International Institute of Information Technology
Bangalore

Digital Signal Processing
EC 303P

Analysis of Breath rate and Heart rate using ECG Signals

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Components Used:-

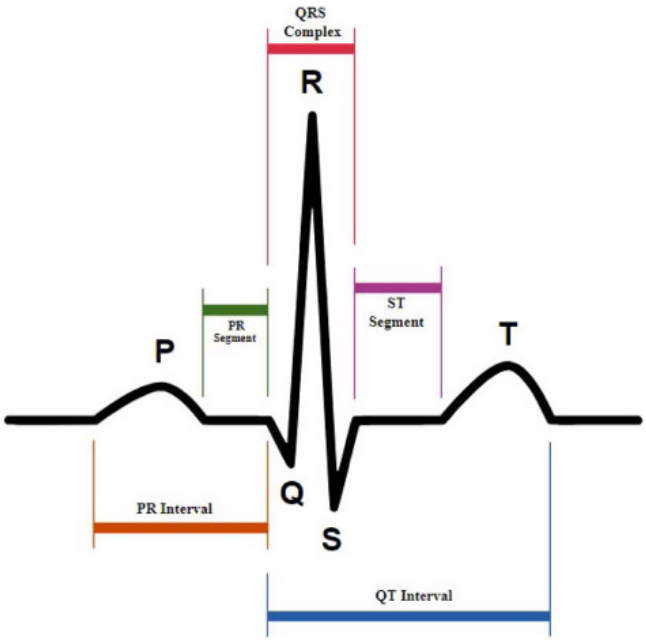
1) Arduino UNO Board
2) AD8232 ECG Sensor
3) Connecting Wires
4) Bread board

Working of Sensor Used:-

The AD8232 module breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heartbeat.

Theory(about ECG):-

The signal obtained from the ECG comprises various PQRST sequences. Here, the PQRST sequence basically represents the conduction of the atria of the heart and the speed at which they are able to conduct an electrical impulse.
So a single round of this cycle can be broken down into 3 waves, i.e. the P wave, the QRS wave, and the T wave.
The initiation of a heartbeat from the generation of an electrical signal at the heart's pacemaker to the AV node comprises the P-wave. The electrical signal travels from the SA node to the AV node (which basically are a bunch of cells) causing the contraction of the atria. The blood then flows from the atria to the ventricles of the heart.
The electrical impulse now passes from the AV node to the Purkinje Fibers while passing through the Bundle of His. This segment gives rise to the QRS wave in the ECG. The Purkinje fibers are a group of specialized cells, that distribute this impulse throughout the ventricles. This causes the ventricles to contract and finally pump the blood out of the heart.
The T wave represents the heart's electrical activity returning to baseline—ventricular repolarization. In the previous state, the ventricles go through depolarization, which causes them to contract. So now the muscles of the heart go through this phase of repolarization or resting state so as to come back to a normal uncontracted state.



Relation between Heart Rate and Breath Rate:

