Using Digital Blood Pressure Measurements in Introductory Biology and Physiology Classes.

Blood pressure, which is basically the force that blood exerts on the inner walls of a vessel, is an important determinant in the flow of blood in the body. When the heart is contracting during ventricular systole, the maximum pressure exerted against the walls of the arteries is systolic pressure. During relaxation of the ventricle, the pressure that results is termed diastolic pressure. These pressures are measured in millimeters of mercury (mm. Hg.). The typical adult blood pressure is 120/80 mm. Hg. Young people may have lower values.

A relatively ancient mercury column can be a good device for explaining how blood pressure is measured. With a stethoscope illustrating the Korotkoff sounds and the mercury sphygmomanometer showing the pressure differential, it is easy to explain the basis of the measurements. However, many students have trouble distinguishing the Korotkoff sounds between systolic and diastolic pressure. This is particularly a problem when they are trying to hear the sounds over the background noise of other students in the class. The newer electronic instruments have a similar problem with sensitivity to sounds as well as overall accuracy.

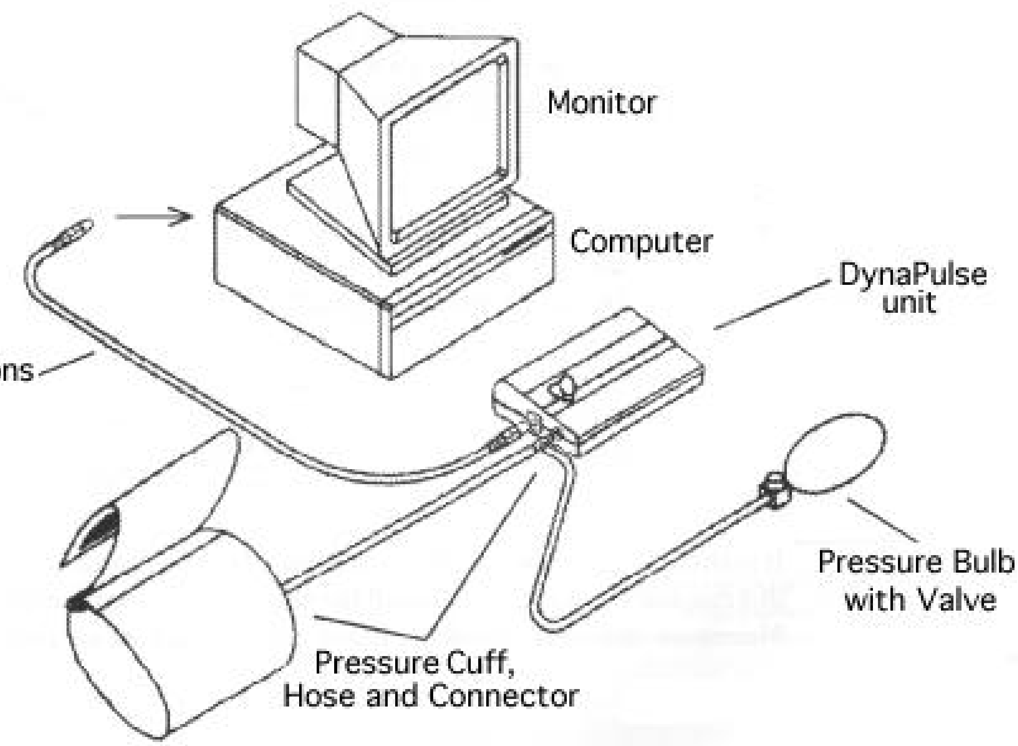
DynaPulse sphygmomanometers, introduced in recent years, can be coupled to PC and Macintosh computers. These instruments do not depend on the students' hearing the systolic and diastolic sounds. They can be calibrated and the pressure ranges set. Students can screen capture the results and incorporate them in a word processing document as part of their laboratory write-ups.

