study participants, provided that they can stand independently. Neither should the measurement of sitting height, provided that the participant can sit independently with hands crossed at the thighs.

4. Participant and Exam Room Preparation

The participant should be relaxed. He should also be barefoot or wearing thin socks or stockings.

Ask the participant to remove any hairpiece or rearrange any hair styling that might interfere with firm contact between the headboard and the scalp.

The stadiometer should be mounted on a straight wall that is at a true 90° angle to the floor. The heel plate should be mounted on the floor in the same vertical plane as the back board of the stadiometer. The floor should be level and free of carpeting. If bare floor is unavailable, firm, non-compressible carpeting (e.g., indoor-outdoor) is acceptable. There should be about a foot or more of unoccupied wall space on either side of the stadiometer.

5. Measurement Procedures

5.1 General Issues

To perform this measurement accurately, it is important that the recorder observe both the position of the participant and of the stadiometer. The participant should be instructed to avoid slouching and the stadiometer brought down in the midline of the head.

5.2 Administration

- 1) Have the participant stand with their back against the wall-mounted stadiometer, heels together. The back (scapulae), buttocks and both heels should be touching the wall-plate. Note: the participant should be standing with head erect and in the Frankfort horizontal plane (see below), but, in general, the back of the head does not need to be in contact with the wall-plate.

Check that the participant is in the correct position, starting with the heels and checking each point of contact with the wall-plate.

Check that the arms are relaxed and hanging loosely at the sides and that the shoulders are relaxed by running your hands over them and feeling the relaxed trapezius muscle.

The head should be in the "Frankfort Horizontal Plane" in which the lowest point on the inferior orbital margin (orbitale) and the upper margin of the external auditory meatus (tragion) form a horizontal line (Figure 1). To verify that the head is in the Frankfort plane, hold the base of a clear plastic right angle (or T of a T-square) against the wall and make sure that the edge perpendicular to the wall is parallel to the "Frankfort Horizontal Plane".

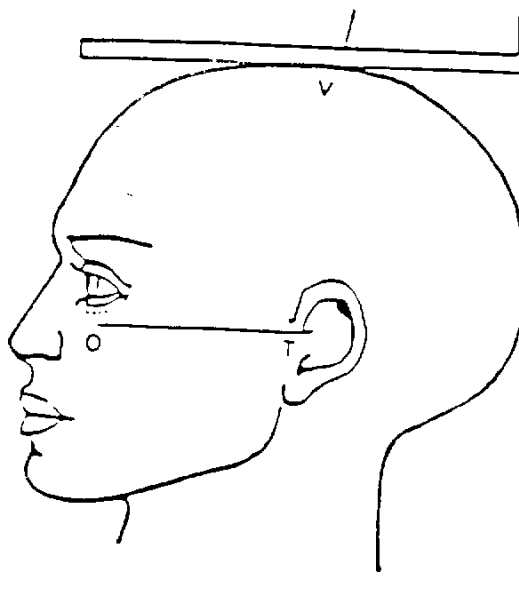


Figure 1.

Orbitale: Lower margin of eye socket

Tragion: Notch above tragus of ear

Frankfort plane: Orbitale-tragion line horizontal

Be sure that the participant maintains the correct posture during the measurement.

Script: "Please stand with your back against the board mounted on this wall. Your legs should be together and your heels, your buttocks and your back should be touching the wall-plate. Look straight ahead and stand tall. (Optional: I will position your head so that I can measure your height more accurately.)"

- 2) Bring the horizontal bar down firmly onto the top of the participant's head. Place a weight, of about 0.5 kg, on the headboard. (This weight presses down on the hair, thus flattening any hairstyle, and overcomes the natural friction of the machine so that any upward or downward movement during the measurement is recorded on the counter.) It may also be necessary, upon occasion, to alter the hair styling of some of the participants for the horizontal bar to make contact with the top of the scalp.

(Optional: To ensure that the Frankfort Plane has been achieved the examiner may find it helpful to grip the head with their open hands and pivot it gently backwards and forwards while observing the counter. The counter should register the greatest height when the head is tilted not too far forward or backwards. It is a relatively easy matter to ensure correct positioning.)