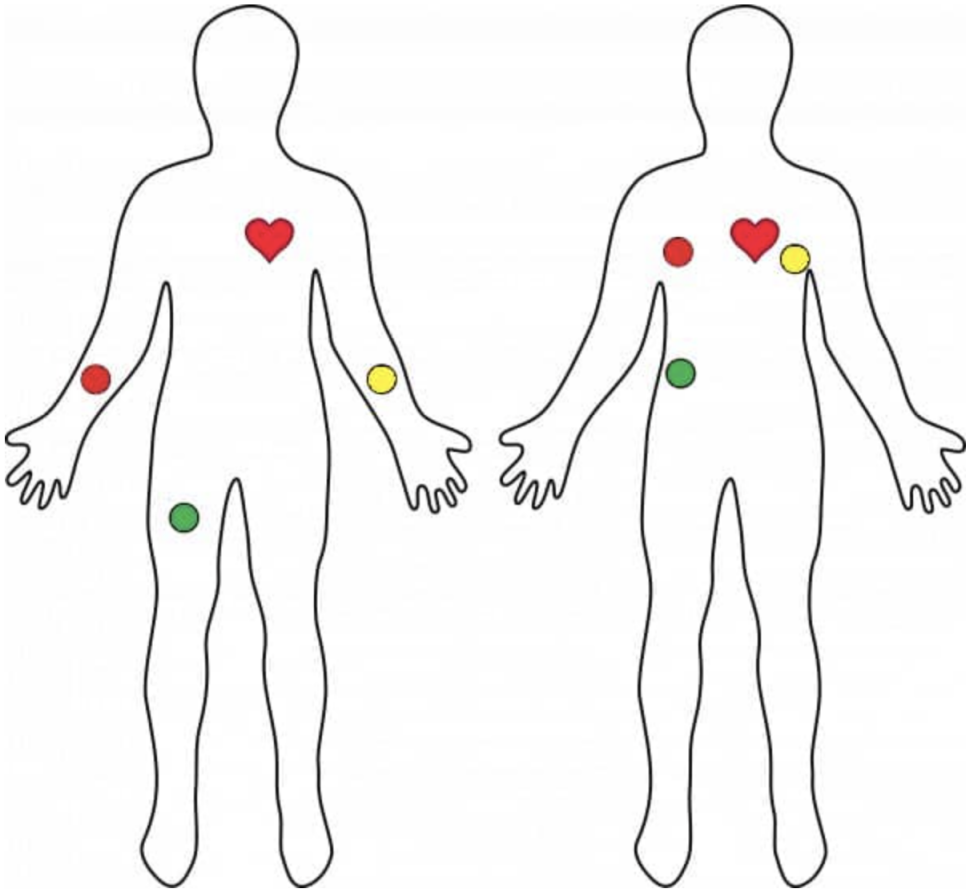
The more the heart beats, the more breathing occurs. As the heart beats faster, it uses more energy and sends more oxygen to the body. If a person is exercising the oxygen is used very quickly in order to provide the muscles with needed energy to move. Thus the heart beats faster to pump more oxygen to the muscles. In order to meet the increased demand for oxygen, the brain signals the lungs and diaphragm to inhale and exhale with a greater frequency, thus obtaining more and more oxygen. The oxygen is exchanged for carbon dioxide in the lungs, and is then quickly sent to the heart in order to be pumped to the body.

Arduino Connections:-

Board Label	Pin Function	Arduino Connection
GND	Ground	**GND**
3.3v	3.3v Power Supply	**3.3v**
OUTPUT	Output Signal	**A0**
LO-	Leads-off Detect -	**11**
LO+	Leads-off Detect +	**10**
SDN	Shutdown	**Not used**

Placement of the ECG Electrodes on the Body:-

Before applying the sensor pads to the body, it is advisable to snap them onto the leads. For better measurement accuracy, it is recommended placing the pads as near to the heart as possible.
The cables are color-coded to facilitate correct placement identification.
Red: right-hand side of the heart
Yellow: the left-hand side of the heart
green: Right leg side



Arduino Code:

