ROHINI
COLLEGE OF ENGINEERING AND TECHNOLOGY
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DEPARTMENT OF BIOMEDICAL ENGINEERING

BM3491 Biomedical Instrumentation

UNIT-II BIOSIGNAL CHARACTERISTICS

2.4 Electromyogram

2.4.1 Introduction:

Electromyography (EMG) is a diagnostic test that evaluates the health and function of your skeletal muscles and the nerves that control them. It's one form of electrodiagnostic testing. Every body movement you make, from lifting your leg to nodding your head, involves complex communication between your central nervous system (your brain and spinal cord), nerves and muscles.

To produce movement, your motor (movement) nerves send electrical signals to your muscles. An EMG can detect issues with your motor nerves, muscles or the communication between the two.

2.4.2 EMG Measurement:

i. Although action potentials from individual muscle fibers can be recorded under special conditions, it is the electrical activity of the entire muscle that is of primary interest.
ii. In this case, the signal is a summation of all the action potentials within the range of the electrodes, each weighted by its distance from the electrodes.
iii. Since the overall strength of muscular contraction depends on the number of fibers energized and the time of contraction, there is a correlation between the overall amount of EMG activity for the whole muscle and the strength of muscular contraction.

iv. In fact, under certain conditions of isometric contraction, the voltage-time integral of the EMG signal has a linear relationship to the isometric voluntary tension in a muscle.

v. There are also characteristic EMG patterns associated with special conditions, such as fatigue and tremor.

vi. The EMG potentials from a muscle or group of muscles produce a noise like waveform that varies in amplitude with the amount of muscular activity. Peak amplitudes vary from 50 μV to about 1 mV, depending on the location of the measuring electrodes with respect to the muscle and the activity of the muscle. A frequency response from about 10 Hz to well over 3000 Hz is required for faithful reproduction.

vii. Surface, needle, and fine-wire electrodes are all used for different types of EMG measurement. Surface electrodes are generally used where gross indications are suitable, but where localized measurement of specific muscles is required, needle or wire electrodes that penetrate the skin and contact the muscle to be measured are needed. As in neuronal firing measurements, both unipolar and bipolar measurements of EMG are used.

2..4.3 Electrodes for EMG:

There are two major types of electrodes used to measure EMG signals—the needle electrode and the surface electrode. Needle electrodes (Fig. 2.4.1) are further classified into three subtypes: mono-polar single electrodes, single-fiber EMG electrodes, and concentric-EMG electrodes.

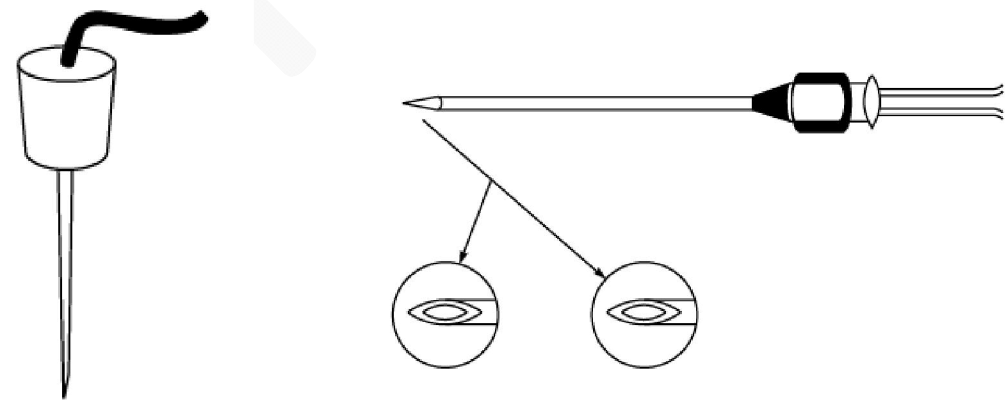


Fig. 2.4.1 (a) Needle type EMG electrode (b) Hypodermic needle type EMG electrode

i. Needle electrodes are used to record the net result of a number of cells, such as one motor unit; surface electrodes are used to record the results of many motor units. Micro electrodes are not generally used for the above purpose. When the needle electrode is placed near these muscle cells, it will detect current flow from many fibers of the corresponding motor unit.

ii. These fibers are being fired in the motor end-plates at practically the same instant by the branching nerve. The different fibers of a motor unit do not develop their action currents simultaneously; small time variation between fibers occurs. These varying delays are due to varying lengths of the terminal branches between the motor nerve and the muscle.

