Curriculum for the DynaPulse 200M Complete Educational System

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Introduction

The DynaPulse 200M, Education Edition, a microcomputer based lab (MBL), combines curriculum and medical instrumentation with interactive, easy-to-use software to demonstrate the practical applications of computer and medical technologies. Educators have access to a modern educational method to teach cardiovascular function that is designed for students to identify the biological, anatomical, physiological, and physical education applications.

The curriculum begins with simple definitions of blood pressure and hypertension and goes on to describe the techniques for blood pressure determination and the cardiovascular system in more depth. Also included are five labs designed to provide practical hands-on approach to cardiovascular monitoring.

DynaPulse is used in many physicians' offices, hospitals, medical universities, and research facilities across the U.S. and worldwide. Students may explore cardiovascular function in their future work with the same DynaPulse available for the classroom today.

Blood Pressure and Hypertension

One of the most important determinants of cardiovascular function is the blood pressure. The blood pressure is defined as the force or pressure of the blood against the vessel walls of the cardiovascular system. Blood pressure is transient and fluctuates as a result of the pulse cycle. When the heart contracts, pushing blood out of the heart and into the vessels of the cardiovascular system, the blood pressure increases, and the maximum pressure in the vessel is known as the systolic blood pressure (SBP). In contrast, when the heart relaxes in between heart beats (pulses), the pressure in the vessels decreases and the lowest pressure is referred to as the diastolic blood pressure (DBP). Clinically, the systolic and diastolic blood pressures are denoted as the systolic pressure over the diastolic pressure. For example, a systolic pressure of 120 mmHg and diastolic pressure of 80 mmHg, would be referred to as "120 over 80". Although pressure can be recorded in several different units, clinically, blood pressures are measured in millimeters of mercury (mmHg).

The systolic and diastolic pressures are two of several independent values representing the cardiovascular performance of the heart. Clinically, these two values can be combined to form an average blood pressure, called the mean arterial pressure, which reflects the influence of the systolic and diastolic pressure on the cardiovascular system. The mean arterial pressure (MAP) is the time weighted average of the blood pressure during the entire pulse cycle. During a single pulse, approximately one third of the cycle is maintained near the systolic pressure, and two thirds of the cycle is maintained near diastolic pressure. Therefore, estimated:

$$MAP = 1/3\ SBP + 2/3\ DBP$$

The calculation of the main arterial pressure is an excellent way to evaluate the stress on the walls of the vessels. This new parameter may be useful to quickly evaluate excessive load on the cardiovascular system in the future.

Hypertension:

Blood pressure not only fluctuates due to the pulse cycle, but also as a result of external factors. Diet, stress, and physical exertion are only a few of the factors that may influence blood pressure changes. However, in healthy individuals, the blood pressure will return to "normal" when external factors are minimized or negligible. In contrast, when the blood pressure remains high for an extended period of time, an individual may be diagnosed as having high blood pressure/hypertension. Hypertension is a serious disorder that affects approximately 50 million American adults. Hypertension is not necessarily difficult to treat, however, it is hard to detect because it shows no symptoms and therefore is known as the "silent killer." Some people claim that they can feel high blood pressure, but estimates are rather unreliable. Only by performing regular measurements with an accurate method can one assess the blood pressure and cardiovascular health.

In recent years, medical research has revealed a link between hypertension and other cardiovascular diseases. The elevated blood pressure resulting from hypertension, can cause excessive stress on the heart and blood vessels. As a result of the excessive load, the risk of heart attack and stroke increases substantially. In order to help prevent cardiovascular disease, early detection of hypertension is critical. The National Institute of Health (NIH) has developed guidelines (1997) in order to assess blood pressure status. The guidelines have been developed to more clearly define hypertension as a cardiovascular risk factor and provide direction for intervention.

The blood pressure classifications, defined by the NIH, are based on the average of at least two blood pressure measurements for an adult, assuming they are not on anti hypertension medication nor actually ill.

Category	**Systolic (mm Hg)**	**Diastolic (mm Hg)**
Optimal	<120	<80
Normal	<130	<85
High Normal	130-139	85-89
Hypertension:		
stage 1	140-159	90-99
stage 2	160-179	100-109
stage 3	> or equal 180	> or equal to 110

When the systolic and diastolic blood pressures fall into different categories, the higher category should be selected to classify the blood pressure status. For example, 160/92 should be classified as "moderate" and 180/92 should be classified as "very severe." In addition, a classification of Isolated Systolic Hypertension (ISH) may be made when SBP>140 and DBP<90. **Therefore, a blood pressure of 160/82 Should be classified as "ISH".**

Once a blood pressure classification has been established, the following guidelines should be used as a reference for follow-up.

Initial Screening Blood Pressure (mmHg)	**Initial Screening Blood Pressure (mmHg)**	
Systolic	**Diastolic**	**Followup Recommended**
<130	<85	Recheck in 2 years
	85-89	Recheck in 1 year
		Confirm within 2 months
		Evaluate or refer to source of care within 1 month
		Evaluate or refer to source of care immediately, or within 1 week depending on clinical situation.

If the systolic and diastolic blood pressure fall into different categories, follow the recommendations for the shorter follow-up.