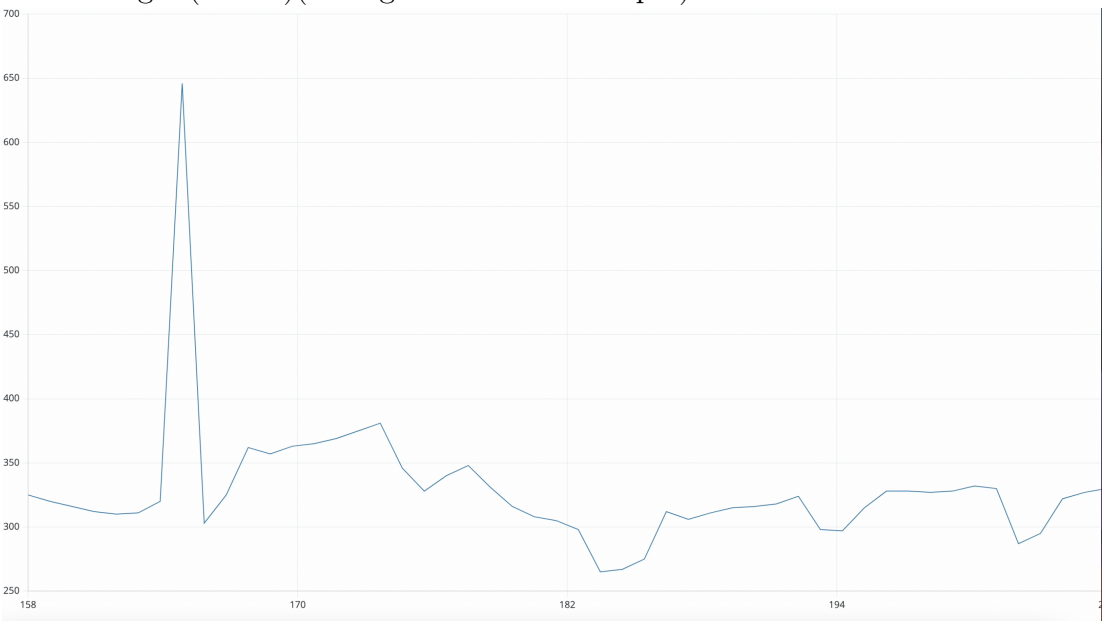
```
void setup() {
Serial.begin(9600);
pinMode(10, INPUT);
pinMode(11, INPUT);
}
void loop() {
if((digitalRead(10) == 1)||(digitalRead(11) == 1)){
Serial.println('!');
}
else{
Serial.println(analogRead(A0));
}
delay(1);
}
```

DataSet:

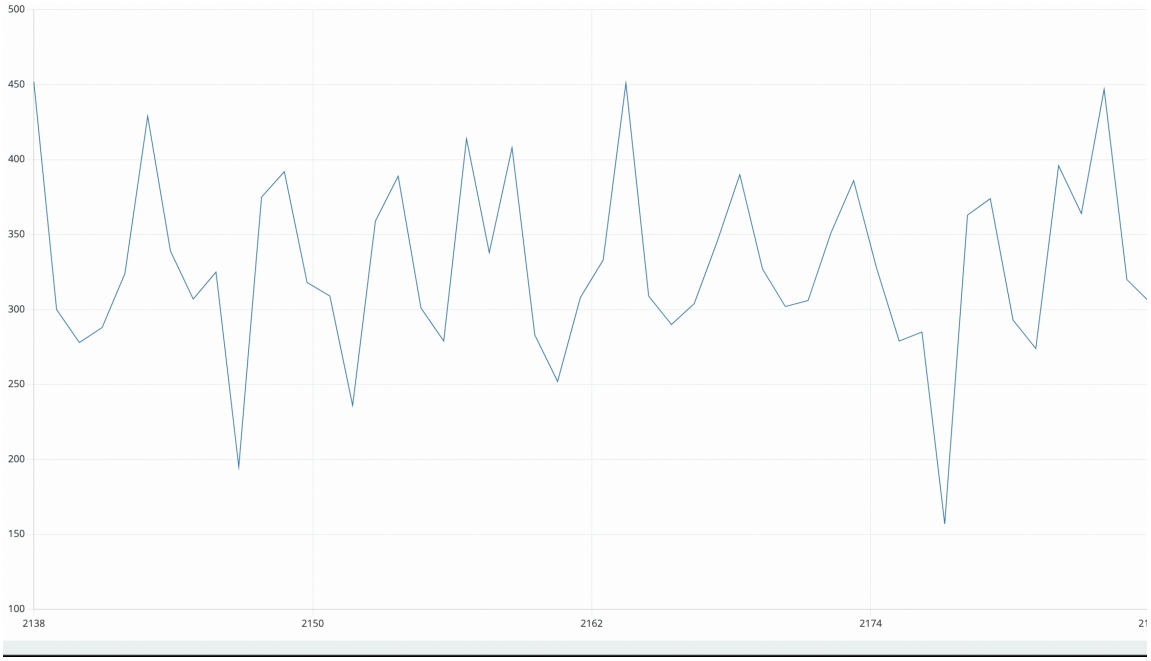
We had taken ECG signals for four different people before and after exercise:
The ECG signals were first measured when the person was in resting phase(Rest ECG) after

