Al-Mustaqbal University
College of Engineering & Technology
Biomedical Engineering Department

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Lecturer: Dr.Ameer Najah saud

ENG: Ikram Falah Hadi

Email: *amir_najah@uomus.edu.iq*

Email: *ikram.falah.hadi@uomus.edu.iq*

Lecture No.: - 1

Lecture Title: [Skeletal Muscle Biomechanics]

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AL - Mustaqbal University
College of Engineering and Engineering Technologies
Biomedical Engineering Department
Biomechanics Design Lab
DR. Ameer Najah
Lecturer. Dhuha Hussein
Lecturer. Ikram Falah

EXP.NO.1

Skeletal Muscle Biomechanics

Aim of EXP.

- The objectives of this experiment are to observe and calculate the moment of force of the biceps muscle through a range of elbow flexion.

Introduction

A simple way to explain biomechanics as it relates to the biceps muscle is with the following moment of force equation: M x MA = R x RA where M is the moment of force or torque required to move the weight, MA (movement arm) is the perpendicular distance from the line of action of muscle force to the axis of rotation (joint), R (resistance) is the weight to be lifted, and RA (resistance arm) is the perpendicular distance from the joint to the weight and it is the length from the medial epicondyle, a bony prominence that can be felt on the inside of the arm at the elbow, to the middle of the palm (Fig. 1). It is important to note that the equation above states a condition of equilibrium, i.e., there is no rotation.

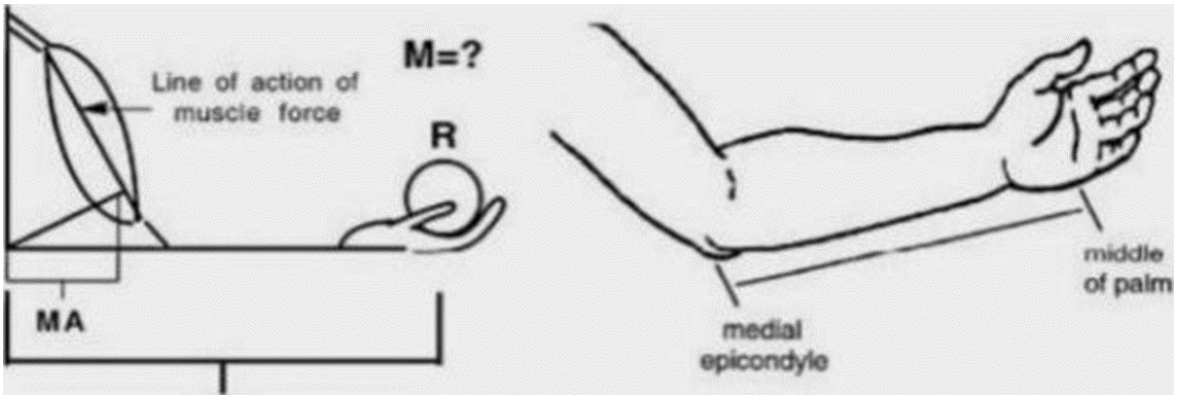

Fig. 1 : (a) Components of moment of force equation and (b) the distance to be measured as the resistance arm.

There are both physiological and mechanical advantages involved in muscle contraction and maximum tension generated. The length-tension concept states

that the maximum tension generated by the muscle occurs at its resting length when there is the greatest number of cross bridges between myosin and actin. However, there are optimal angles at which the maximum moment of force or torque can be generated throughout a joint range of motion. The idea of locating the point at which the maximum muscle moment of force can be generated is relevant to exercise training and rehabilitation to increase muscle strength according to the overload principle.

Materials Needed:

This exercise requires a variable-weight one-arm curling bar and a set of free weights (it is essential to have a weight set that can be increased in small increments).

Procedure:

This experiment involves two protocols.

Protocol 1

l. Measurement of maximum weight that biceps muscle can hold at various joint angles. In this experiment, you will test the concept that: changing the joint angle changes the length of the muscle and changes the mechanical advantage of the lever system. Thus the maximum weight that can be held will vary as the joint angle changes.

2.Place the subject's right arm (shoulder to elbow) flat on a desk. Now line up the forearm (elbow to hand) with the board at an angle of 30'.

3.Estimate the maximum weight that the subject can hold at the specified angle. Place a weight smaller than the estimated maximum in the subject's right hand. The subject should maintain his / her arm at the same starting angle even as weights are being added.

4.Add additional weight in the smallest increments possible until the subject can no longer hold the weight. Record the maximum weight that the subject can hold at the 200 angle in Table 1.4. Repeat the procedure for the angles labeled in table 1.

5.Repeat steps 1—4 with the left arm at each angle.

6.Plot maximum weight held at each angle for the right and left arm. Use a solid line for right arm and a dashed line for left arm. Table I Maximum weight held at each angle with right and left arm.