By regularly calculating the blood pressure and following the structure guidelines developed by the NIH, one can reduce hypertension and the risk of cardiovascular disease.

Cardiovascular Physiology

Structures of the Heart:

The heart serves as the central pump for the cardiovascular system and is responsible for moving the blood to the tissues of the body. About the size of a person's fist, and composed of four separate chambers, the unique size and structure of the heart (figure 1) is truly remarkable, providing an excellent adaptation of mechanics. The chambers are broken down into the left and right atria, which are small chambers in the upper heart, and the left and right ventricles, the strong powerful chambers in the lower heart. The muscular wall of the heart, or the myocardium, is subdivided into four distinct muscle layers overlapping and wrapping around the heart to produce a wringing motion that is responsible for the pumping action. The myocardium is primarily composed of cardiac muscle fibers that resemble skeletal muscle due to striations or stripes across the fiber. The myocardium is lined with an inner layer of endocardium and covered with an outer layer called the epicardium. The entire package is situated in a fibrous sac, the pericardium, containing a small quantity of pericardial fluid that helps reduce friction between the heart and other organs.

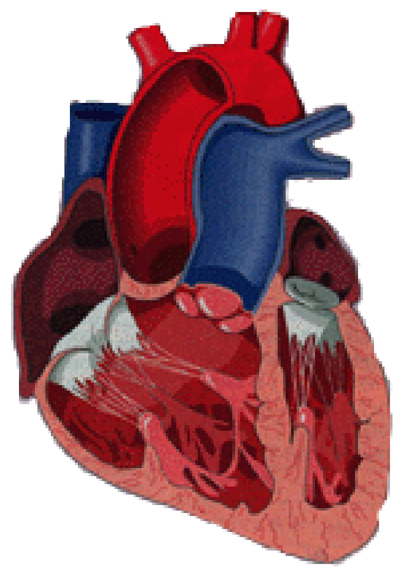

Figure 1

Several other structures of the heart are important in the establishment of the blood flow direction through the heart. The intra-atrial septum divides the left and right atria and the intraventricular septum divide the ventricles, creating a double pump system within the same organ. Thus, it is sometimes convenient to refer to the left and right heart as if they were separate units although both sides of the heart act simultaneously in a heartbeat. The atrioventricular (AV) valves are sheets of connective tissue employed to separate the atria from the ventricles. The right AV valve is made up of three cusps or leaflets called the tricuspid valve. The left AV valve has two leaflets, thus called the bicuspid valve, and also known as the mitral valve. These AV valves allow ventricular filling of blood, while simultaneously preventing the back-flow of blood back into the atria during ventricular contractions. Two other valves (semilunar valves), situated at the beginning of the pulmonary artery and aorta, avert back-flow of the blood to the heart from the pulmonary and systemic circulation.

Electrical Conduction:

The pattern of conduction for contraction of the heart is an electrical coupling event between cardiac muscle cells. Cardiac cells can be divided into three functional classes: myocardial or contractile cells, pacemakers or nodal cells, and conducting cells. The myocardial cells make up about 99% of the heart's mass and are responsible for contraction and force generation. The second class of cells, pacemaker cells, provide the rhythmic electrical signals that will spread across the whole heart, causing a wave of contractions (heartbeats). Pacemaker cells can be found at the sinoatrial (SA) node and the atrioventricular (AV) node of the heart. The SA node has the highest rate of rhythmic discharge and is considered the heart's natural pacemaker.This cluster of pacemaker cells determines the frequency of heartbeats, or heart rate. The signal that initiates in the SA node travels to the AV node where it is delayed. The third class of cells, conducting cells, form a conduction system specialized for conducting a signal rapidly from one part of the heart to another. From the AV node the signal follows a tight network of conducting cells known as the bundle of His. The bundle of His is comprised of one right, and two, left bundle branches that direct the signal to the lower tip (apex) of the heart. These branches curve back up to form a complex network of Purkinje fibers beneath the endocardium of the two ventricles, causing synchronized contraction throughout the heart.

Circulatory System:

The circulatory system is composed of the heart and an intricate system of vessels responsible for delivering blood to the tissues of the body and back to the heart. Three types of vessels complete the task of blood delivery. They are arteries; elastic blood vessels that carry blood away from the heart, capillaries; the smallest vessels in the body and the major site for exchange of materials between blood and tissues, and veins: vessels that carry blood back to the heart.

The circulatory system is arranged as a circuit composed of two major loops. The first loop is known as the systemic circulation. Blood leaves the left ventricle through the aorta and is delivered to the tissues of the body before returning to the right atrium through the vena cava. In the systemic capillaries, the blood gives up some of its oxygen in exchange for carbon dioxide, produced by tissue metabolism. The pulmonary circulation comprises the second loop of the circuit and primarily found on gas exchange. Blood leaves the right ventricle through the pulmonary artery and is delivered to the lungs for gas exchange. The pulmonary vein returns blood to the left atrium from the lungs. In the pulmonary capillaries, the burden of carbon dioxide acquired by the blood in the systemic capillaries is transferred to pulmonary gas, and the oxygen that was unloaded in the systemic loop is replaced.

