# Muscle Synergies and Kinematic Analysis of Bicep Curls and Compensatory Movements

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## Background

- Compensatory movement is a phenomenon that brain coordinates other muscle groups to aid the weakened primary muscle in performing an action. It happened because of injury or fatigue.
- Traditionally, it is detected by the physiotherapist using manual inspection. However, it is labour-intensive and empirical-based.
- Our research is interested in analyzing the bicep curl exercise and identify the difference between the standard bicep curl and fatigued bicep curl and propose a metric for developing a sensor that capture compensatory movements during rehabilitation

## Key Contribution

- Presented the **muscle synergy module and joint kinematics** of standard bicep curl and fatigued bicep curl.
- Analyzed the results collected from 12 subjects and suggested an optimal **metric** to differentiate standard bicep curl and fatigued bicep curl.

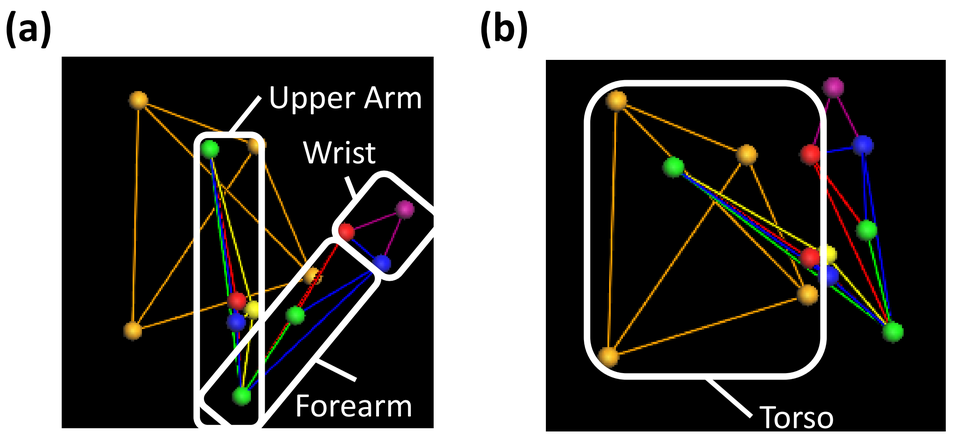


Fig. 1. The VICON labeling skeleton of a subject's torso and right upper limb. (a) Subject conducting standard bicep curl. (b) Subject conducting fatigued bicep curl