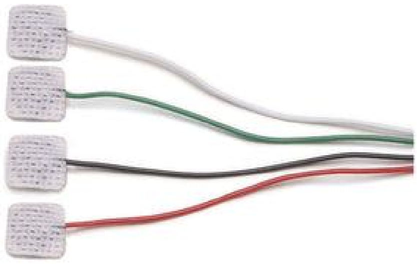
iii. Thus, excitation, as it travels along, is slightly ahead in some fibers compared with other. The result is that current flow in any small area from the cells of one motor unit lasts 2 to 5 milliseconds. This is several times the duration of the current from any single muscle fiber. This asynchronous action helps to produce smoothness of muscle action.

iv. Surface electrodes are used to record the electrical activity of muscles near the skin surface. They are commonly employed in clinical settings, research, and biofeedback applications to assess muscle function and activity.

v. **Design**: Surface electrodes are typically small, flat sensors with conductive surfaces that adhere to the skin. They may have multiple contact points to capture signals from different muscle fibers.

vi. **Placement:** Electrode placement is crucial for accurate signal acquisition. The electrodes are usually placed over specific muscle bellies or along the muscle fibers of interest. Proper skin preparation (cleaning and possibly shaving) is important to ensure good electrode-skin contact.

vii. **Signal Measurement**: The electrodes pick up the electrical signals generated by muscle contractions, known as action potentials. These signals are then amplified, filtered, and processed to create a record of muscle activity over time.



Disposable EMG surface electrode

2.4.4 Unipolar and Bipolar Modes:

2.4.4.1 Unipolar Electrodes

Unipolar electromyography (EMG) electrodes are a type of surface electrode used to measure the electrical activity of muscles. Unlike bipolar electrodes, which have two contacts on the same electrode, unipolar electrodes consist of a single contact point. Here are some key characteristics and considerations regarding unipolar EMG electrodes:

Single Contact Point: Unipolar electrodes have only one sensing or recording contact point. The reference or ground is usually placed elsewhere on the body, often at a location where muscle activity is minimal.

Signal Measurement: The unipolar electrode records the electrical activity generated by muscle contractions. The electrical potential at the muscle site of interest is measured in relation to a reference point, allowing the detection of muscle activity.

Reference Electrode: In unipolar EMG, a separate reference electrode is needed to complete the circuit. The reference electrode is typically placed at a location where muscle activity is expected to be minimal, ensuring that the recorded signal reflects the activity of the specific muscle being studied.

Placement: Proper placement of both the unipolar electrode and the reference electrode is crucial for accurate signal recording. Electrode placement is usually determined by the specific muscle or muscle group under investigation.

Applications: Unipolar EMG electrodes are used in various applications, including clinical assessments, research studies, and biofeedback training. They provide a non-invasive means of evaluating muscle function and activity.

Advantages:

Sensitivity: Unipolar electrodes can be sensitive to small changes in muscle activity, allowing for detailed analysis.

Flexibility: They are versatile and can be applied to different muscle groups.

Limitations:

Interference: The recorded signal may be influenced by factors such as skin impedance, movement artifacts, and the distance between the recording and reference electrodes.

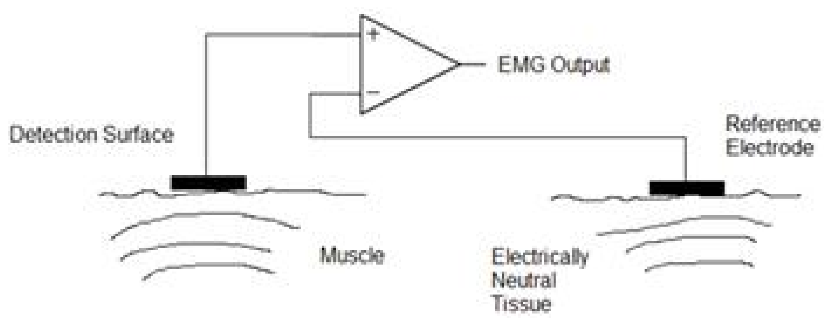
Localization: While unipolar electrodes provide overall muscle activity, they may not provide as precise information about specific regions within the muscle as intramuscular (needle) electrodes.