which the person was made to exercise for a couple of minutes in order to increase the breath rate, after which the ECG was taken once again.(Stress ECG). We measure heart rate from the RR interval. The R wave is the most prominent wave on the ECG and represents the depolarization of the ventricles of the heart.The time interval between two consecutive R waves to get the RR interval. Divide 60 seconds (the number of seconds in a minute) by the RR interval (in seconds) to get the heart rate in beats per minute (BPM).Here, in every reading we took average of the heart rate obtained from first 5 RR intervals.

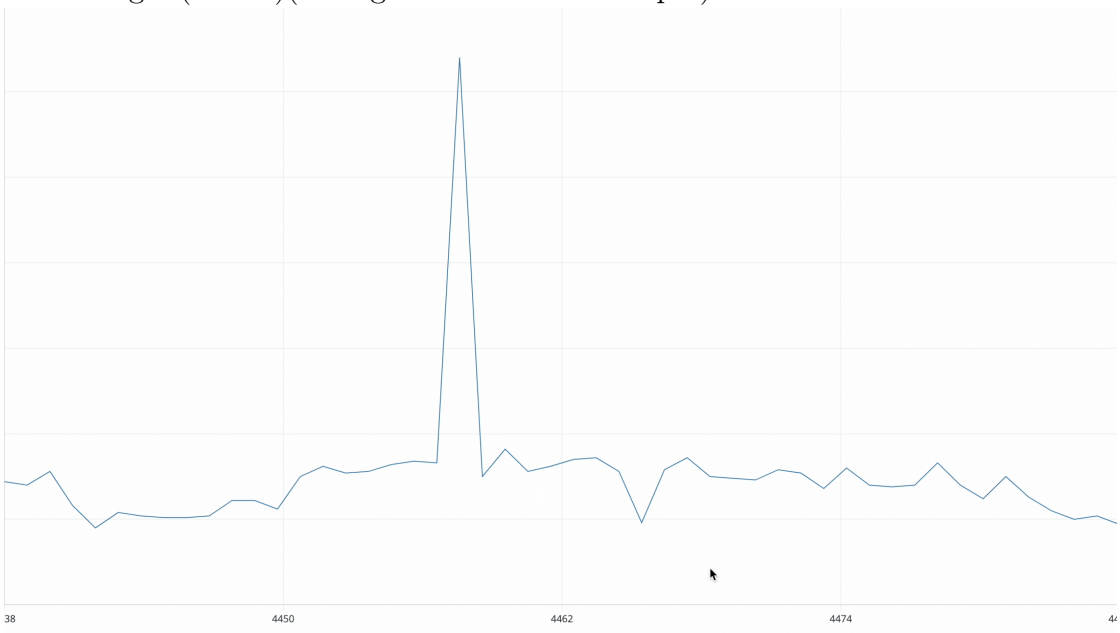
Reading 1:(before)(average heart rate:95.6bpm)



