33 EXERCISE

Human Cardiovascular Physiology: Blood Pressure and Pulse Determinations

Time Allotment: 2 hours (with some shared small-group data).

Multimedia Resources: See Appendix B for Guide to Multimedia Resource Distributors.

Human Biology (FHS: 58 minutes DVD)
Interactive Physiology® 10-System Suite: Cardiovascular System (PE: CD-ROM, Website)
Life Under Pressure (FHS: 26 minutes, DVD, 3-year streaming webcast)
The Physiology of Exercise (FHS: 15 minutes, DVD)
A record, audiotape, or CD-ROM of *Interpreting Heart Sounds* (if available on free loan from the local chapters of the American Heart Association) or any suitable Web resource featuring heart sounds.

Laboratory Materials

Ordering information is based on a lab size of 24 students, working in groups of 4. A list of supply house addresses appears in Appendix A.

12 stethoscopes
12 sphygmomanometers
Watch (or clock) with second hand
Alcohol swabs
6 felt-tipped pens
6 small basins or large finger bowls
6 laboratory thermometers
Ice
Audio recording of *Interpreting Heart Sounds* (if available on free loan from local chapters of the American Heart Association) and appropriate player, or any suitable Web resource featuring heart sounds
BIOPAC® BSL System for Windows with BSL software version 3.7.6 to 3.7.7, or BSL System for Mac OS X with BSL software version 3.7.6 to 3.7.7, MP36/35 data acquisition unit, PC or Mac computer, BIOPAC® pulse plethysmograph
Cot (if available)
6 meter sticks
Step stools (0.4 m [16 in.] and 0.5 m [20 in.] in height)

Advance Preparation

1. Set out stethoscopes (both bell and diaphragm) and sphygmomanometers (two per group). Check the valves on the bulbs of the cuffs to be sure that air is released from the cuff when the valves are opened (replacement valves can be ordered). If electronic monitoring equipment is to be used, prepare instructions and distribute.
2. Set out or ask students to bring watches with second hands. Provide each group with a meter stick, alcohol swabs, a felt-tipped pen, a small basin or large finger bowl, and a laboratory thermometer. Have ice available.

3. Set out one 0.4 m (16-inch) high bench (for women) and one 0.5 m (20-inch) high bench (for men). You may have to compromise with a 0.45 m (18-inch) bench. Set up a cot, if available.
4. Set up the appropriate player for heart sounds.
5. Divide the class into small groups to collect data for Effect of Various Factors on Blood Pressure and Heart Rate. It may be hard to define *well-conditioned* and *poorly conditioned* subjects. A runner or a member of an athletic team might be compared to a more sedentary person (see Comments and Pitfalls, item 4).
6. Set out equipment and materials for conducting the BIOPAC® activity. Introduce your students to the basic features of the equipment prior to beginning the lab activity.

Comments and Pitfalls

1. Most students in the health sciences will have no trouble with this lab, and in fact enjoy bringing their own stethoscopes and sphygmomanometers to lab if they are given advance notice.
2. If students have trouble hearing the heart sounds with the bell stethoscope, have them try the diaphragm model. This will be particularly helpful when trying to hear the split sounds. The sounds are louder with the bell stethoscopes, but placement must be more precise.
3. Caution students against overtightening the valve on the sphygmomanometer. If the air in the cuff can't be released, it is very painful to the subject. If the valve does stick, most cuffs can be undone even when filled with air. To avoid problems once the cuff is inflated, have students practice first with the bulb valve.
4. Students performing the Harvard step test should be carefully monitored to be sure that they step completely up and completely down at the prescribed rate. This can be very fatiguing. If the student population is fairly uniform it may be difficult to detect major differences between the *well-conditioned* and *poorly conditioned* individuals. Try to compare people of the same general age and sex, and do not compare a smoker to a nonsmoker. Students who are aware that they have heart problems should be discouraged from acting as subjects.
5. Many fitness tests are designed for people in their early twenties. Some tests take age and gender into account (see The President's Challenge, Physical Fitness Test at www.presidentschallenge.org).
6. If a person with Raynaud's disease is used as the subject for the cold pressor test, he or she may experience temporary loss of feeling in the hand.
7. Students who are testing the effects of venous congestion should be reminded to keep both arms quietly on the lab bench for the full 5 minutes. Check to be sure pressure is maintained at 40 mm Hg.

