Lab 2: Kinematic and EMG Patterns of Rapid Target-Directed Movements

Introduction

The purpose of the present laboratory activity is to examine the control of voluntary movement. Insight into the control of voluntary movement can be obtained through a careful analysis of the mechanical features and the patterns of muscle activation associated with goal-directed movements.

In this lab, we will analyze the kinematic (displacement, velocity, acceleration) and electromyographic (EMG) patterns associated with fast single-joint movements to a target.

Two types of voluntary movement will be performed: (1) Uni-directional, and (2) Reversal movements.

The kinematic characteristics and muscle activation patterns associated with the execution of these movements will be examined through the measurement and analysis of specific kinematic and EMG measures.

Read: Cooke JD, & Brown SH (1990). Movement-related phasic muscle activation II. Generation and functional role of the triphasic pattern. *Journal of Neurophysiology*, *63*, 465-472.

Objectives

The objectives of this lab activity are:

1. Learn how to derive and analyze performance, kinematic, and EMG measures.
2. Examine the influence of Movement Type and specific Movement Parameters on kinematic and EMG markers of rapid target-directed movements.

Lab Activity Procedure

- Pick a volunteer to perform rapid elbow-extension/flexion movements using the manipulandum (Figure 1).

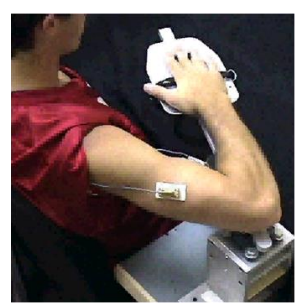

Figure 1

- The position of the manipulandum (and hence the limb) will be monitored using a potentiometer at its axis of rotation. The voltage signal provided by the potentiometer will be used as a measure of limb position.
- Triceps and biceps EMG activity will be monitored using surface electrodes placed over the belly of the muscles. Place a pair of surface electrodes (electrodes should be close together, without touching) over the lateral head of the triceps and over the center of mass of the biceps. Place the electrode pair along the length of the muscle fibers. Place the electrodes with subject's arm already positioned on the manipulandum (Figure 1). Place the ground electrode over the bony portion of the elbow. The biological signals from these electrodes will be amplified by a bio-amplifier and collected via an analog-to-digital recording system.

- For (1) **Uni-directional Movements** –subjects will execute a single, discrete, and rapid targeted movement to the specified target position. (Figure 2)

  Two movement amplitudes will be used: **20** deg and **60** deg.

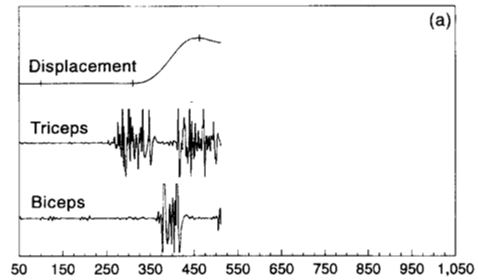

Figure 2

- For (2) **Reversal Movements** – subjects will execute a rapid and smooth reversal movement, in which they move first to the **40** deg target and return to the **10** deg target.

  Two types of Reversal Movements will be performed:

  Continuous: reversal movement should be continuous (no stopping at the first target) and the point of the reversal should be as accurate as possible with respect to the first target position (Figure 3).

  Pause: reversal movement should come to a complete stop with a very brief pause (e.g., 500 ms) at the reversal point.

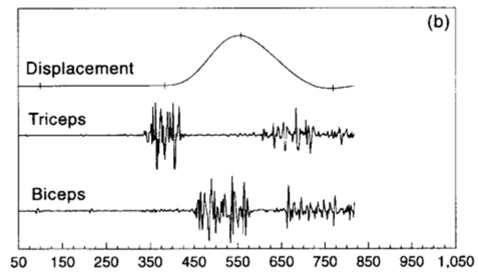

Figure 3

- The task is to react and move as quickly and as accurately as possible to the target position, following the onset of the target light.

Methodological Details to Record

Calibrated Positions (volts):

Uni-Directional

Start ________ 20° Target Position ________ 60° Target Position ________

Reversal

Start ________ 10° Target Position ________ 40° Target Position ________

Data Sampling Rate (samples per second [Hertz]): ________

Data to Record and Present

A primary objective of this lab activity is to ***learn how to analyze and derive performance, kinematic, and EMG measures****. You will need to do some* ***self-directed research*** *to learn how to derive the measures below. Make sure that you understand each of the measures, their relation to one another, and how they might change based on the type of movement or movement distance.*

You are expected to derive the following dependent measures. You can use a selected trial (i.e., choose a good trial to analyze) to derive the values for the following measures. Be able to plot the values of these measures on the appropriate graphs. The raw analog signals from the manipulandum and EMG amplifier can be saved to an Excel –formatted file that you can use for analysis.