Types of Unipolar Electrodes:

Disposable: Single-use electrodes that are discarded after each session.

Reusable: Electrodes that can be cleaned and reused for multiple sessions.

Unipolar EMG electrodes are commonly used in clinical settings and research where non-invasive assessment of muscle activity is required. Proper electrode placement and attention to factors affecting signal quality are essential for obtaining reliable and meaningful data.



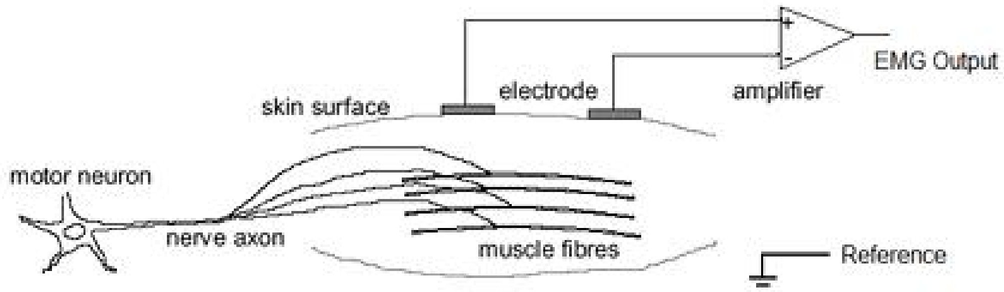
Monopolar signal acquisition technique

The monopolar configuration is implemented using only a single electrode on the skin with respect to a reference electrode as shown in the above figure. This method is used because of its simplicity, but is strictly not recommended as it detects all the electrical signals in the vicinity of the detecting surface

2.4.4.2 Bipolar EMG Electrodes:

Bipolar electromyography (EMG) electrodes are another type of surface electrode used for measuring the electrical activity of muscles. Unlike unipolar electrodes, which have a single contact point, bipolar electrodes consist of two closely spaced contacts on the same electrode. Here are some key characteristics and considerations regarding bipolar EMG electrodes:

Two Contact Points: Bipolar electrodes have two closely spaced recording contacts on the same electrode. The distance between these contacts is typically small, allowing for the measurement of the potential difference between the two points.



Bipolar Configuration

Signal Measurement: The bipolar electrode records the electrical activity generated by muscle contractions by measuring the potential difference between the two contacts. This provides information about the spatial distribution and orientation of muscle fibers in the region between the contacts.

No Separate Reference Electrode: Unlike unipolar electrodes, bipolar electrodes do not require a separate reference electrode. The potential difference between the two contacts serves as the basis for measuring muscle activity.

Placement: Proper placement of bipolar electrodes is important for capturing the electrical activity of the specific muscle or muscle group of interest. The distance and orientation between the two contacts can influence the recorded signal.

Applications: Bipolar EMG electrodes are commonly used in both clinical and research settings for assessing muscle function, diagnosing neuromuscular disorders, and studying muscle activity patterns. They are versatile and can be applied to various muscle groups.

Advantages:

Spatial Information: Bipolar electrodes provide information about the spatial distribution and orientation of muscle fibers between the two contacts.

Ease of Use: They are relatively easy to use compared to intramuscular (needle) electrodes.

Limitations:

Interference: Signal quality may be affected by factors such as skin impedance, movement artifacts, and the distance between the recording contacts.

Depth Limitation: Like all surface electrodes, bipolar electrodes measure activity from superficial muscle layers and may not provide information about deep muscles.

Types of Bipolar Electrodes:

Disposable: Single-use electrodes that are discarded after each session.

Reusable: Electrodes that can be cleaned and reused for multiple sessions.

Bipolar EMG electrodes are widely used for routine clinical assessments and research studies where a non-invasive method of measuring muscle activity is sufficient. Proper electrode placement and attention to factors affecting signal quality are crucial for obtaining reliable and meaningful data.

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