

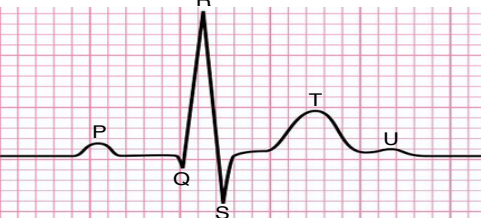
# Understanding the Effect of Exercise on ECG Signals

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## Electrocardiogram

The electrocardiogram (ECG) is a simple and fast test to evaluate the condition of the heart. Natural electrical impulses trigger the heart to beat, thus regulating blood flow throughout the body. Changes in an ECG can be an indicator of many heart-related conditions.

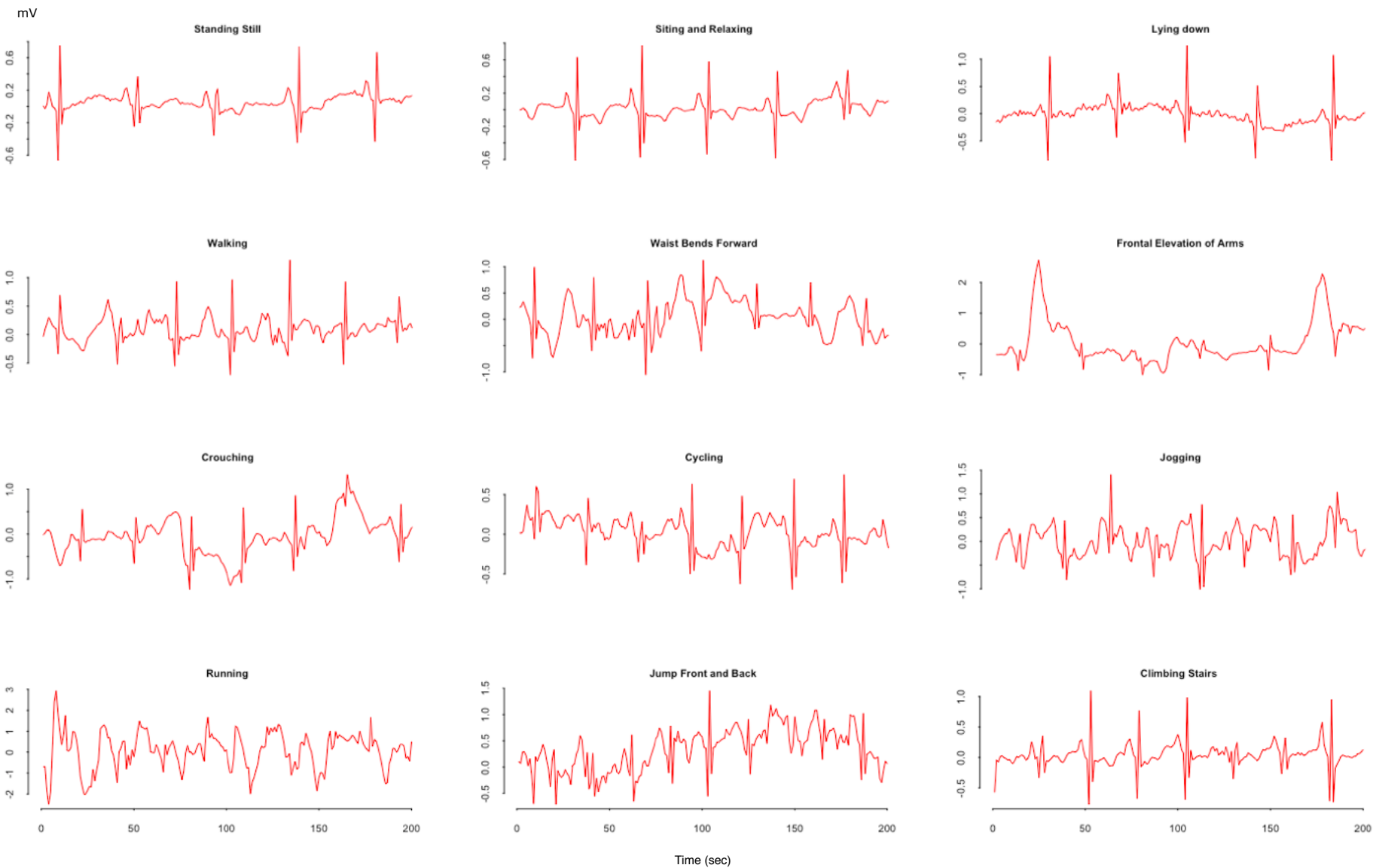
## ECG Waveforms



A normal ECG is illustrated above. It should consist of elements below:

1. P wave: It is associated with right and left atrial depolarization. Normal duration of P wave is  $\leq 0.12$  seconds(s). Its amplitude should be  $\leq 2.5$  mV.
2. QRS complex: The 3 deflections reflect the current associated with right and left ventricular depolarization.
  - a. Q wave: Duration is  $\leq 0.04$  seconds; amplitude is  $\leq 1/3$  of that of the R wave in the same lead.
  - b. R wave: R wave is the first upward deflection after P wave. It represents the electrical stimulus that pass through the main portion of the ventricular walls that pump blood to all of the body, so it has the biggest voltage.
  - c. S wave: It may not be present in all ECG leads in a given individual.
3. T wave: It represents the current of rapid phase 3 ventricular repolarization. Isolated T wave inversion in an asymptomatic adult is generally a normal variant.
4. U wave: U waves generally become visible when the heart rate falls below 65 bpm. It normally goes in the same direction as the T wave. Its maximum amplitude is 1-2 mV.

## ECG Readings of One of the Subjects from MHEALTH Dataset

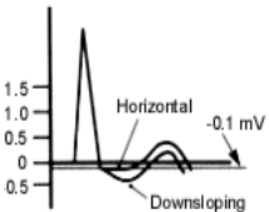


## Exercise ECG

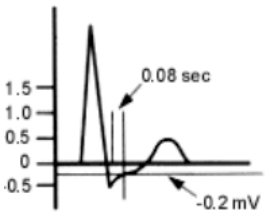
The exercise ECG measures how well the heart responds to stress or exercise. The exercise ECG can detect any mismatch between myocardial oxygen supply and demand, thus leading to the discovery of myocardial ischemia (MI).

## MI Indicators

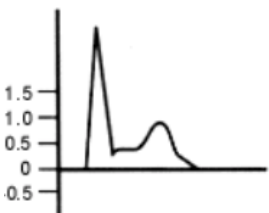
1. Horizontal downsloping of ST-segment depression  $\geq 0.1$  mV



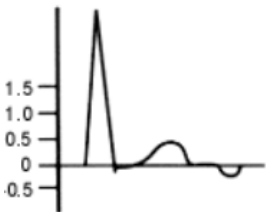
2. Upsloping of ST-segment depression  $\geq 0.2$  mV, 0.08 seconds from the J point



3. Elevation of ST-segment  $\geq 0.1$  mV



4. Inversion of U wave



## Analysis of ECG Data above

1. Exercise-induced ECG changes such as shortening of QT and PR intervals and peaking of T and P waves are insignificant indicators of myopathy.
2. At rest (standing still, sitting and relaxing, lying down), this subject seems to have a deep Q wave. Q waves represent the normal left-to-right depolarization of the interventricular septum, causing contraction. Q waves are considered pathological if they are 2 mV in depth and greater than 25% of the depth of QRS complex, or last more than 0.04s. This could be due to lead placement errors or the subject was not totally resting; otherwise, if similar pattern persists, it could indicate a myocardial infarction, cardiomyopathies, rotation of the heart, etc. Additionally, although the amplitude of SQR complex varies from time to time, ranging from 1 mV to 2 mV, it does not exceed the normal level of less than 2.5 mV to 3.0 mV.
3. Frontal elevation of the arms seems to have a great effect on ECG signals as PQRST waveforms are not identifiable. It also has the second largest change in amplitude. One possible reason for this might be that the arms are closest to the heart, so it reflects the fastest on the ECG signals.
4. As the person jumps front and back, his/her ECG signals keep increasing in terms of mV. Inversion of U wave and elevation of ST-segment are also present, indicating possible MI.
5. Exercise should only increase the heart beats. The representation on ECG should be increased frequency of the waveforms, but not irregular ups and downs. These ECGs might indicate that the person's heart responds poorly to stress or exercise. Further testing and medical attention is recommended for this individual.