A typical laboratory exercise consists of the following:

A class demonstration using the mercury sphygmomanometer is coupled with an explanation of how Korotkoff sounds are used in establishing systolic and diastolic pressure. This is followed by an explanation of how an electronic (microphone) sphygmomanometer operates, as well as how it differs from the mercury instrument.

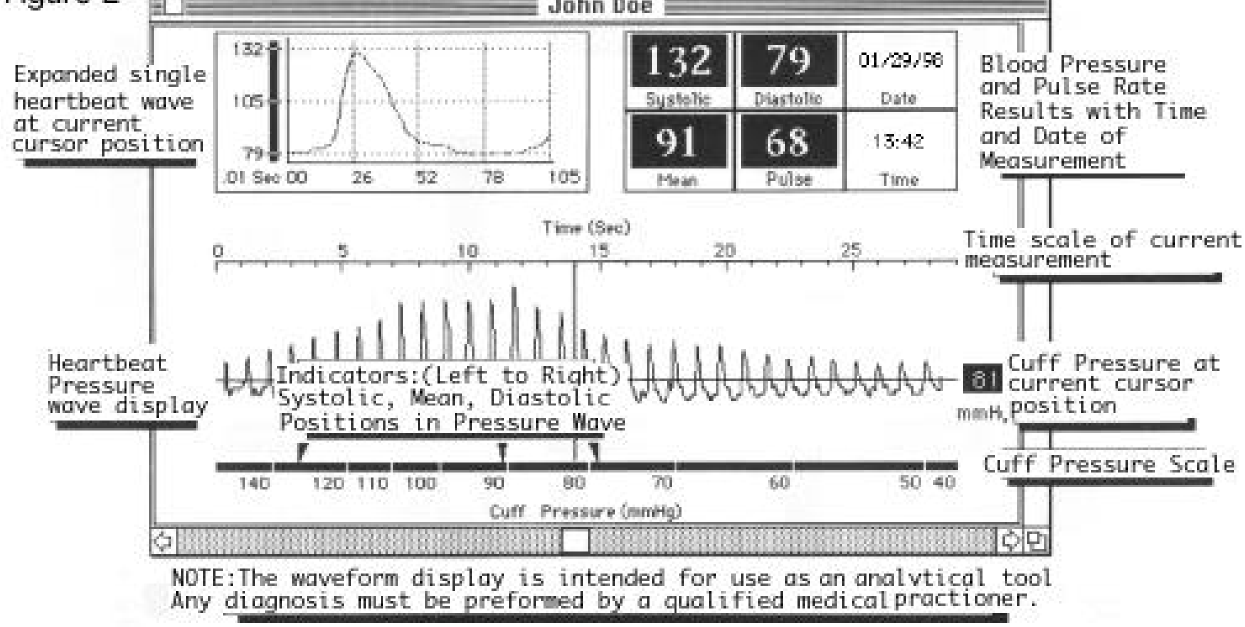
Figure 1 shows how the pressure bulb and valve connect to a microphone containing cuff by way of the DynaPulse unit. This unit is powered by 4 - AAA batteries. The DynaPulse unit is connected to the computer's modem or printer port by a serial cable. The computer software provides a step by step guide to taking the pressure readings. The manual that is included with this instrument and the menu bar give clear instructions about calibrating the instrument and establishing minimum and maximum ranges for the person using the instrument.

Figure 1



In the first laboratory exercise, the students use the DynaPulse instruments to measure resting blood pressures followed by blood pressures after activity such as stair climbing or running in place. The students save their results by doing a screen capture on the computers. They can then go to the hard drive to label their captured images and put them in a folder. These folders are then put on the server for later analysis. The DynaPulse results graph (Fig. 2), shows a reading of mean pressure and pulse rate in addition to systolic and diastolic pressure.

Figure 2



As a follow up, students discuss their results and make some hypotheses about the causes of the results. A series of follow-up activities can investigate blood pressure more thoroughly.