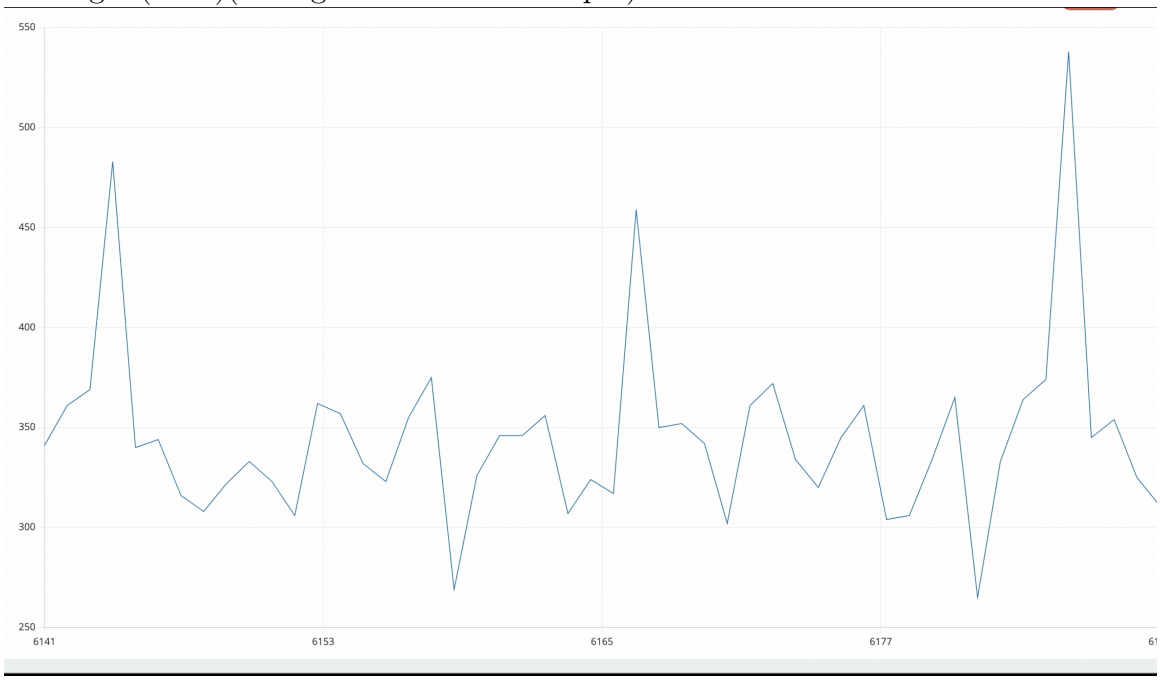
reading 1:(after)(average heart rate:134.7bpm)



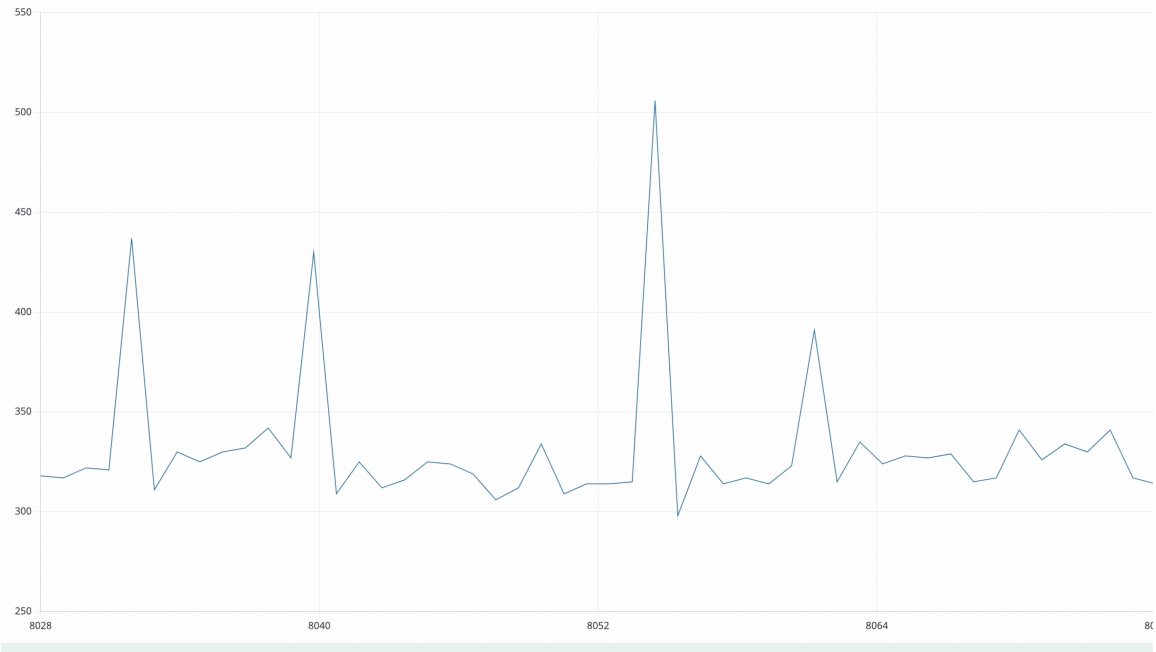
reading 2:(before)(average heart rate: 100.2bpm)