- 3) Have the participant breathe in deeply. They should not alter their position by, for example, raising the heels off the floor as they breathe in.

Script: "Take a deep breath."

- 4) Record the reading on the stadiometer just before the participant exhales.

Script: "Breathe out."

- 5) Have the participant step away from the stadiometer, then step back in to the measurement position. Repeat steps 1 - 4 and take a second measurement.
- 6) If the two measurements differ by ≥ 4 mm, take an additional two measurements.
- 7) A chart converting millimeters to inches should be mounted near the stadiometer so that the participant can be told their height in inches (and centimeters).

5.3 Deviations and exceptions to standard positioning:

Obese participants and those with a kyphotic posture may not be able to place the heels, buttocks, and scapulae in a single vertical plane while maintaining a reasonable natural stance. These participants may be positioned so that only the buttocks, and possibly the scapula, are in contact with the wall-plate. The essential point is that the participant stand erect with the buttocks in contact with the wall plate and the legs as close together as possible. In very obese participants, if it is not possible to obtain contact between the headboard and the top of the skull, then the participant may need to lean back slightly (without tilting the head) until proper contact can be made.

For participants with severe spinal curvature, if the spine is the part that protrudes the farthest, then that should be the part that is touching the wall plate, together with heels and buttocks.

For participants with extreme kyphotic posture, it may not be possible to obtain contact between the headboard and scalp when the participant's back is against the wall-plate. In this case, measure height with the participant standing sideways (side of arm and shoulder in contact with the wall-plate) and positioned so that the headboard contacts the scalp. The head should be in the Frankfurt Horizontal Plane. Record that the participant was measured in the sideways position on the scoring form so that follow-up measurements will be made in the same position.

If the participant has 'knock-knees' then have them separate the heels so that the knees are in contact but do not overlap. Obese participants may also not be able to stand comfortably with the heels touching and may stand with the legs together and the heels separated.

6. **Alert Values/Follow-up/Reporting**

Height will be included in the form given to the participant at the time of the visit. These measurements will also be included in the final reports to the participant and their physician.

7. **Quality Assurance**

7.1 **Training Requirements**

The technician requires no special qualifications for performing this assessment. The training should include:

- Read and study manual
- Attend Mr.OS training session on techniques (or observe administration by experienced examiner)
- Practice on other staff or volunteers with a special emphasis on heavy participants and women with kyphotic posture and compare measurements with those made by an experienced colleague (Goal: keep differences in repeat measurements and between examiners to less than 4 mm)
- Discuss problems and questions with local expert or QC officer

7.2 **Certification Requirements**

- Complete training requirements
- Demonstrate calibration check procedures for stadiometer
- Conduct exam on 2 volunteers:
 - According to protocol, as demonstrated by completed QC checklist
 - Differences between repeat measures should be less than 4 mm
 - Differences between trainees and QC officer's measurements should be less than 4 mm

7.3 Quality Assurance Checklist

- 0.5 kg weight on stadiometer
- Hairpiece removed, hair style altered, if necessary
- Checks that heels are together
- Checks for heels, buttock, scapula touching wall-plate (all touching if possible)
- Two more measurements made if first two differ by ≥ 4 mm

8. References

1. Methany E. Some differences in bodily proportions between American Negro and white male college students as related to athletic performance. *Res Quart* 1939;10:41-53.
2. Lohman TG, Roch AF, Martorell R, eds. *Anthropometric Standardization Reference Manual*. Human Kinetics Books, Champaign, Illinois, 1988.
3. Ortiz O, Russel M, Daley TI, et al. Differences in skeletal muscle and bone mineral mass between black and white females and their relevance to estimates of body composition. *Am J Clin Nutr* 1992;55:1-6.
4. Gerace L, Aliprantis A, Russell M, et al. Skeletal differences between black and white men and their relevance to body composition estimates. *Am J Human Biol* 1994;6:255-262.
5. Gallagher D, Visser M, Sepulveda D, et al. How useful is body mass index for comparison of body fatness across age, gender, and ethnic groups? *Am J Epidemiol* 1996;143:228-239.
6. Gallagher D, Visser M, DeMeersman RE, et al. Appendicular skeletal muscle mass: effects of age, sex, and ethnicity. *J Appl Physiol*, in press.