Answers to Pre-Lab Quiz (pp. 493–494)

1. diastole
2. b, cardiac cycle
3. true
4. b, 75
5. murmurs
6. c, pulse
7. radial
8. Sphygmomanometer
9. 90
10. d, sounds of Korotkoff

Answers to Activity Questions

Activity 1: Auscultating Heart Sounds (p. 496)

3. The interval is about 0.5 second. It is about twice as long as the interval between the first and second heart sounds.

Activity 2: Palpating Superficial Pulse Points (p. 497)

The carotid pulse point has the greatest amplitude, and the dorsalis pedis artery has the least. This is related to distance from the left ventricle of the heart.

Activity 6: Estimating Venous Pressure (p. 501)

4. During the Valsalva maneuver, peripheral venous pressure increases due to the increase in intrathoracic pressure.

Activity 7: Observing the Effect of Various Factors on Blood Pressure and Heart Rate (pp. 502–503)

Exercise

6. Greater elevation of blood pressure is generally noted just after completion of exercise. Increased cardiac output during exercise results in increased systolic pressure. A poorly conditioned individual usually has a higher systolic pressure at the end of exercise, and it usually takes a longer time for the pressure to return to normal. A well-conditioned individual usually has a larger stroke volume and thus can pump more blood with fewer beats per minute than a poorly conditioned individual. Diastolic pressure usually does not increase significantly, as it is the resting pressure of the vessels.

A Noxious Sensory Stimulus (Cold)

Blood pressure changes will be variable. The pulse rate will probably increase.

Activity 8: Examining the Effect of Local Chemical and Physical Factors on Skin Color (pp. 504–506)

Vasodilation and Flushing of the Skin Due to Local Metabolites

7. Stopping blood flow causes the hand to turn very pale. Weakness and a tingling sensation may be felt (variable). The skin flushes bright red immediately upon release of pressure and normal color is restored after several minutes or longer. There may be some lingering pain in the forearm region.

Effects of Venous Congestion

2. Slight pressure may be felt in the hand at the end of 5 minutes (variable). The veins are bulging and the hand has a mottled appearance, much darker in color than the control. Upon release of pressure, the veins deflate, and color and feeling return to normal.
3. Intensity of skin color (pink or blue) is related to the volume of blood in the area. The color is determined by the degree of oxygenation of the blood. In this experiment, venous blood gives a blue tint and arterial blood gives a pink tint.

Collateral Blood Flow

5. Results are variable. The hand usually turns intensely red and a warm tingling sensation may be felt. Redness may last for several minutes.
6. The hand does not become totally ischemic. The second test result is much less dramatic, with much less intense reactive hyperthermia.
7. With only the ulnar artery compressed, the results are intermediate between questions 5 and 6. The ulnar artery has a larger diameter than the radial artery, but they anastomose in the hand to serve the same areas.

Effect of Mechanical Stimulation of Blood Vessels of the Skin

Results will vary. A red streak develops with moderate pressure. With heavy pressure, a wider, darker, longer-lasting streak develops and may swell.