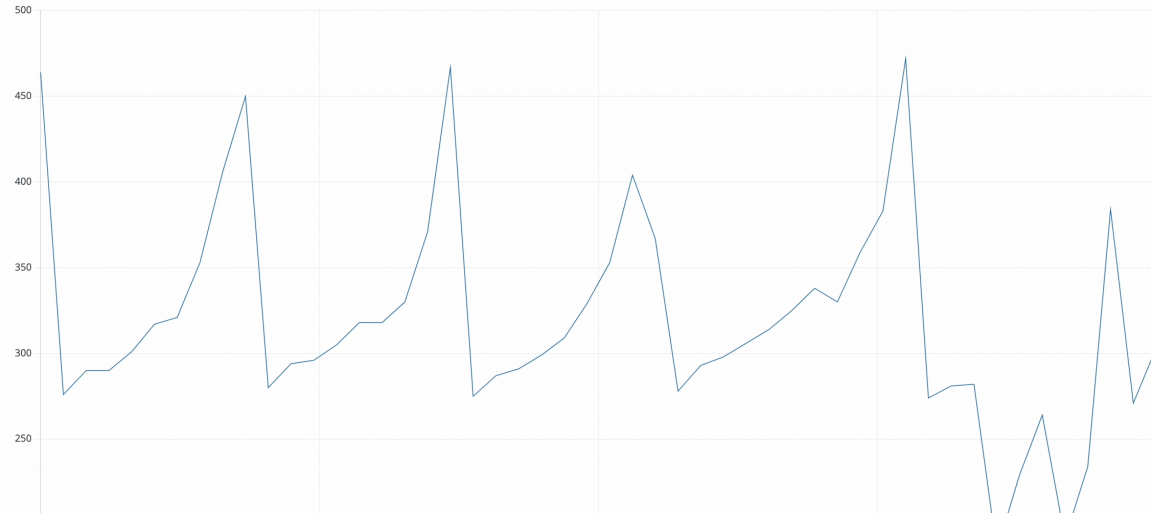
reading 2:(after)(average heart rate:120.4bpm)



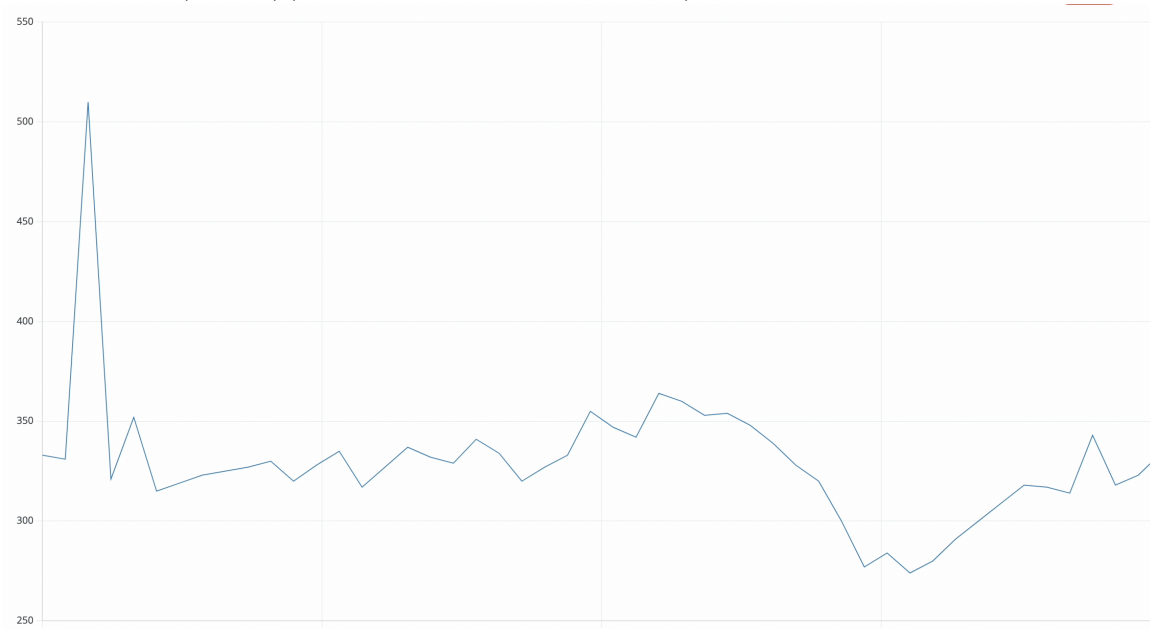
reading 3:(before)(average heart rate:96.77bpm)