## Method

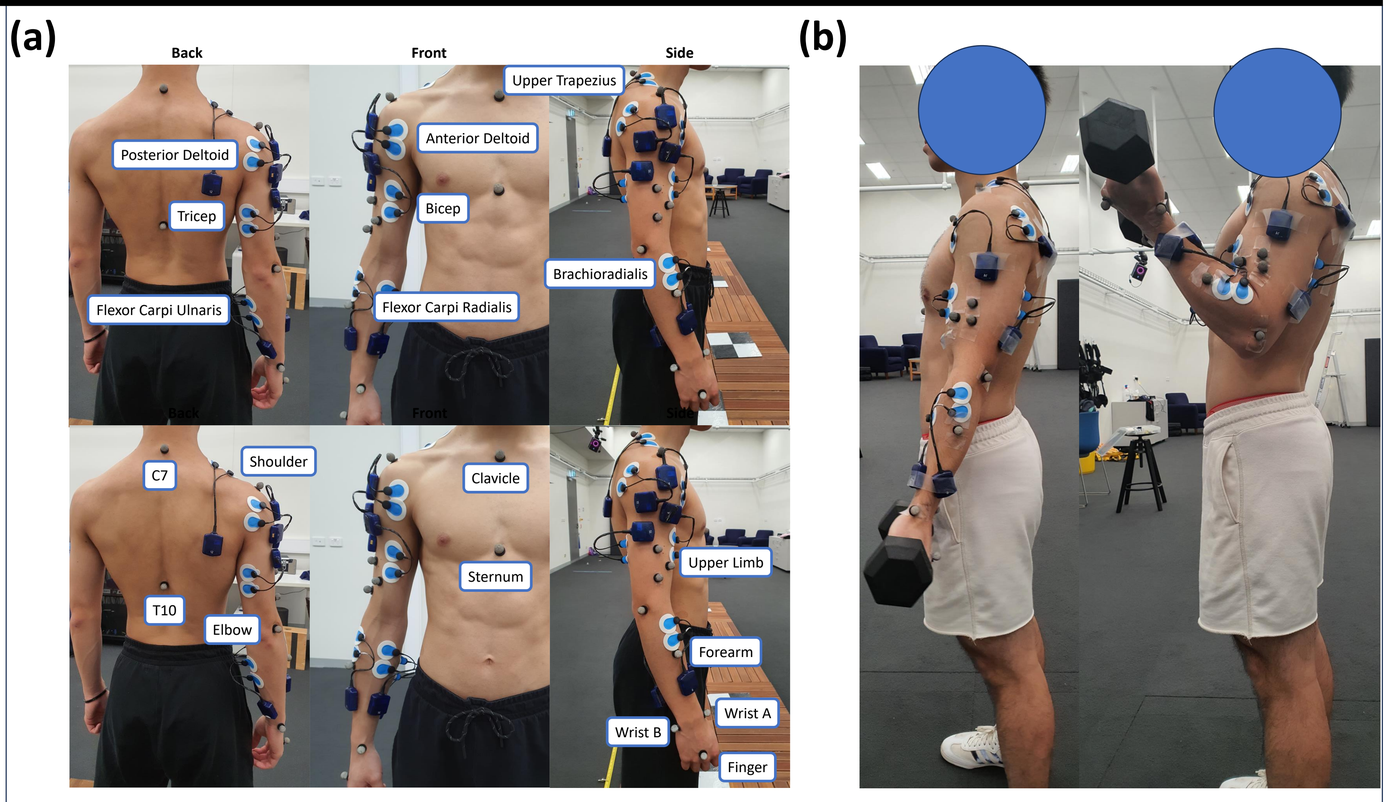


Fig. 2. The experimental procedure. (a) The sEMG sensors and VICON markers are attached to the subject. (b) The subject is instructed to conduct bicep curl under standard and fatigue conditions.

## Result

- Upper Trapezius muscle has statistically significant increment in the relative contribution during fatigue condition.
  - The RMS amplitude of the sEMG signal has a 127% increment.
- The range of motion (ROM) of the shoulder joint is changed.
  - The shoulder flexes more vigorously for approximately 20 degrees during fatigue compared to standard, approximately 10 degrees.
  - The shoulder elevates for approximately 10 degrees during fatigue.