Name _____

Lab Time/Date _____

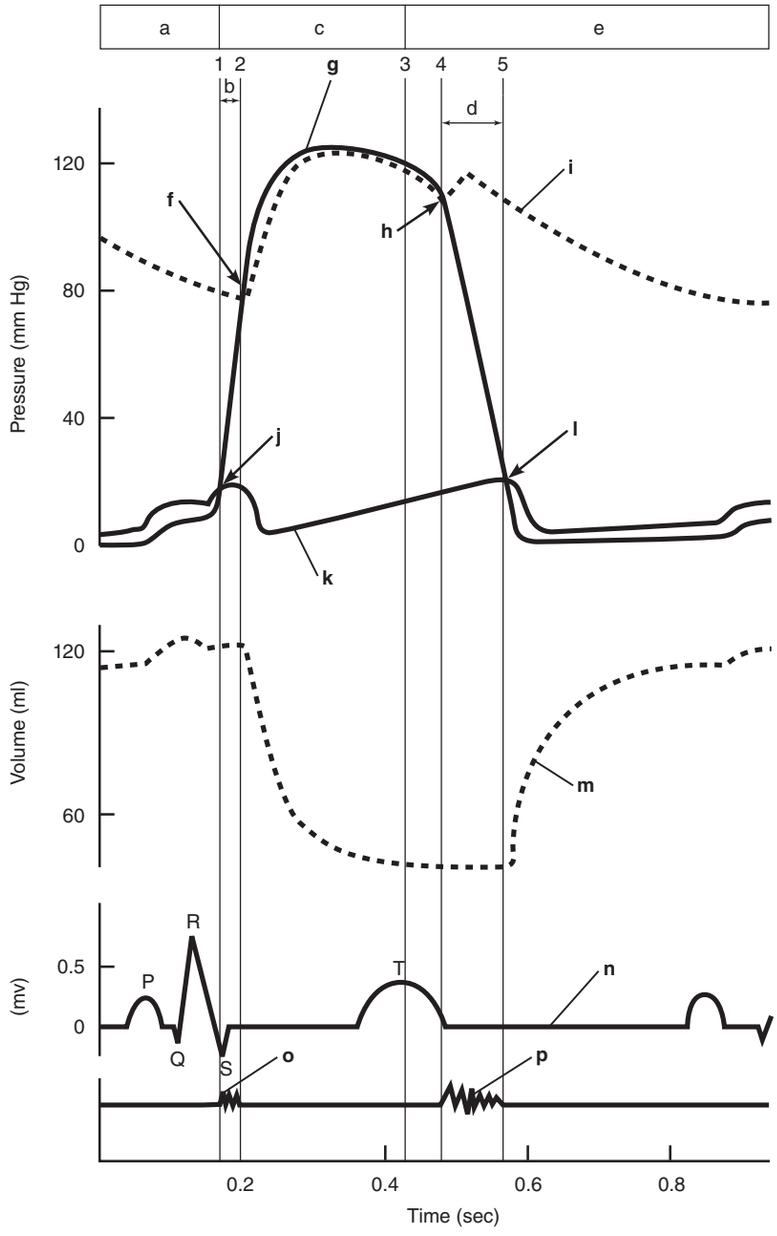
EXERCISE 33

REVIEW SHEET

Human Cardiovascular Physiology: Blood Pressure and Pulse Determinations

Cardiac Cycle

1. Using the grouped sets of terms to the right of the diagram, correctly identify each trace, valve closings and openings, and each time period of the cardiac cycle.



i 1. aortic pressure

k 2. atrial pressure

n 3. ECG

o 4. first heart sound

p 5. second heart sound

g 6. ventricular pressure

m 7. ventricular volume

h 8. aortic (semilunar) valve closes

f 9. aortic (semilunar) valve opens

b, d 10. AV and semilunar valves closed (2 letters)

j 11. AV valve closes

l 12. AV valve opens

a, e 13. ventricular diastole (2 letters)

c 14. ventricular systole

2. Define the following terms.

systole: *Contraction of the ventricles (general usage)*

diastole: *Ventricular relaxation (general usage)*

cardiac cycle: *One complete heartbeat including atrial and ventricular contraction*

3. Answer the following questions concerning events of the cardiac cycle.

When are the AV valves closed? *During ventricular systole*

What event within the heart causes the AV valves to open? *Atrial pressure greater than ventricular pressure*

When are the semilunar valves closed? *During the period of relaxation of the heart as a whole and during atrial contraction*

What event causes the semilunar valves to open? *Ventricular pressure greater than pressure in great arteries*

Are both sets of valves closed during any part of the cycle? *Yes*

If so, when? *Momentarily after atrial contraction and ventricular systole.*

Are both sets of valves open during any part of the cycle? *No*

At what point in the cardiac cycle is the pressure in the heart highest? *Ventricular systole*

Lowest? *Ventricular diastole*

What event results in the pressure deflection called the dicrotic notch? *The momentary increase in aortic pressure that occurs when its semilunar valves snap shut*

