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UWTSD Sport and Exercise Science Physiological Testing Protocols

Blood Pressure

Taken From:

Lab 3

**Housh, T.J., Cramer, J.T., Weir, J.P., Beck, T.W. and
Johnson, G.O. (2016). Laboratory manual for
Exercise Physiology, Exercise Testing and Physical
Activity. London: Routledge.**

BACKGROUND

In addition to measuring heart rate, physical fitness assessments may involve the measurement of another basic vital sign: blood pressure (BP). Blood pressure is commonly defined as a measurement of the force of the blood acting against the vessel walls during and between heartbeats.² The pressure exerted against the vessels during a heartbeat (systole) is called the systolic blood pressure, while the pressure recorded between heartbeats (diastole) is called the diastolic blood pressure. The BP measurement is a combination of both the systolic and diastolic pressure and is usually written as “systolic / diastolic” (e.g., 120/80). BP is usually measured in units of millimeters of mercury (mmHg). A common and normal BP measurement would be written as 120 / 80 mmHg.

Sounds are emitted as a result of the pressure exerted against the vessel walls, and these sounds are called Korotkoff sounds. The detection and disappearance of Korotkoff sounds when external pressure is applied provides the basis of traditional BP assessments. Sphygmomanometry is the most common and clinically acceptable technique to measure BP.³ The American Heart Association regards the mercury sphygmomanometer as the gold standard measurement device for clinical BP assessment.³ However, other techniques, such as aneroid (pressure gauge) and automated sphygmomanometers, are increasingly common, but these may be more prone to errors than mercury sphygmomanometers.³ Nevertheless, with either mercury or aneroid sphygmomanometry, auscultation with a stethoscope placed over the brachial artery is necessary to hear the Korotkoff sounds. Therefore, sphygmomanometry is commonly called the “cuff,” “auscultation,” or “Korotkoff” technique.³



PHOTO 3.1A mercury sphygmomanometer. (A) Mercury column with pressure gradients listed from 0 to 300 mmHg, (B) stethoscope, (C) cuff, (D) air bulb and pressure release valve for inflating the cuff.



PHOTO 3.2An automated sphygmomanometer.

Classification of hypertension (JNC*–7). TABLE 3.1		
Blood pressure classification	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)
Normal	< 120	< 80
Prehypertensive	120–139	80–89
Stage 1 hypertension	140–159	90–99
Stage 2 hypertension	> 160	> 100

* Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure

Source: JNC 7: A. V. Chobanian, G. L. Bakris, H. R. Black, et al. Seventh Report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure. *Hypertension* 42: 1206–1252, 2003

The premise of sphygmomanometry with auscultation is that the brachial artery is occluded with an air-inflated cuff placed around the arm (just distal to the shoulder). The amount of pressure used to inflate the cuff to occlude brachial artery blood flow should be greater than the individual's systolic BP.³ As the cuff is deflated slowly, blood will eventually squeeze past the occlusion point (cuff) at a pressure that is equal to the systolic BP. A stethoscope is placed over the brachial artery distal to the cuff to auscultate the sounds made by the blood (i.e., Korotkoff sounds). The cuff pressure at which the first audible Korotkoff sounds occur while the cuff is deflating is denoted as the systolic BP, and the cuff pressure of the last audible Korotkoff sounds is recorded as the diastolic BP.

BP assessments are important for detecting hypertension (table 3.1) and monitoring the antihypertensive effects of an exercise program or dietary changes.⁴ BP measurements are most often performed at rest (before exercise). BP can be assessed during and after exercise; however, these techniques require advanced skills for measurement and interpretation and will not be covered in this context.¹ The BP measurement technique described in this laboratory focuses on resting BP to evaluate the presence of hypertension and, consequently, the readiness of individuals to undergo other physical fitness tests. For example, if successive BP measurements indicate the possibility of hypertension (table 3.1) for an individual, then physical fitness testing may have to be postponed until medical clearance is granted by a physician. For more information on pre-exercise health status evaluations, see Lab 1.

KNOW THESE TERMS & ABBREVIATIONS

- auscultation = listening to sounds arising from organs to aid in diagnosis and treatment
- BP = blood pressure, measured in millimeters of mercury (mmHg). BP is defined as a measurement of the force of the blood acting against the vessel walls during and between heartbeats.
- systolic blood pressure = the pressure exerted against the vessels during a heartbeat (systole)
- diastolic blood pressure = the pressure recorded between heartbeats (diastole)
- Korotkoff sounds = the sounds emitted as a result of the pressure exerted against the vessel walls; these sounds provide the basis of traditional BP assessments

- sphygmomanometer = the instrument used to measure blood pressure in an artery, consisting of a pressure gauge and a cuff, used with a stethoscope. Mercury and aneroid sphygmomanometers are available.
- hypertension = an abnormally high BP reading ($\geq 140/90$)

PHOTO 3.3A Gullick tape.

PROCEDURES

Mercury Sphygmomanometry (Auscultation Technique)^{3,4}

1. To prepare for a resting BP assessment, the subject should be relaxed and comfortably seated upright with the legs uncrossed and the back and arms supported. All clothing that covers the location of the cuff should be removed. The room temperature should be comfortable (not hot or cold), the environment should be free from distracting background noises, the subject's bladder should be relieved prior to the test, and no talking should be allowed by the subject or the tester during the test. Resting BP should always be taken prior to exercise, and caffeine, alcohol, and nicotine should be avoided for at least 30 minutes prior to any BP measurement.

2. Since various cuff sizes are available, the appropriate cuff size should be determined by measuring the arm circumference with a tape measure at 50% of the distance from the shoulder to the elbow. Once the arm circumference has been recorded, determine the appropriate BP cuff size according to the user manual.