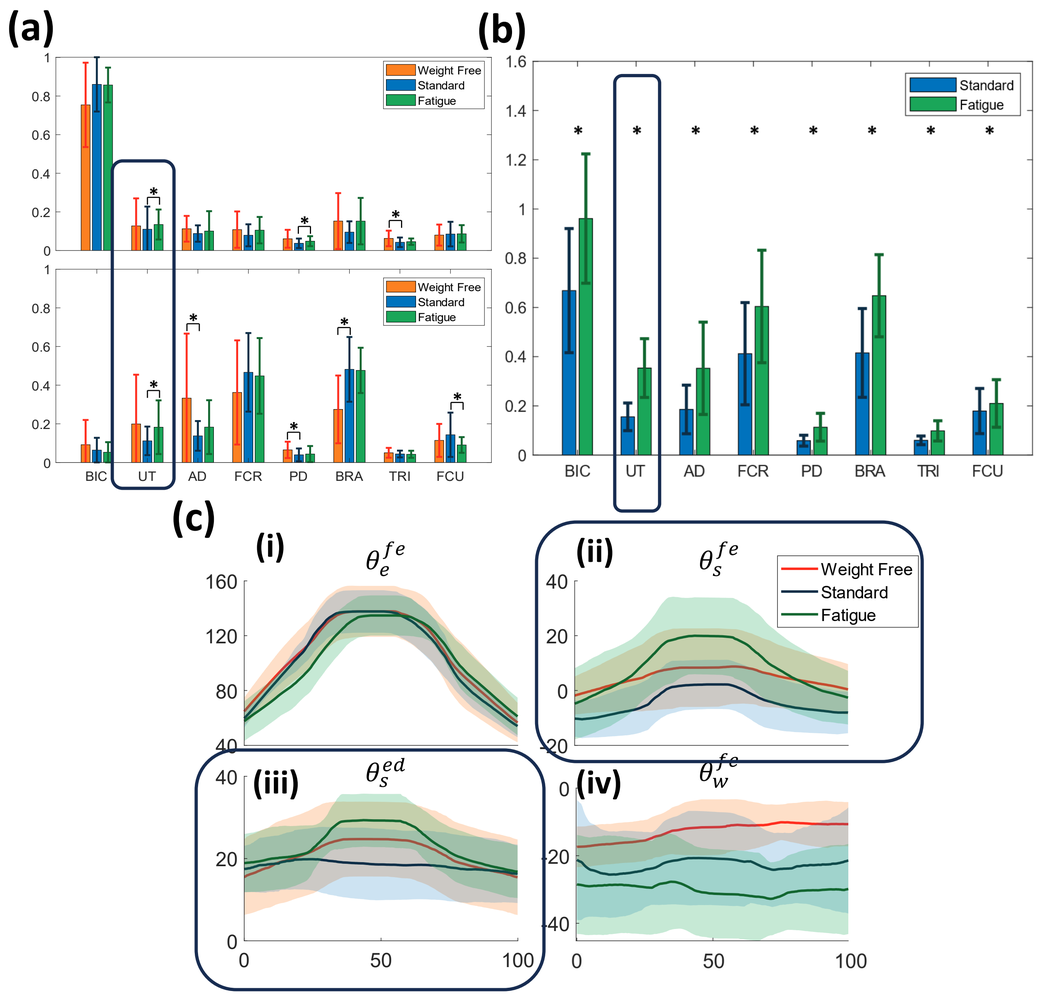


Fig. 3. The results obtained from the subject study. (a) Relative contribution of muscle synergy. (b) RMS amplitude of sEMG signal. (c) Joint kinematics; (i) Elbow Flexion-Extension, (ii) Shoulder Flexion-Extension, (iii) Shoulder Elevation-Depression, (iv) Wrist Flexion-Extension

## Conclusion & Future Work

- This work presented the muscle synergy and joint kinematics of bicep curl under standard and fatigued conditions. A series of subject experiments have been conducted to verify that the shoulder joint should be observed to differentiate between standard bicep curl and fatigue bicep curl.
- The result from this study could benefit the development of wearable sensor by providing a metric for identifying fatigue during bicep curl exercise. In this study, the strain sensor measures the shoulder elevation movement.

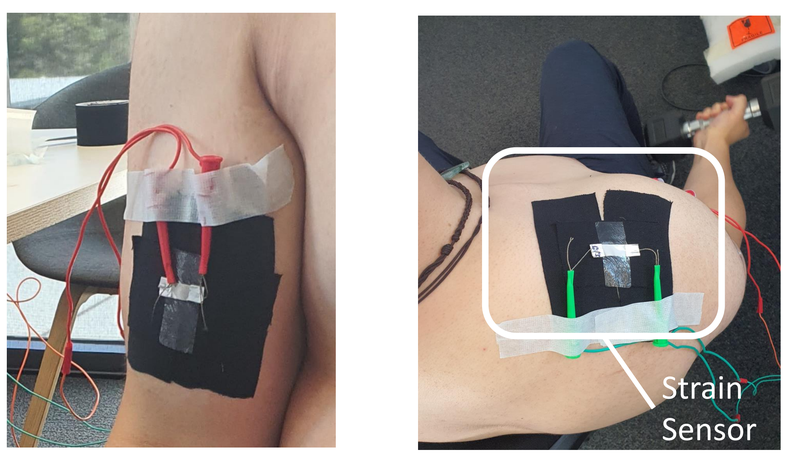


Fig. 4. The wearable strain sensor developed based on the result from this study

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