4. Using the key below, indicate the time interval occupied by the following events of the cardiac cycle.

Key: a. *0.8 sec* b. *0.4 sec* c. *0.3 sec* d. *0.1 sec*

a 1. the length of the normal cardiac cycle

d 2. the time interval of atrial systole

b 3. the quiescent period

c 4. the ventricular contraction period

5. If an individual's heart rate is 80 beats/min, what is the length of the cardiac cycle? *0.75 sec* What portion of the cardiac cycle decreases with a more rapid heart rate? *Quiescent period (ventricular relaxation period)*

6. What two factors promote the movement of blood through the heart? *Alternate contraction and relaxation of the myocardium* and *opening and closing of the heart valves*

Heart Sounds

7. Complete the following statements.

The monosyllables describing the heart sounds are 1. The first heart sound is a result of closure of the 2 valves, whereas the second is a result of closure of the 3 valves. The heart chambers that have just been filled when you hear the first heart sound are the 4, and the chambers that have just emptied are the 5. Immediately after the second heart sound, both the 6 and 7 are filling with blood.

1. *lub-dup*
2. *atrioventricular*
3. *aortic and pulmonary (semilunar)*
4. *ventricles*
5. *atria*
6. *atria*
7. *ventricles*

8. As you listened to the heart sounds during the laboratory session, what differences in pitch, length, and amplitude (loudness) of the two sounds did you observe? *First heart sound is longer, louder, and lower in pitch than the second heart sound, which is short, sharp, and high-pitched.*

9. In order to auscultate most accurately, indicate where you would place your stethoscope for the following sounds:

closure of the tricuspid valve: *Left or right sternal border of the 5th intercostal space*

closure of the aortic valve: *Right sternal border of the 2nd intercostal space*

apical heartbeat: *5th intercostal space in line with the middle of the left clavicle*

Which valve is heard most clearly when the apical heartbeat is auscultated? *Mitral*

10. No one expects you to be a full-fledged physician on such short notice, but on the basis of what you have learned about heart sounds, how might abnormal sounds be used to diagnose heart problems?

Abnormal sounds such as swishing sounds after valvular closure or high-pitched sounds arising when blood is forced through constricted (valve) openings might indicate valvular problems.

The Pulse

11. Define *pulse.* *Pressure surges in an artery occurring during each contraction and relaxation of the left ventricle*

12. Describe the procedure used to take the pulse. *Place the first 2–3 fingertips of one hand over an arterial pressure point. Compress firmly and then release the pressure slightly to palpate the pulse.*

13. Identify the artery palpated at each of the pressure points listed.

at the wrist: *Radial*

in front of the ear: *Temporal*

on the dorsum of the foot: *Dorsalis pedis*

at the side of the neck: *Carotid*

14. When you were palpating the various pulse or pressure points, which appeared to have the greatest amplitude or tension?

Carotid artery Why do you think this was so? *The carotid arteries are the major arteries that deliver blood to the brain and they are closest to the heart.*

15. Assume someone has been injured in an auto accident and is hemorrhaging badly. What pressure point would you compress to help stop bleeding from each of the following areas?

the thigh: *Femoral artery* the calf: *Popliteal artery*

the forearm: *Brachial artery* the thumb: *Radial artery*

16. How could you tell by simple observation whether bleeding is arterial or venous? *If it spurts, it is arterial. It will flow evenly if it is venous blood.*

17. You may sometimes observe a slight difference between the value obtained from an apical pulse (beats/min) and that from an arterial pulse taken elsewhere on the body. What is this difference called?

Pulse deficit

Blood Pressure Determinations

18. Define *blood pressure.* *Pressure exerted by blood against the walls of the blood vessels*

19. Identify the phase of the cardiac cycle to which each of the following applies.

systolic pressure: *Systole (ventricular contraction)* diastolic pressure: *Diastole (relaxation)*

20. What is the name of the instrument used to compress the artery and record pressures in the auscultatory method of determining blood pressure? *Sphygmomanometer*

21. What are the sounds of Korotkoff? *Sounds that can be auscultated over a partially occluded artery*

What causes the systolic sound? *Sound of turbulent blood flow as it first begins to move through the constricted artery*

What causes the disappearance of the sound? *Blood is flowing freely; the artery is no longer constricted*

22. Interpret the pressure reading for each of the three numbers listed: 145/85/82. *145=systolic pressure; 85=diastolic pressure reported as the point where the sound muffles; 82=diastolic pressure reported as the point at which sound disappears*

23. Assume the following BP measurement was recorded for an elderly patient with severe arteriosclerosis: 170/110/–. Explain the inability to obtain the third reading.