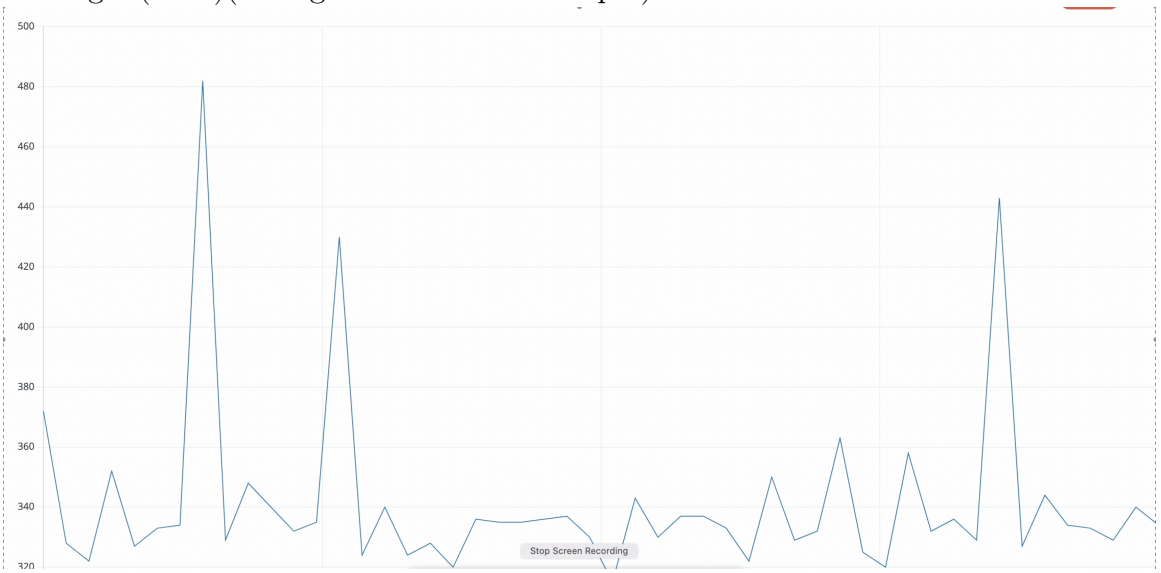
reading 3:(after)(average heart rate:138.67bpm)



reading 4:(before)(average heart rate:93.75bpm)



reading 4:(after)(average heart rate:171.23bpm)



Observations:

Here through the ECG signals obtained for four different people we can observe that with the heart rate increases with the increase in breath rate as after exercise the oxygen requirement increases and to catch up with the extra oxygen requirement the heart beats faster thus increasing the heart rate.

Sources of error:-

1)Poor electrode placement:
The placement of the ECG electrodes is critical to obtaining an accurate ECG recording. If the electrodes are not placed correctly or if there is poor skin contact, it can result in incorrect ECG readings.

2)Misinterpretation of waveforms:
Misinterpretation of waveforms, such as mistaking a U wave for a P wave or T wave, can result in incorrect ECG interpretation.

3)Poor quality ECG recording:
Poor quality ECG recording,such as low signal amplitude, baseline wander, and movement artifact, can result in inaccurate ECG readings. Noise from the signal can be removed by using EMD(Emperical mode demcomposition)

References:

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