Vital Signals Lab
Experiment 2 (Blood Pressure)

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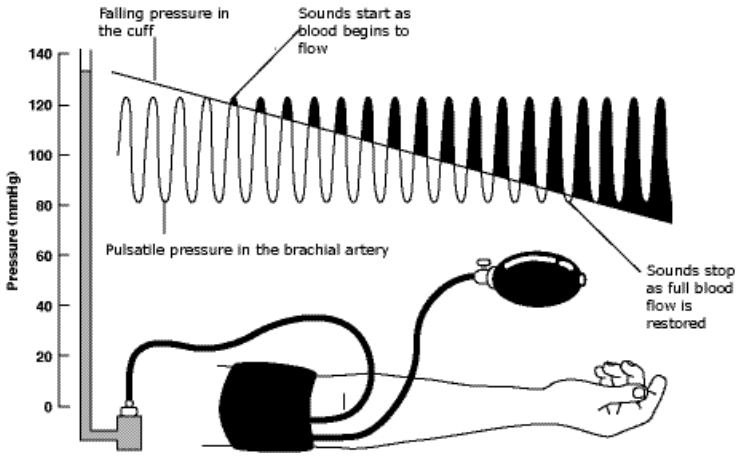
This file contains the report and results of the simulations conducted.

Abstract

In this experiment, we are focusing on blood pressure and its correlation with received signals.

The pressure in the arteries varies during the cardiac cycle. The ventricles contract to push blood into the arterial system and then relax to fill with blood before pumping once more. This intermittent ejection of blood into the arteries is balanced by a constant loss of blood from the arterial system through the capillaries. When the heart pushes blood into the arteries there is a sudden increase in pressure, which slowly declines until the heart contracts again. Blood pressure is at its highest immediately after the ventricle contracts (systolic pressure) and at its lowest immediately prior to the pumping of blood into the arteries (diastolic pressure).

Systolic and diastolic pressures can be measured by inserting a small catheter into an artery and attaching the catheter to a pressure gauge. Such a direct measurement might be accurate, but is invasive and often inconvenient and impractical. Simpler estimates of blood pressure can be made with acceptable accuracy using noninvasive, indirect methods.



Auscultation of blood pressure

In this section, we aim to measure systolic and diastolic blood pressure using a cuff, stethoscope, and sphygmomanometer. By listening to the sounds, we can determine blood pressure. The first sound, as the cuff pressure decreases, indicates the systolic pressure, while the second sound signifies the diastolic pressure.

The results are as follows:

NAME	SYSTOLIC PRESSURE	DIASTOLIC PRESSURE
SUBJECT1	135	87
SUBJECT2	120	80
SUBJECT3	130	85
AVERAGE	128.3	84

Table 1 (Estimates of blood pressure using auscultation (mmHg))

Additionally, one of our subjects had been running before the test, and their initial test blood pressure was:

SYSTOLIC PRESSURE	DIASTOLIC PRESSURE
165	105

Table 2 (Estimates of blood pressure using auscultation in unnormal condition (mmHg))

Measuring systolic pressure (from upper arm)

In this section, as the cuff pressure decreases by 10 mmHg, we record the signal from the fingertip, middle finger, and big toe, with the cuff applied to the upper arm, forearm, and leg (in a seated position). The results can be seen in Table 6 and Table7.

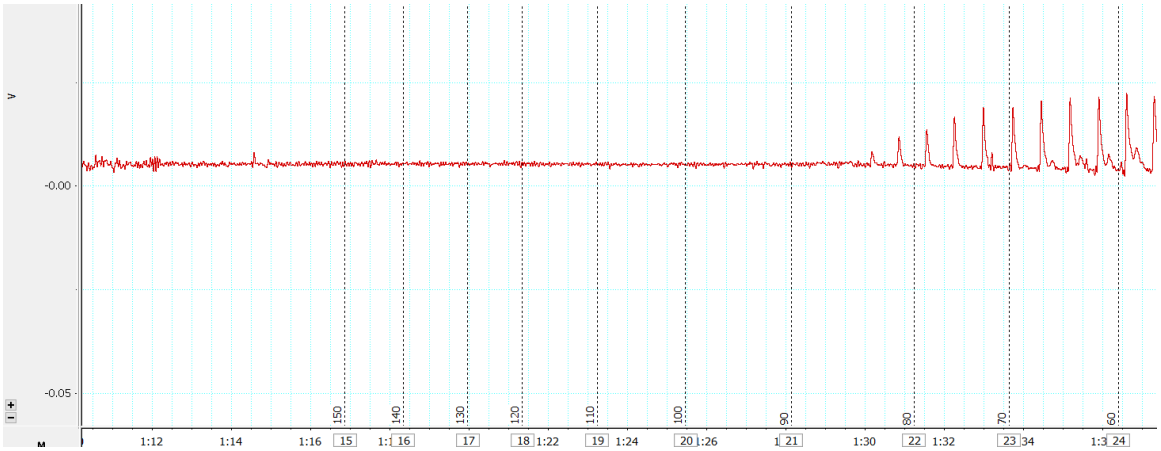


Figure 1 (subject1 measurement from upper arm)