The patient's arteries are so narrowed by arteriosclerosis that blood flow is always partially occluded. Hence, the sound.

24. Define *pulse pressure.* *Systolic pressure minus diastolic pressure*

Why is this measurement important? *It indicates the actual working pressure (actual amount of blood forced out of the heart during systole).*

25. How do venous pressures compare to arterial pressures? *Venous pressures are lower.*

Why? *Veins are far removed from the pumping action of the heart.*

26. What maneuver to increase the thoracic pressure illustrates the effect of external factors on venous pressure? *Valsalva maneuver*

How is it performed? *A person takes a deep breath, and mimics the motions of exhaling forcibly, but without actually exhaling. The glottis will close and the intrathoracic pressure will increase.*

27. What might an abnormal increase in venous pressure indicate? (Think!) *Heart failure. With the heart unable to adequately pump blood, it pools in the lower extremities and increases venous pressure.*

Observing the Effect of Various Factors on Blood Pressure and Heart Rate

28. What effect do the following have on blood pressure? (Indicate increase by ↑ and decrease by ↓.)

↓ 1. increased diameter of the arterioles

↑ 2. increased blood viscosity

↑ 3. increased cardiac output

↓ 4. hemorrhage

↑ 5. arteriosclerosis

↑ 6. increased pulse rate

29. In which position (sitting, reclining, or standing) is the blood pressure normally the highest?

Standing The lowest? *Reclining*

What immediate changes in blood pressure did you observe when the subject stood up after being in the sitting or reclining position? *It decreased initially and then increased.*

What changes in the blood vessels might account for the change? *Upon standing, gravitational pull caused blood pooling in the lower part of the body, but then vasoconstriction initiated by the vasomotor center caused blood pressure to rise.*

After the subject stood for 3 minutes, what changes in blood pressure were observed? *It decreased once again.*

How do you account for this change? *Decreased activity of the sympathetic nervous system.*

30. What was the effect of exercise on blood pressure? *It increased the blood pressure.*

On pulse rate? *It increased the pulse rate.* Do you think these effects reflect changes in cardiac output *or* in peripheral resistance? *Both; cardiac output increases, but peripheral resistance also changes (it decreases as vessels to skeletal muscles and the heart dilate, and increases as vessels to other organs, e.g., GI tract and kidneys, constrict). Overall, peripheral resistance often decreases during exercise, but it decreases less than cardiac output increases. Therefore, blood pressure rises.*

Why are there normally no significant increases in diastolic pressure after exercise? *Since diastolic pressure reflects the heart in relaxation, it would not be expected to increase in healthy individuals.*

31. What effects of the following did you observe on blood pressure in the laboratory?

cold temperature: *Increased BP*

What do you think the effect of heat would be? *Decreased BP*

Why? *Vasodilation would occur.*

32. Differentiate between a hypo- and a hyperreactor relative to the cold pressor test. *Hyperreactors exhibit a rise of 23 mm Hg or more in BP during the test. Hyporeactors exhibit a smaller increase or a decrease in BP.*

Skin Color as an Indicator of Local Circulatory Dynamics

33. Describe normal skin color and the appearance of the veins in the subject's forearm before any testing was conducted.

Skin pink; veins flat and difficult to see.

34. What changes occurred when the subject emptied the forearm of blood (by raising the arm and making a fist) and the flow was occluded with the cuff? *Skin becomes pale (cyanotic in some cases) and cool.*

What changes occurred during venous congestion? *Skin becomes pink (red) and warm, and veins are congested and very visible.*

35. What is the importance of collateral blood supplies? *Can maintain the blood supply to an organ or body part in case the major nutrient artery is occluded*

36. Explain the mechanism by which mechanical stimulation of the skin produced a flare. *Local inflammatory response produced by the chemical mediators released by injured tissue cells*