An interesting investigation can be pursued by asking students the following question:

"If another student were to raise your arm while you had the cuff on, would your systolic pressure go up or down?" The majority of students assume the pressure will go up. When this is tried, in every case there is a significant systolic pressure drop. To explain this, students work through the following procedure.

1. Find an accurate resting pressure. (This might involve two or more readings until the readings are within 5 mm. of each other.

2. One student holds the raised arm of the student having his blood pressure taken.

3. Find the new systolic reading as well as the height in millimeters that the arm is raised. This measurement is taken from the middle of the blood pressure cuff resting compared with the middle of the cuff in a raised position.

In analyzing this data it is noted that blood, even allowing for its solid component, has a specific gravity that is very close to 1. Mercury has a specific gravity that is 13.6 times that of water (or blood). If we were to divide the difference in cuff height (mm.) by the specific gravity of mercury we should get the height of a corresponding column of mercury. The drop in systolic pressure can be explained by the effect of gravity

pulling blood down and thus reducing the pressure in the brachial artery.

(See Fig. 3) This figure should be very close to the drop that the students experience in the actual results. If the arm is supported, this drop is due to the "pull" of gravity

Fig. 3

Resting:		Arm Raised 20"
135 Systolic	Results of a student holding his arm 20" above the normal resting position.	100 Systolic
72 Diastolic		69 Diastolic

Calculations

A. $(20 \text{ inches}) \dfrac{(25.4 \text{ mm})}{\text{inch}} = 508$ mm. above resting.

B. Equivalent Height of column of mercury

$$\frac{(508 \text{ mm.})}{1} \frac{(1.0 \text{ Sp. G. Blood})}{(13.6 \text{ Sp. G. Hg.})} = 37.4 \text{ mm. Hg.}$$

C. Actual Systolic Pressure drop =

135 mm. Hg. - 100 mm. Hg. = 35 mm. Hg.

D. $\% \text{ Deviation} = \dfrac{(37.4 - 35 \text{ mm. Hg.})}{(37.4 \text{ mm. Hg.})} = 6.4\%$

Further student considerations might be:

1. Knowing the millimeter distance your head is above your heart, can you calculate what the systolic pressure is in the arteries of your brain?

2. Can you explain why the increased gravitational force or “gs” during flight might cause a pilot to pass out?

3. A 16’ giraffe typically has its heart some eight and one-half feet above ground level. If the brain of a giraffe requires a systolic pressure of 120 mm. Hg, what systolic pressure must be produced by the heart to satisfy this demand?

4. The mean pressure, or mean arterial pressure, is the average pressure exerted by the blood against the inner walls of the artery. It is calculated by taking one third of the difference between the systolic and diastolic pressures. This figure is then added to the diastolic number to get the mean pressure. The reason for this calculation is that the heart (at rest) is typically contracting only one-third of the time in the typical pulse cycle so two-thirds of the time it is resting. Students can examine an electrocardiogram (ECG) or take their own ECG using a variety of Universal Laboratory Interfaces (ULI) that are presently available for secondary school use. Resting ECG records show the contracting time period to be approximately 1/3rd. of a single average cycle.

For the laboratory exercise report, all the student results are put on our academic server. This makes their results accessible through a number of machines at the school. In a subsequent class using this server, students open their results using the freeware program NIH Image (see bibliography). This is a program they are familar with from having used it extensively in the analysis of biological images. Using the select tool in NIH Image they copy part or all of an image like that shown in Figure 2. and then open up a word processing document. Students paste in relevant parts of the images as needed to explain results in their laboratory report.

By explaining these problems, students gain experience in using a variety of software and integrating their data in a finished report.

References

Center for Image Processing for Teachers (CIPE)- P.O. Box 13750 Tucson, AZ 85732 General Information and download site for NIH Image - http://iptlpl.arizona.edu

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Pulse Metric - DynaPulse 200 -

Pulse Metric, Inc. 6190 Cornerstone East #103, San Diego, CA 92121 Phone 1-800-927-PULSE http://www.pulsemetric.com/pulsemetric/edu/educat.html

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