Another important system is the coronary circulation, which is actually a component of the systemic circulation. The coronary arteries branch from the beginning of the systemic circulation and serve the capillaries of the heart itself. Venous blood is returned to the heart by the coronary sinus. Maintenance of the heart tissue is possible by the coronary circulation.

Blood Components:

Blood consists of three types of cells suspended in a liquid called plasma. The three types are red blood cells (RBC), white blood cells (WBC), and platelets. The red blood cells form the largest percentage of blood cells and are primarily devoted to the transport of nutrients to the body. Red blood cells, also known as erythrocytes, set aside 25% of their cytoplasmic volume for an iron containing protein, hemoglobin, responsible for oxygen transport and update of carbon dioxide wastes from the living tissues. Clinically, the amount of red blood cells is known as the hematocrit. The hematocrit is the percentage of total blood volume composed of red blood cells. Normal hematocrit volume for men varies between 40%-50% and for women ranges between 35% - 45%.

Unlike red blood cells, white blood cells are divided into two groups, the granulocytes whose primary purpose is to engulf and digest bacteria and other foreign materials, and non-granulocytes, which are responsible for specific immune response in the body. The platelets make up the last type of blood cell. Platelets play a critical role in the formation of clots, which reduce blood loss following injury.

Simple Fluid Mechanics

Pipe Mechanics:

To understand blood flow in the cardiovascular system, one must understand simple fluid mechanics. Pressure, flow, and resistance are all fundamental elements of fluid mechanics. The relationship between these parameters clearly defines the behavior of the blood in the heart and vessels of the human body. The fundamental equation of fluid mechanics is a derivative of Ohm's Law. Simply stated:

$$\text{Pressure} = \text{Flow} \times \text{Resistance}$$

Pressure is measured in millimeters of mercury (mmHg), flow is measures in liters per minute (L/min), and resistance is measured in millimeters of mercury per liter per minute (mmHg/L/min).

Artery Mechanics:

In order to understand blood flow at the local level, one must examine a single straight arterial segment. Therefore, the fundamental equation becomes:

Mean Arterial Pressure = Arterial flow x Peripheral Resistance

The local equation considers only the flow of blood through a single arterial segment. The arterial flow is the volume of blood flowing through the segment per minute which is dependent on both the cross sectional area of the arterial segment (a) and the velocity (u).

Arterial flow = cross sectional area (a) x velocity (u)

Therefore, as an example, a large artery with a slow flow velocity or a small artery with rapid flow velocity can maintain the same flow rate.

The peripheral resistance is the resistance of the artery to the flow and it is dependent on both the cross sectional area (a) and the elasticity (ke) of the arterial segment.

Peripheral Resistence = 1/a x 1/kehard

For example, if an artery is hard and thin it will provide great resistance to blood flow.

Cardiovascular Mechanics:

In contrast, in order to evaluate the behavior of the complete cardiovascular system one must examine the heart and all the vessels of the body. Therefore, our fundamental equation becomes:

Mean Arterial Pressure = Cardiac Output x Systemic Vascular Resistance

The cardiovascular system equation takes into account not just a single artery, but the entire vascular system. In this case, the cardiac output reflects the volume of blood exiting the heart and entering the arterial system per minute. The cardiac output is dependent on both the stroke volume (SV), which is the volume of blood ejected per contraction, and the heart rate (HR).

Cardiac Output = Stroke Volume (SV) x Heart Rate (HR)

The systemic vascular resistance is the resistance of the vasculature to the flow. Much like the peripheral resistance, the systemic vascular resistance is dependent on the cross sectional area. However, in this case it is dependent on the total arterial cross sectional (A). In addition, the elasticity of the entire arterial system (KE) must be evaluated.

Systemic Vascular Resistance =1/A x 1/Ke

Height Dependent Pressure Variations:

A fundamental property of pressure is that the pressure is the same for all points at a certain level. For example, the pressure at the surface of a pool is the same for all points. However, as the depth increases the pressure also increases as a result of hydrostatic pressure.

Hydrostatic pressure is defined as the pressure due to a fluid. Therefore, the pressure at depth is defined as:

$$P_{Depth} = P_{Surface} + p \times g \times h$$

In which P_{Depth} is defined as the pressure at a depth (h) below the surface, measured in millimeters of mercury (mmHg), r is the density of the fluid which is defined as mass of the fluid per volume, (Water = 1.0 kilograms/Liter), g is the acceleration due to gravity (m/sec 2), and h is the depth below the surface (meters).

Hydrostatic pressure not only applies to simple physical examples but also to the human body. For example, the cardiovascular system must constantly adjust to changes in pressure due to hydrostatic pressure. As one moves from a sitting to standing position, the vessels of the legs must constrict to counterbalance the additional pressure caused by an increase in height. A similar reflex may occur in the arm as it is raised, however, in this case the vessels relax to adjust to a decrease in height. In the first case, the vessels of the legs constricted due to the increase in hydrostatic load, and in the second case the vessels of the arm dilated due to the decrease in hydrostatic load.