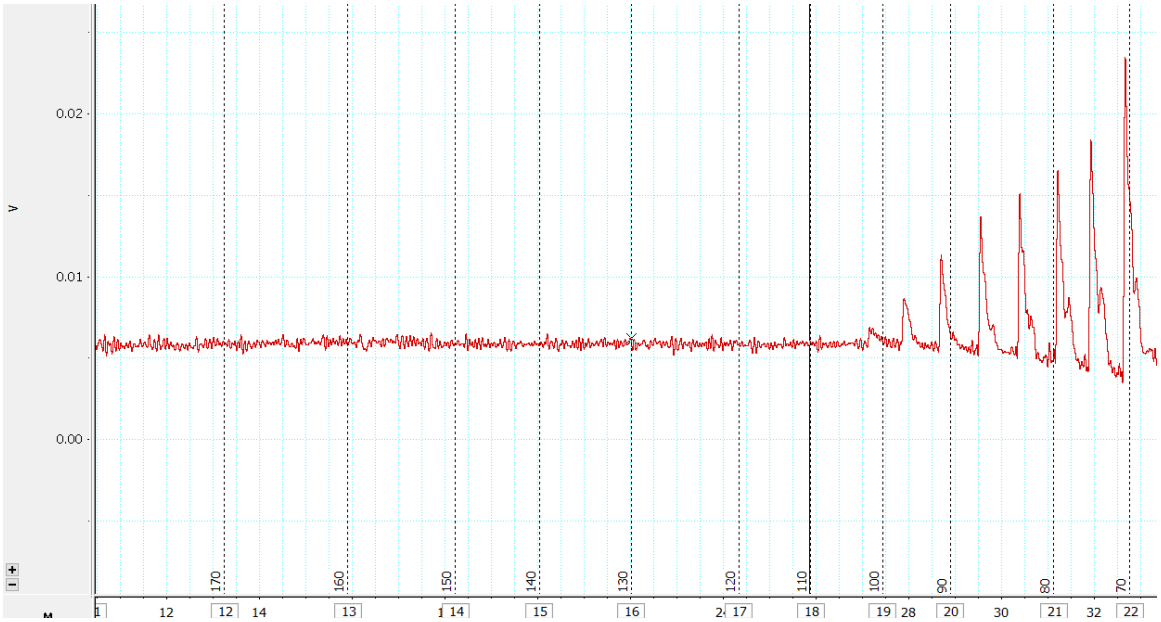


Figure 2 (subject2 measurement from upper arm)

As usual, we place the cuff on the upper arm because this area is aligned with the heart and provides a more accurate reading. The result is as follows:

SUBJECT1	90
SUBJECT2	110

Table 3 (Measuring systolic pressure from upper arm (mmHg))

Measuring systolic pressure (from forearm)

We know that if we move downward from the heart, the pressure increases. So, if we use the forearm for measuring blood pressure, naturally, we will get a higher pressure than in the upper arm.

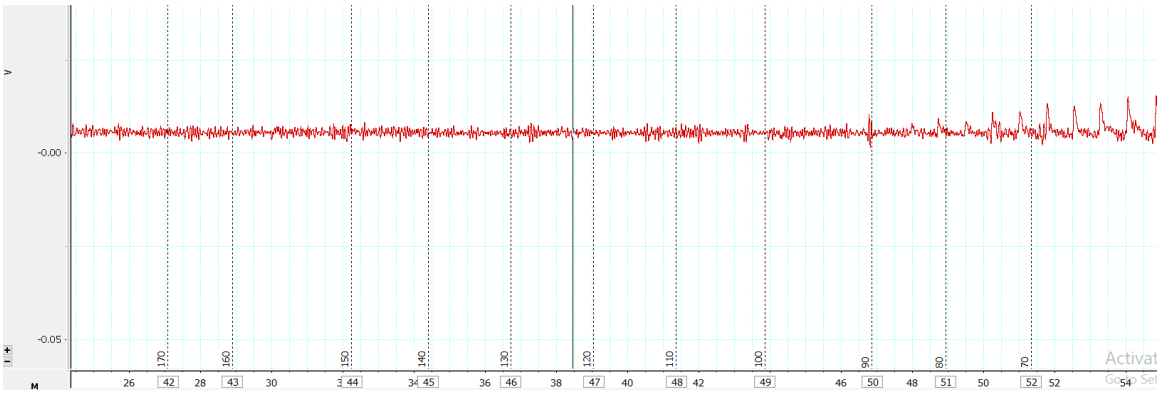


Figure 3 (subject1 measurement from forearm)