The derivation of these dependent measures, and the information they represent, will be examinable material for the Lab Exam.

Performance Measures: (derive for a trial for each movement type and each movement parameter)

1. **Constant error** (volts) of final limb position with respect to target.
2. **Constant error** (volts) of limb reversal position with respect to reversal target.
3. **Reaction time** (ms) based on onset of movement of the manipulandum.
4. **Premotor Reaction Time** (in milliseconds).
5. **Motor Time** (ms).
6. **Movement time** (ms) based on end of manipulandum movement.

Kinematic Measures: (derive for a trial for each movement type and each movement parameter)

1. **Displacement** profile (volts): Show start and end points of displacement based on your estimate.
2. **Velocity** profile (volts/sec): Show peak velocity in forward (and backward) direction(s).
3. **Acceleration** profile (volts /sec^2): Show peak acceleration and peak negative acceleration

NOTE:

Derive the Velocity profile from the displacement profile by **differentiation**, using a simple central difference calculation. Do the same using the resulting Velocity profile to obtain the Acceleration profile (i.e. calculate the slope between data points - ***Remember HKIN 151***).

IMPORTANT:

You must understand how to calculate the velocity and acceleration profiles via numerical differentiation. Make sure you also understand how to obtain these derivatives via graphical differentiation (i.e., show how to obtain the velocity and acceleration profiles by drawing the plots). Make sure you understand the relation between the displacement, velocity, and acceleration profiles. (Refer to basics of kinematics from HKIN 151).

EMG Measures:

1. **Agonist Muscle -** Onset latency (ms) of 1st agonist muscle burst (interval from stimulus onset to agonist onset).
2. **Antagonist Muscle -** Onset latency (ms) of antagonist muscle burst with respect to 1st agonist burst (interval from 1st agonist onset to antagonist onset).
3. **Agonist Muscle -** Onset latency (ms) of 2nd agonist burst with respect to 1st agonist burst (if 2nd agonist onset can be clearly distinguished).

NOTE: You can rectify (absolute value) the muscle EMG signals to help visualize the EMG on a plot.

Data Plots: (putting it all together)

1. Plot the trials (that you have chosen to analyze) for each movement type and movement parameter.

   Plot a figure that shows:

   - Displacement profile of manipulandum (potentiometer voltage signal) as a function of time
   - Velocity profile
   - Acceleration profile
   - EMG pattern from agonist (rectified) as a function of time
   - EMG pattern from antagonist (rectified and negated [negative values]) as a function of time

2. Show and label on these plots the performance, kinematic, and EMG measures/landmarks that you have been asked to derive.

3. Based on your results, indicate how each of the performance (movement accuracy), kinematic (velocity and acceleration peaks), and EMG measures might change as a function of Movement Type (Uni-directional vs. Reversal), Movement Amplitude (for Uni-directional movements), and Reversal Type (for Reversal movements).

Other References:

For a basic review and tutorial on EMG:
HKIN 151 EMG Resource: http://www.educ.ubc.ca/faculty/sanderson/EMG/Index.htm

For a review of definitions of Kinematics and Differentiation:
http://en.wikipedia.org/wiki/Kinematics
http://en.wikipedia.org/wiki/Slope
http://en.wikipedia.org/wiki/Derivative#Differentiation_and_the_derivative

Questions for Lab Activity and Lab Reading

1. In the data collected from the Lab #2, consider the following:

    a) How many triphasic patterns are associated with a uni-directional movement?

    b) How many triphasic patterns are associated with a continuous reversal movement? Why? How does the triphasic pattern in a uni-directional movement compare to the continuous reversal movement?

    c) How many triphasic patterns are associated with reversal movement with a pause? Why?

Reading:

Cooke JD, & Brown SH (1990). Movement-related phasic muscle activation II. Generation and functional role of the triphasic pattern. *Journal of Neurophysiology*, *63*, 465-472.

1. What is the basic function of the phasic bursts of muscle activity typically observed during fast movements?

2. Cooke and Brown propose that the triphasic EMG pattern "is not a basic unit of movement control." In their view, and based on their data, what is the "basic unit?" Describe and discuss how these authors supported their claim.

3. With respect to #2, what was the critical aspect of Cooke and Brown's experimental procedures? Explain the importance of this experimental procedure to the authors' investigation and theoretical position regarding the functional role of phasic muscle bursts in movement control.

4. According to Cooke and Brown, what is the basis for the triphasic EMG pattern? Is it actually "triphasic?" Explain.