Cardiovascular Parameters

The behavior, health, and status of the cardiovascular system can be described in many ways. One of the most popular techniques is to evaluate certain cardiovascular parameters that may be used as an index to cardiovascular fitness. They are as follows:

Heart Rate (HR): The number of beats (contractions) per minute. [beats/min]
Stroke Volume (SV): The stroke volume is the volume of blood ejected from the heart during heart contraction. [ml]
Cardiac Output (CO): The cardiac output is the volume of blood ejected from the heart per minute.

Cardiac output is calculated as: CO = SV X HR [L/min]

Peripheral Resistance (PR):

The peripheral resistance is the effect of the vessels resisting flow. The peripheral resistance is primarily a function of vessel size and of the number of vessels open. It can be calculated by the following:

PR = MAP/CO [mmHg/(L/min)]

Compliance (C):

The compliance is a relatively new cardiovascular parameter that was developed to assess the elasticity or rigidity of the heart and arteries. The compliance is calculated as:

Change in Volume/Change in Pressure

In order to assess the systemic compliance, which is the compliance of the heart and large arteries, the change in volume of the heart (stroke volume) is divided by the change in pressure within the heart (systolic pressure minus the diastolic pressure):

$$C = SV/(SBP-DBP) \times [ml/mmHg]$$

Blood Pressure Regulations

Homeostasis:

Homeostasis is defined as the condition of constancy of the "internal environment" in terms of its cells, tissues, and organs. Thus in blood pressure regulation, homeostasis will tend to stabilize the blood pressure, maintaining it at a steady resting state. For example, if a person exercises, the heart rate will increase, inducing higher blood pressure. Homeostasis will accommodate the body through various mechanisms to decrease the heart rate and reduce the high blood pressure. Homeostasis is the primary basis by which normal body functions are maintained in order to sustain life.

Negative Feedback System:

One of the most important techniques for maintaining homeostasis is the negative feedback system. The system works to maintain a physiological set-point of the body by sensing changes and returning the body to the original set-point. That means, if a physiological disturbance occurs, the body via a negative feedback system will counteract the disturbance and try to return the body to its normal set-point. There might be more than one negative feedback systems that can counter the changes of a particular disturbance (as is the case of blood pressure regulation). Whenever the condition of constancy is deviated and corrections are not possible, damage to the body and death can result.

Some of the important tools to regulate blood pressure in the body are as follows:

Baroreceptors:

Baroreceptors are pressure sensors which monitor blood pressure. One population of these receptors is located in the walls of the common carotid artery, forming the carotid sinus. Others are scattered throughout the wall of the aortic arch. They are very sensitive to blood pressure leaving the heart and act as the sensor to keep the overall pressure of the heart at a set point. If the blood pressure begins to fall, baroreceptors activation decreases, and the autonomic nervous system acts to increase blood pressure. In contrast, if the blood pressure increases, baroreceptor activation also increases, and the autonomic nervous system must act to decrease the blood pressure.

Vasodilation:

Smooth muscles of most vessels are innervated by the autonomic nervous system. When blood vessels “dilate” or vasodilate through relaxation of the smooth muscles in the wall of the vessels, the radius and compliance of the vessels increase. Not only does the larger opening in the vessels increase blood flow through the vessels, but also the larger compliance gives the vessels the ability to stretch with an increased load, permitting an even greater volume of blood flow through the vessels.

Vasoconstriction:

Similar to vasodilation, vasoconstriction is also controlled by the autonomic nervous system, and causes the smooth muscles in the wall of the blood vessel to “constrict” or vasoconstrict. As a result of vasoconstriction, the vessels stiffen and become less compliant. However, the effects of vasoconstriction in the arteries and veins are quite different. In arterial vasoconstriction (major site of flow resistance in the body), the effect is to redirect blood flow and increase the total peripheral resistance. In the veins, vasoconstriction does not affect total peripheral resistance as greatly as in the arteries, which have lower overall compliance (stiffer). Instead, the primary outcome of vasoconstriction is to decrease the venial wall compliance, which decreases the volume of blood within the veins.

Precapillary Sphincters:

Located at the entrance to the capillary vessels are precapillary sphincters consisting of a single smooth muscle fiber per sphincter. These capillary “gate- keepers” open and close in response to changes in their immediate environment, such as blood pressure. This helps to maintain blood pressure in the venous circulation. Another important function of the precapil lary sphincter is to prevent back flow of blood, driving blood flow in one direction.

History of Blood Pressure Measurement

In 1733, Reverend Stephen Hales published one of the first methods of blood pressure measurement. He developed a technique in which a glass tube could be inserted into the arteries of the neck of a horse. By holding the glass tube in an upright position, the blood would be pumped out of the neck and into the tube by the pumping of the heart. As a result, the level of the blood in the tube could determine the blood pressure. Unfortunately for the horse, since the blood in the tube was not returned to the cardiovascular system, the measurement was irreversible.

The tools for the direct assessment of blood pressure have come a long way since the early 1700’s. Today, direct techniques of blood pressure evaluation called catheterization take place in hospitals around the world daily. Catheterization involves inserting a pressure transducer known as the catheter, into different areas of the cardiovascular system. For instance, in order to understand the pressure changes inside the left ventricle of the heart, the catheter is inserted into the femoral artery of the patient (the groin area), guided up the femoral artery into the aorta, past the aortic valve and into the left ventricle. The results of the catheter pressure are displayed as a waveform on the screen of a computer system. Although discomforting, in most cases the patient experiences no long-term side effects.