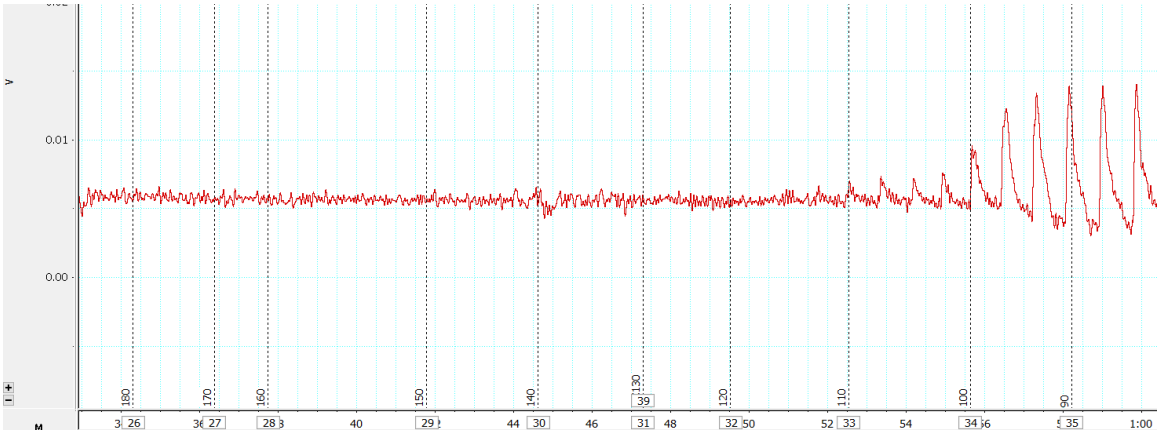


Figure 4 (subject2 measurement from forearm)

SUBJECT1	100
SUBJECT2	120

Table 4(Measuring systolic pressure from forearm(mmHg))

Measuring systolic pressure (from leg)

The same point applies to the blood pressure measured at the ankle, where the pressure should also be higher.

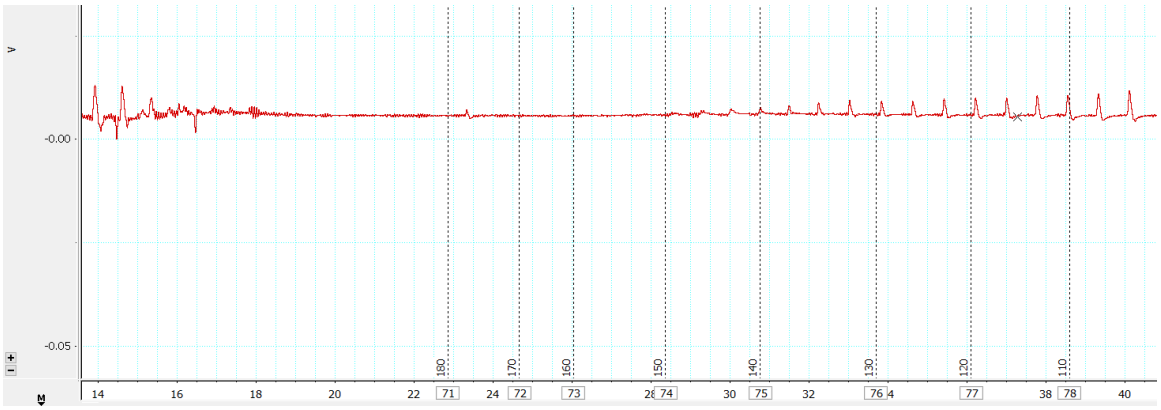


Figure 5 (subject1 measurement from leg)