Angle	Max wt Held With Right Arm	Max wt Held With Right Arm
30		
45		
60		
90		

Table 1 Maximum weight at each angle with right and left arm

Protocol Il:

Calculation of Moment of Force Required to Hold Maximum Weight at Various Angles. This test is for measuring and recording the change in the moment arm and the change in the resistance arm that occurs as the elbow is flexed. MA, at an angle of 00, is the distance from the elbow to the point of insertion of the biceps muscle as shown in Fig.l , (it is estimated that the biceps insertion is N2.54 cm from the elbow in females and —5 cm from the elbow in males). RA, at an angle of 00, is the length of the forearm. At angles other than O, both MA and RA will change.

1.Measure the length of each subject's right forearm (RA) in centimeters.

2.Plot the right forearm length on the x-axis of Fig. 2 (this length represents the RA). The y-axis represents the right arm. (Remember that the arm is the region from the shoulder to the elbow, and the forearm is from the elbow to the wrist). Fig. 2 illustrates how the forearm length is plotted on the graph.

3.Plot the length from the elbow to the point of insertion of the biceps on the x-axis of the graph (this length represents the MA).

4.Use a protractor to mark the angles O, 30, 45, 60, and 90' on Fig. 2. Line up the protractor with the y-axis so that O' is at the x-axis and 90' is at the y-axis. Use a ruler and draw lines the length of the right forearm from the xy intercept through each angle. All five lines should be the same length.

5.Use a ruler to mark the point of muscle insertion on the line at each angle; the distance from the joint to the insertion remains the same through all of the angles.

6.Using the protractor, draw perpendicular lines from the endpoints of the five lines drawn through each angle. The distance on the x-axis from the joint (x-y intercept = O) to the perpendicular line represents the resistance arm (RA).

7.With the aid of a protractor, draw perpendicular lines from the muscle insertion to the x-axis. The line from the insertion point should intersect the x-axis at a right angle. The distance on the x-axis from the joint (x-y intercept = O) to the perpendicular line represents the moment arm (MA).

8. Record this measurement for each angle in Table 2.

9.Compute the moment of force (M) the subject requires to hold the weight at each angle. For the resistance (R), use the values entered in the first column of Table 1. Insert the value calculated for the moment of force in Table 2.

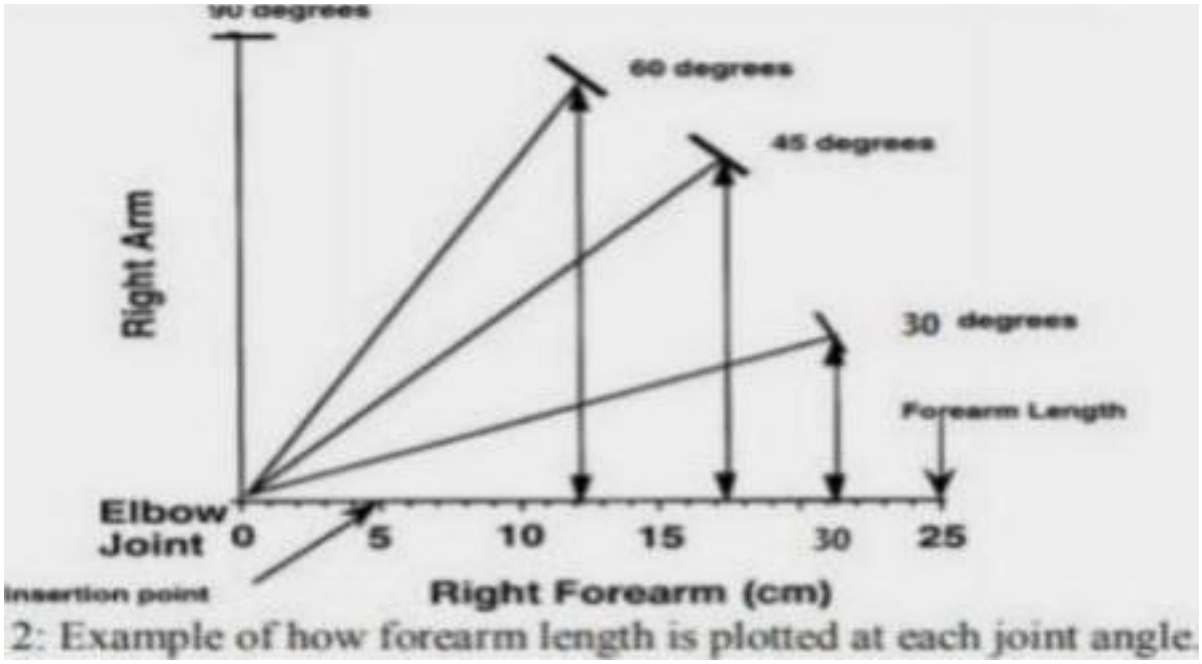

Fig 2: Example of how forearm length is plotted at each joint angle.

Angle	Max. Wt Held With Right Arm	Moment Arm	Resistance Arm	Moment of Force
30				
45				
60				
90				

Table 2 Maximum weight held at each joint angle, moment arm, resistance arm, and moment

Discussion:

A. When is maximum force generated?
B. At which angle can the biceps muscle hold the greatest weight?
C. At which angle is the body at a mechanical advantage? Why?
D. At which angle is the body at a length-tension advantage? Why?