Catheterization procedures, however, have several drawbacks. First, the procedures can only be performed in a sterile environment such as a hospital under the supervision of a cardiologist. Second, due to the need for infection control and professional personnel, most catheterization procedures are time consuming and extremely expensive ranging in the thousands of dollars. Finally, as a result of any invasive procedure, the patient is under the risk of complications such as infection, which may lead to very serious consequences. As a result of these weaknesses, great time and effort was taken in the development of new fast and convenient methods of blood pressure measurement. The development of indirect blood pressure measurement techniques has reduced cost, time and risk of complications to the patient making indirect blood pressure assessment the standard technique for regular blood pressure evaluation.

Non-Invasive Blood Pressure Measurement Techniques

During the past 90 years two primary methods of non-invasive blood pressure assessment have been developed. Although they depend on different mediums in order to detect the blood pressure signal, both the auscultatory and oscillometric techniques depend on the use of an air filled cuff to occlude the brachial artery. Cuff measurement principles are based on simple fundamental physics. As illustrated in Figure 2, when the cuff is inflated to a pressure greater than the maximum arterial pressure (systolic pressure), no blood flows through the artery under the cuff. When the cuff slowly deflates to a pressure equal to the systolic pressure, blood begins to flow through the artery (figure 3). As the cuff pressure continues to deflate, the oscillation of blood jetting through the artery begins to flow stronger. When the cuff no longer occludes the artery and the artery has returned to the original state (figure 4), the minimum pressure (diastolic pressure) is observed. Both indirect methods of assessment depend on this simple physical phenomenon.

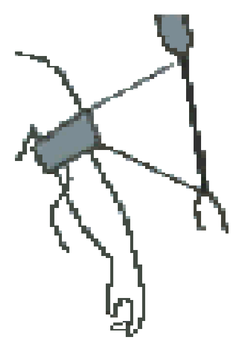

Figure 2

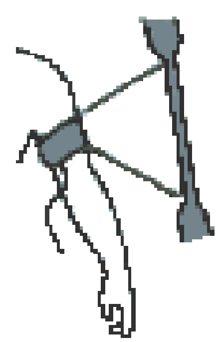

Figure 3

The auscultatory method of blood pressure determination depends on sound to transmit the blood pressure signal. The physical phenomenon due to the cuff occluding the brachial artery is detected by the human ear through a stethoscope. The Korotkoff sound signals, as they are known, correlate to characteristics of the cuff deflation principle.As the pressure decreases from above the systolic pressure due to the deflation of the cuff, the Korotkoff sounds become audible and then fade away as the cuff pressure decreases.

The systolic pressure is the pressure at which the Korotkoff sounds first become audible. The sounds then become muffled as the blood jets through the brachial artery and finally disappear.The pressure at which the sounds become extremely muffled and disappear is the diastolic pressure. Unfortunately, inaccurate blood pressure determination may occur due to hearing problems or noisy backgrounds, in addition to inherent limitations of the human ear. However, an automated auscultatory technique using a microphone may improve inherent limitations of the manual technique providing more accurate blood pressure determinations.

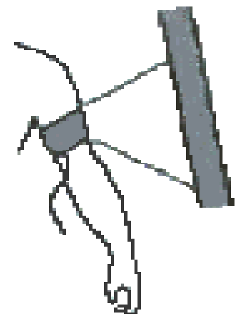

Figure 4

The oscillometric method of blood pressure determination is dependent on pressure changes in the brachial artery as air released from a pressure cuff. The pressure volume coupling between the brachial artery and the cuff is fundamental in the determination of blood pressure. A change in blood pressure within the artery causes a change in volume of the brachial artery due to the elasticity of the vessel. The change in volume of the artery causes a change in volume in the cuff due to the coupling of the cuff to the arm. A sensitive pressure transducer that creates a digital signal detects the corresponding pressure change within the cuff. The signal is displayed as a blood pressure waveform (figure 5) in which blood pressure can be calculated. The waveform is recorded as the cuff pressure deflates from a cuff pressure greater than the systolic pressure to cuff pressure that is less than the diastolic pressure. Although traditional oscillometric methods use the amplitude of the signal to detect the blood pressure, the DynaPulse utilizes pattern recognition. Based on this technique, a new patented algorithm is used to determine the systolic, diastolic, and mean arterial pressure from the non-invasive blood pressure waveform. The single pulse pressure wave (figure 6), which is normalized to the systolic and diastolic pressures, is utilized to examine individual pulse behaviors.