3. Place the cuff around the left or right arm so that the cuff is level with the heart. To do this, it is important to position the subject so that the arm is resting in the same horizontal plane as the heart. BP measurements taken with the arm hanging below or raised above the heart level will be inaccurate.³ In addition, most cuffs have an identification line that is to be placed over the brachial artery. This feature allows the air bladder within the cuff to be positioned directly over the brachial artery. This is important for the occlusion of the artery during cuff inflation. Position the cuff so that the bottom edge of the cuff is approximately 1 inch (2.5 cm) above the antecubital space (elbow crease).

4. Once seated and relaxed, allow the subject to rest for at least 5 minutes prior to the first BP measurement.

5. With the subject's palm facing up, place the stethoscope head in the antecubital space firmly but not hard enough to indent the skin. It is recommended that the tester use his or her dominant hand to control the air bulb and the inflation/deflation of the cuff, while the nondominant hand should be used to hold the stethoscope.

6. Assure that the mercury column (or aneroid pressure gauge) is easily readable by the tester. For aneroid pressure gauges, it is recommended to place the gauge in the tester's lap or clip it to the cuff to enable a quick and accurate pressure reading.

7. It is important to avoid contacting the stethoscope head with the air tubes connected to the mercury sphygmomanometer. If the air tubes contact the stethoscope head, the sound may be mistaken for a Korotkoff sound and may result in erroneous BP measurements. Therefore, position the air tubes away from the stethoscope head as much as possible.

8. Once the cuff, stethoscope, and sphygmomanometer have been properly placed, make sure the air release valve is closed on the air bulb and then quickly inflate the cuff either to 160 mmHg or to 20 mmHg above the anticipated systolic BP.

9. Upon reaching the maximum inflation pressure, carefully turn the air release valve counterclockwise to release the cuff pressure. The rate of pressure release should be approximately 2 to 3 mmHg per second.

10. While the cuff is deflating, listen carefully for the Korotkoff sounds. Record the systolic BP as an even number to the nearest 2 mmHg where the first Korotkoff sound is heard. Record the diastolic BP as an even number to the nearest 2 mmHg where the last Korotkoff sound is heard. Usually, Korotkoff sounds are described as sharp tapping noises that are similar to tapping the stethoscope head (bell) gently with a finger. After the Korotkoff sounds have disappeared, observe the mercury column for another 10 to 20 mmHg of deflation to confirm the absence of sounds.

11. When it is confirmed that no more Korotkoff sounds are audible, rapidly deflate and remove the cuff.

12. After a minimum of 2 minutes of rest, measure BP again using the same technique described above. If the two consecutive measurements of either systolic BP or diastolic BP differ by more than 5 mmHg, take a third BP measurement. After either two or three consecutive BP measurements, calculate the average systolic and diastolic BP. The average systolic and diastolic BP values should be used as the final scores.

Automated Sphygmomanometry

The American Heart Association recommends that any BP measurement technique other than mercury sphygmomanometry (including automated systems) should be validated prior to being used in practice.³ Substantial errors in BP measurements and erroneous values may occur in both validated and unvalidated devices, but the probability of errors is reduced with validation.³

Most automated sphygmomanometers operate very similarly to the regular auscultation technique described above, except that a stethoscope is not required. Subject positioning and cuff placement are usually the same. Therefore, steps 1–4 and step 12 (above) may be applied. Because individual manufacturers may have different procedures, the manufacturer's directions should be carefully followed for any automated BP assessments.

Worksheet 3.1 BLOOD PRESSURE FORM

Name _____ Date _____

Gender: _____

Age: _____

BLOOD PRESSURE:	TRIAL 1	TRIAL 2	TRIAL 3
Systolic (mmHg)	_____	_____	_____
Diastolic (mmHg)	_____	_____	_____

1. Final resting blood pressure (mmHg) = _____

2. Resting blood pressure classification = _____ (see table 3.1)

REFERENCES

1. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription, 9th edition. Baltimore: Wolters Kluwer/Lippincott Williams & Wilkins, 2014.
2. Beam, W. C. and Adams, G. M. Exercise Physiology Laboratory Manual, 7th edition. New York: McGraw-Hill, 2014.
3. Pickering, T. G., Hall, J. E., Appel, L. J., Falkner, B. E., Graves, J., Hill, M. N., Jones, D. W., Kurtz, T., Sheps, S. G., and Roccella, E. J. Recommendations for blood pressure measurement in humans and experimental animals. Part 1: Blood pressure measurement in humans: A statement for professionals from the subcommittee of professional and public education of the American Heart Association Council on high blood pressure research. Circulation 111: 697–716, 2005.
4. Ryan, E. D., and Cramer, J. T., Fitness testing protocols and norms. In NSCA's Essentials of Personal Training, eds. R. W. Earle and T. R. Baechle, 2nd edition. Champaign, IL: Human Kinetics, 2012, pp. 201–250.

Sample Calculations

Gender: Male

Age: 19 years

BLOOD PRESSURE	TRIAL 1	TRIAL 2	TRIAL 3
systolic (mmHg) =	124	118	118

diastolic (mmHg) = 72 66 70

Step 1: Calculate the average systolic and diastolic blood pressure values.

systolic: $(124 + 118 + 118) \div 3 = 120$

diastolic: $(72 + 66 + 70) \div 3 = 69.3$

final blood pressure = 120 / 69.3 mmHg

Step 2: Classify the final blood pressure measurement using table 3.1.

A score of 120 / 69.3 mmHg would be classified as normal in table 3.1.