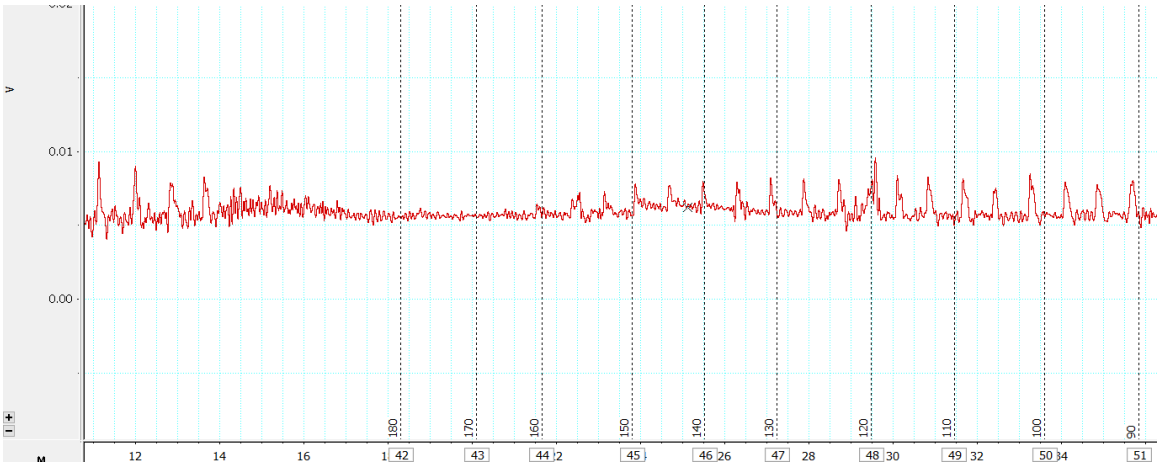


Figure 6 (subject2 measurement from leg)

SUBJECT1	145
SUBJECT2	150

Table 5 (Measuring systolic pressure from leg (mmHg))

The last result is:

MEASUREMENT LOCATION	SYSTOLIC PRESSURE
UPPER ARM	90
FOREARM	100
LEG	145

Table 6 (subject1 result)

MEASUREMENT LOCATION	SYSTOLIC PRESSURE
UPPER ARM	110
FOREARM	120
LEG	150

Table 7 (subject2 result)

Result

MEASUREMENT LOCATION	SYSTOLIC PRESSURE	DIASTOLIC PRESSURE
RESTING MEASUREMENT FROM UPPER ARM	135	87
UPPER ARM (PULSE MEASUREMENT)	90	75
FOREARM (PULSE MEASUREMENT)	100	80
LEG (SITTING)	145	115

Table 8 (subject1 blood pressure result)

MEASUREMENT LOCATION	SYSTOLIC PRESSURE	DIASTOLIC PRESSURE
RESTING MEASUREMENT FROM UPPER ARM	120	80
UPPER ARM (PULSE MEASUREMENT)	110	75
FOREARM (PULSE MEASUREMENT)	120	98
LEG (SITTING)	150	130

Table 9 (subject1 blood pressure result)

There are some differences between pulse measurement and resting measurement. This error may occur due to mistakes in measurement with a stethoscope and sphygmomanometer, or because there is a distance between the cuff placement and the signal detection site, which requires time for the signal to be received. Additionally, data recording delay and labeling can also be causes of error.

Conclusions

1. What are some possible sources of error or variation in this technique of blood pressure measurement?

Doctor's auditory error: For example, if the doctor cannot correctly hear or distinguish the sounds.

Cuff placement: The cuff is not positioned correctly.

Cuff size: The cuff's circumference and length, which we place on the upper arm, must meet specific standards.

Body movement: Body movement can cause additional noise.

Accuracy of measuring instruments: The measuring device (cuff or sphygmomanometer) may lack sufficient accuracy.

2. Explain the events occurring in the heart during:

a. systole

b. diastole

a. systole is the contraction phase of cardiac cycle and it involves two main events which are atrial and ventricular systole

b. Diastole is the relaxation phase of the cardiac cycle and can also be divided into distinct events: isovolumetric relaxation, rapid filling and atrial filling.

3. How does your estimate of systolic pressure in the upper arm compare with your results from part 1 of this lab?

They were very similar but a small difference between these measurements can come from the errors mentioned or the distance between upper arm and fingertip that need a little time to reach the pressure.

4. Does systolic pressure differ between the forearm and upper arm?

Yes, Blood pressure varies in the body due to differences in height. According to the hydrostatic pressure formula:

$$P = \rho g h$$

h is height difference from a reference point (heart). So we can see different result for the measurement.

5. How does your estimate of systolic pressure in the leg compare with that from the upper arm?

As mentioned earlier, blood pressure is influenced by height. The legs are further from the heart compared to the upper arm, leading to differences in hydrostatic pressure. Blood pressure measured in the legs tends to be higher than in the upper arm when standing or sitting due to the gravitational effect on blood columns.

6. What happened to blood pressure in the leg when you were standing up?

In a standing position, hydrostatic pressure increases as the heart is higher than the legs, often resulting in higher blood pressure readings due to gravitational effects. Conversely, when sitting, the hydrostatic pressure difference is reduced, leading to potentially lower blood pressure readings. Additionally, venous return is generally more efficient in the sitting position, stabilizing blood pressure, while standing may cause temporary pooling of blood in the legs.