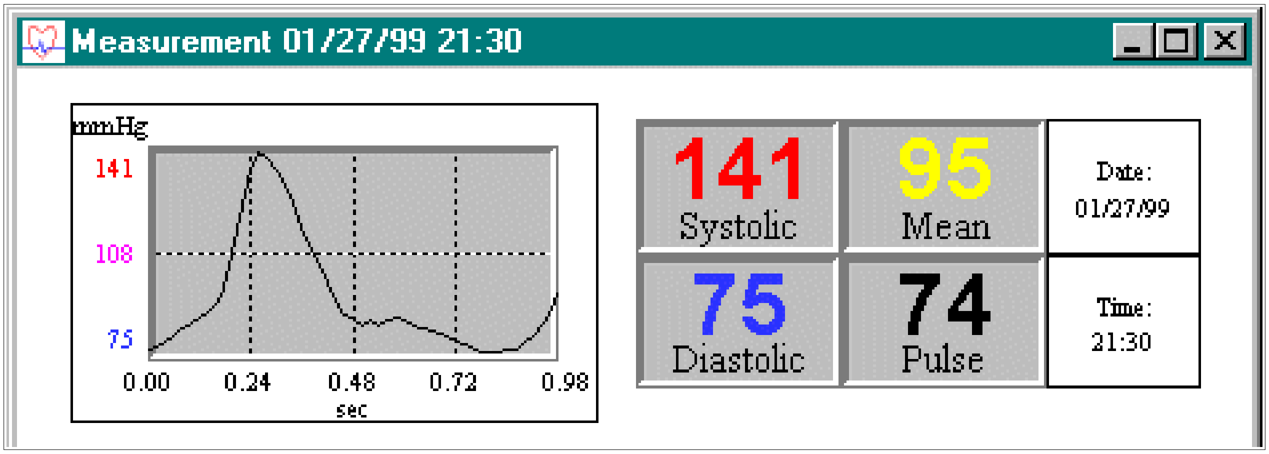

Figure 6: Single pulse waveform

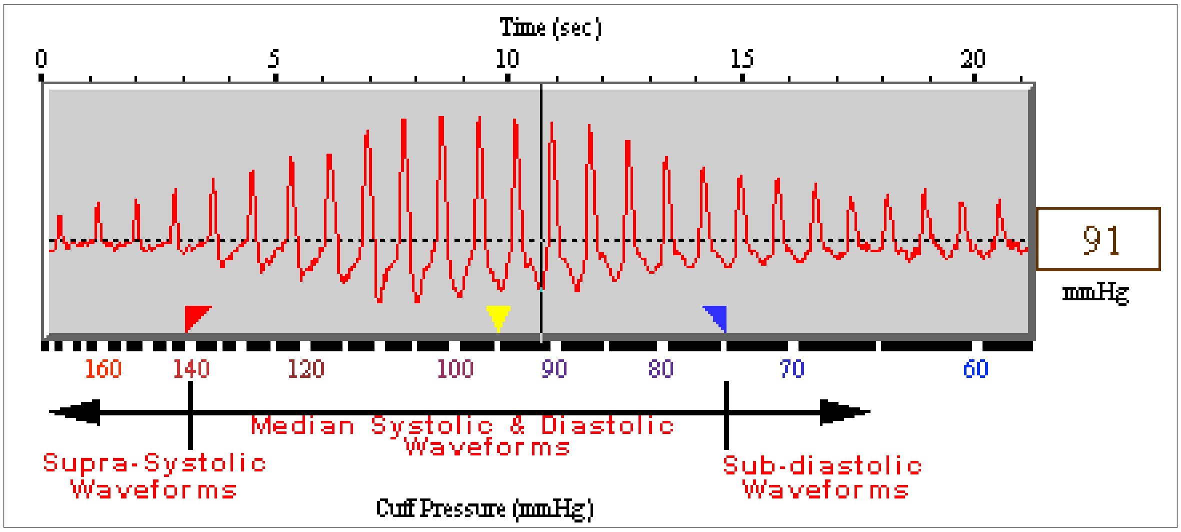

Figure 5: Three sections of DynaPulse pressure waveforms

Pathology

In order to develop a broader understanding of the cardiovascular system, it is important to develop an understanding of cardiovascular complications and some of the risk features that lead to heart disease.

Atherosclerosis:

A disease process that results in the formation of abnormally thickened vascular walls due to plaque. Plaque is characterized by the abnormal proliferation of modified smooth muscle cells and large deposits of cholesterol. When plaque formation develops and narrows the arteries, especially in the heart and the brain, damage can result as a reflection of blood deprivation. Also, plaque is considered to be a foreign surface to the body, and clot formation can occur. Therefore, if a clot develops in the coronary circulation, preventing blood flow to the heart, myocardial infraction may result. On the other hand, a stroke may occur from a blood clot becoming dislodged in the brain. About 50% of all deaths from heart disease in developed nations are the results of atherosclerosis in the arteries of the heart and brain.

Coronary Artery Disease (CAD):

An umbrella term used for various diseases that reduce or halt blood flow in the coronary arteries. In most cases, atherosclerosis of the coronary artery reduces blood flow to the heart over a period of years. Typically, the patient receives a warning - chest discomfort known as Angina. Angina indicates that a portion of the heart muscle is being deprived of oxygen. If untreated, CAD may continue to cause chest discomfort and result in a myocardial infarction or heart failure.

Myocardial Infarction (MI):

A heart attack brought about by an acute damage to the myocardium due to a sudden occlusion of the coronary blood flow (lack of oxygen).

Heart failure:

A decrease in myocardial contractility brought on by disease or damage. Heart failure may be the result of a slow reduction in coronary blood flow over a period of time, leading to progressive damage to the heart muscle, or due to the accumulation of blood in the body, causing excessive load on the heart.

Risk Factors and Prevention:

All of these cardiovascular diseases are a function of many factors. Some of these factors are uncontrollable, however, many factors can be minimized in order to reduce the chance of a cardiovascular problem.

Uncontrollable Factors:

- Age (higher risk for elderly people)
- Sex (higher risk for men than women)
- Family history of heart attacks

Controllable Factors:

- High blood pressure (hypertension)
- High cholesterol level
- Smoking
- Lack of exercise
- Overweight
- Diabetes
- Alcohol
- Salty foods
- Constant work stress
- Personality (aggressive, self-confident, ambitious, persistent, fast-paced, outgoing, and talkative)

By minimizing the impact of controllable factors, one can reduce the risk of cardiovascular complications, and live a longer and higher quality life.

LAB 1: Ausculatory vs. Oscillometric Measurement Techniques

Suggested Time: 30 minutes Purpose:

To compare two methods of indirect blood pressure measurement.

Materials:

- computer
- sphygmomanometer
- stethoscope
- DynaPulse hardware and software package
- paper and pencil

Procedure:

(You should work in groups of 4 or 5)

Part A - Auscultatory Blood Pressure Measurement
1. The study group should be separated into sub-groups of two or three students so that each member can take the blood pressure of another student.
2. Each subject should sit quietly for three minutes before completing a measurement
3. Each student should take turns taking the blood pressure of another student using the sphygmomanometer and stethoscope. (Auscultatory method)
4. The systolic and diastolic blood pressures should be recorded manually.

Part B - Oscillometric Blood Pressure Measurement
1. Each group member should sit quietly for three minutes prior to completing a measure ment.
2. The oscillometric cuff should be placed on the arm of the subject and the computer program activated to take a measurement.
3. In order to ensure an accurate measurement, the subject should relax and minimize all movement including muscle contraction during the deflation of the cuff.
4. Following the measurement, the oscillometric systolic blood pressure (SBP) and diastolic blood pressure (DBP) should be compared to blood pressure values obtained by the auscultatory method in part A.
5. In order to evaluate both methods for the accuracy of their mean arterial pressure (MAP), it is necessary to estimate the MAP attained using the auscultatory method by the following formula:

$$MAP = 1/3\ SBP + 2/3\ DBP$$

Compare the MAP calculations derived by the auscultatory systolic and diastolic pressures with the DynaPulse MAP.

LAB 2: Transient Blood Pressure Changes

Suggested Time: 50 minutes Purpose:

To investigate the physiological changes in blood pressure as a result of arm and body position, noxious stimuli, and mild exercise.

Materials:

- computer
- DynaPulse hardware and software
- container of ice water (0-2 degrees Celsius)

Note: In order to capture changes in blood pressure, the range for blood pressure measurement may need to be changed. During the different parts of the lab the systolic, diastolic, or both may either increase or decrease.

Procedure:

(You will work in groups of 4 or 5)

Part A - Rested Blood Pressure Changes
1. After each member has rested (sitting) quietly for three minutes, measure each group member's blood pressure using the DynaPulse oscillometric system.

Part B - Arm Position Changes - The Gravity Effect
1. Have one subject rest in the seated position for three minutes.
2. Place the measurement cuff on the arm of the subject during the resting stage.
3. Have one member of the group raise the relaxed arm of the subject above the subject's head while another member completes a measurement. For best results make sure to hold the arm directly above the head and ensure that the subject is not contract- ing the muscles of the arm.
4. Compare the subject's base measurement from Part A with the results of Step 3.

Part C - The Cold Reflex
1. Have a different member of the group rest in the seated position for three minutes.
2. Have the measurement cuff placed on the arm of the subject.
3. Place the hand of the subject in a small bucket of ice water for approximately two minutes. (Hand should be submerged to the wrist for the entire time period).
4. After the two-minute period, remove the subject's hand and place arm at their side.
5. Complete another blood pressure measurement as soon as the arm is removed from the

ice water.
6. Compare the results of Part A with Step 5 for the subject.

Part D - Response to Exercise
1. Have a different member of the group jog in place for three minutes.
2. After three minutes, have the subject sit and immediately take a measurement.
3. Following two minutes of recovery, complete another measurement.
4. Compare the baseline measurement in Part A with both Steps 2 and 3.

Part E - Orthostatic Changes in Blood Pressure
1. Have one member of the group lay on a desk in a supine position for three minutes.
2. After three minutes, take the subjects blood pressure using the DynaPulse.
3. Have the subject sit up, swinging their legs off of the table, and take another mea surement. (Remember to minimize movement during the measurement) 4. Compare the results from Step 1 and 2 on your sheet.

LAB 3: Ergometer Training

Suggested time: 35 Minutes Purpose:

To investigate the physiological changes in the cardiovascular system as a result of exercis

Materials:

- cycle ergometer
- computer
- DynaPulse system hardware and software

Procedure:

During an eighteen-minute exercise study we will monitor several parameters of cardiovascular function in order to achieve a better understanding of the behavior of the body under physical stress. The subject will be required to maintain a pedal rate of 80 rpm while the workload is incrementally increased according to the schedule below. In order to achieve an accurate blood pressure and heart rate reading it is essential that the subject discontinue all exercise and remain still during each measurement stage. The DynaPulse is a clinical grade oscillometric blood pressure monitor, and therefore any movement such as minimal muscle contraction or repositioning of the arm will cause the pressure signal to be distorted and skew the measurement. The arm should be held completely still at the height of the heart by a bystander and the subject should completely relax the arm. Following the measurement the subject will continue the protocol as outlined below.

Study Timetable:

TIME	RPM	FORCE
0-3 min	80	300
3-4 min	MEASURE	MEASURE
4-7 min	80	600
7-8 min	MEASURE	MEASURE
8-11 min	80	900
11-12 min	MEASURE	MEASURE
12-15 min	80	1200
15-16 min	MEASURE	MEASURE
16-17 min	RECOVERY	RECOVERY
17-18 min	MEASURE	MEASURE

During testing the following parameters should be received in the table below:

Systolic Blood Pressure (SBP): The maximum pressure in the system
Diastolic Blood Pressure (DBP): The minimum pressure in the system
Mean Arterial Pressure (MAP): Time weighted average of the SBP and DBP
Heart Rate (HR): The number of heart beats per minute
Perceived Exertion (PE): The subject's perceived work on a scale 1-10

Data Table:

STAGE	RPM	FORCE	PE	SBP	MAP	DBP	HR
1	80	300					
2	80	300					
3	80	300					
4	80	300					
5	**RECOVERY**	**RECOVERY**					

- Following testing, the data can be transferred from the chart to a graph.
- SBP, DBP, MAP, HR, PE and work should be plotted versus time.

LAB 4: Research Experiment

Suggested Time: 50 Minutes Purpose:

To study a physical phenomenon such as the influence of gender or age on the blood pressure in order to understand data acquisition, analysis, and presentation.

Materials:

- computer
- DynaPulse hardware and software

Background:

Currently a great deal of medical research is focusing on factors that may effect the blood pressure. Genetics, disease, and aging process are only a few of the factors that may influence blood pressure changes. Therefore, it is critical that we develop a method to systematically evaluate observations.

Procedure:

Part A - Control Group Determination
1. In order to properly evaluate a phenomenon it is necessary to define a control group. Determining control groups may be based on personal interpretation. In most cases, the natural or common state is defined as the "control". When studying the influence of age on blood pressure, a young group would be selected as the control group due to the fact that a higher percentage of young individuals have normal blood pressures. However, in studying the influence of gender on blood pressure, males or females may be arbitrarily selected as the control group.

Part B - Data Acquisition
1. In order to study the influence of gender on blood pressure, separate the study group into males and females. In order to study the effects of age, separate the study group into a young and old group. It should be noted that the larger the study groups the more statistically significant the results.
2. Designate a new group on the Student/Group directory and have each student of the female/male or young/old group complete a seated and rested blood
3. Designate a new group on the Student/Group directory and repeat step 2 for the other group. Once again, make sure to save all measurements.

Part C - Data Analysis and Presentation
1. In order to statistically analyze and graphically display the results for each group, use the Edit feature to “mask” any bad measurements that may be the result of measurement artifact and should not affect the study results.
2. The minimum, maximum, mean, and standard deviation for the systolic, diastolic, mean arterial pressure, and heart rate can be calculated using the Analysis feature. The normal distribution curves will be plotted for each parameter as well.
3. The final results for each group should be presented as the mean +/- the standard deviation for each parameter. For example the systolic blood pressure may be presented as “127 +/- 4 mmHg”.

LAB 5: MEAN ARTERIAL PRESSURE DETERMINATION

Suggested Time: 30 minutes Purpose:

To compare the DynaPulse mean arterial pressure measurement with a simple approximation of the mean arterial pressure based on the systolic and diastolic pressures.

Materials:

- computer
- DynaPulse hardware and software

Background:

The DynaPulse system is a clinical-grade blood pressure device that actually measures the mean arterial pressure extremely accurately. Traditional auscultatory blood pressure devices do not measure the mean arterial pressure and therefore must approximate the value. A simple formula was developed in which:

$$MAP = 1/3\ SBP + 2/3\ DBP$$

However, the formula above is only an approximation.

Procedure:

1. Select a group of individuals in which to compare the mean arterial pressure measurement with the simple approximation.
2. Each member should complete a seated and rested blood pressure measurement with the DynaPulse system. Make sure to save each measurement.
3. Complete the table below to compare the two techniques.

STAGE	SBP	DBP	MAP_{APPROX}	$MAP_{MEASURED}$	DIFFERENCE	%DIFFERENCE

DIFFERENCE = $\mathbf{MAP_{MEASURED} - MAP_{APPROX}}$

%DIFFERENCE = $\mathbf{MAP_{MEASURED} - MAP_{APPROX} / MAP_{MEASURED}}$

4. After completing the table, calculate the average value for each column by dividing the total by the number of subjects.

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