# Upper limb associated reactions: The relationship between movement kinematics and muscle activity in seated versus walking testing

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## Introduction

When people with acquired brain injury (ABI) walk, they often experience abnormal upper limb movements called associated reactions (ARs). Despite being a common phenomenon, no gold-standard assessment exists. A systematic literature review demonstrated that the majority of AR assessments include stationary seated testing positions, with maximal effort protocols. These are likely to have limited ecological validity for ARs that occur during walking. Surface electromyography (sEMG) was commonly employed but with limited clinimetric evaluation for ARs. Recent studies have devised ecologically valid AR outcome measures using three-dimensional motion analysis (3DMA). These 3DMA outcomes may serve as criterion-reference comparison to the seated, maximal effort tests.

## Aim

To evaluate the relationships between stationary seated maximal voluntary isometric (MVIC) tests and tests of ARs during walking in people with ABI using sEMG muscle activity and 3DMA kinematic measures.

## Methodology

Forty-two adults with ABI underwent AR testing with seated contralateral MVIC tests and walking (self-selected and fast speeds). Assessment of ARs included the hemiplegic upper limb biceps brachii sEMG, elbow goniometry and 3DMA kinematics (KDSw outcome measure) during walking. Pearson's 'r' correlations evaluated relationships between seated and dynamic walking AR tests and between kinetic and kinematic measures.

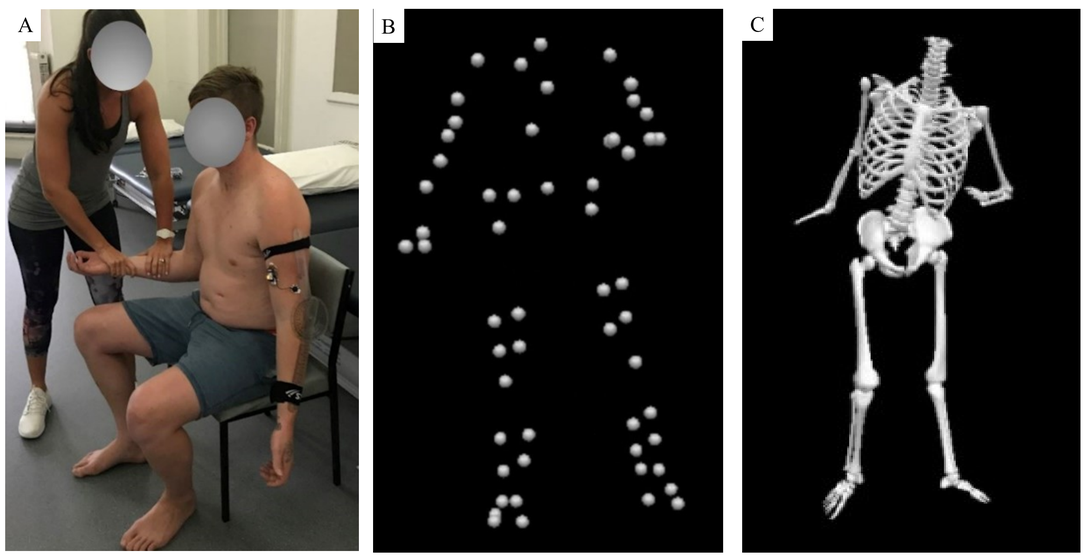


**Figure 1.**
**a) Seated MVIC Test b) 3DMA marker set c) 3DMA skeleton**

## Results

Moderate relationships (Table 1) existed for biceps brachii sEMG during seated and walking tests at self-selected and fast walk, respectively. A low-to-moderate relationship existed between biceps brachii sEMG and kinematics during walking and between seated and walking measures of ARs.

**Table 1. Correlations between seated MVIC versus walking AR tests and between sEMG and 3DMA**

| | Self-selected (r) | Fast (r) |
|---|---|---|
| **Biceps brachii sEMG during walking vs seated tests** | | |
| Gait vs seated contralateral MVIC biceps brachii sEMG | 0.65 | 0.53 |
| **Biceps brachii sEMG vs upper limb kinematics during walking** | | |
| Elbow-KDS | 0.42 | 0.44 |
| KDSw | 0.41 | 0.29 |
| **Seated contralateral MVIC vs upper limb kinematics during walking** | | |
| *Seated contralateral MVIC Biceps Brachii sEMG vs:* | | |
| Elbow-KDS | 0.50 | 0.37 |
| KDSw | 0.49 | 0.22 |
| *Seated contralateral MVIC elbow flexion angle $\Delta^0$ vs:* | | |
| Elbow-KDS | 0.53 | 0.53 |
| KDSw | 0.46 | 0.27 |

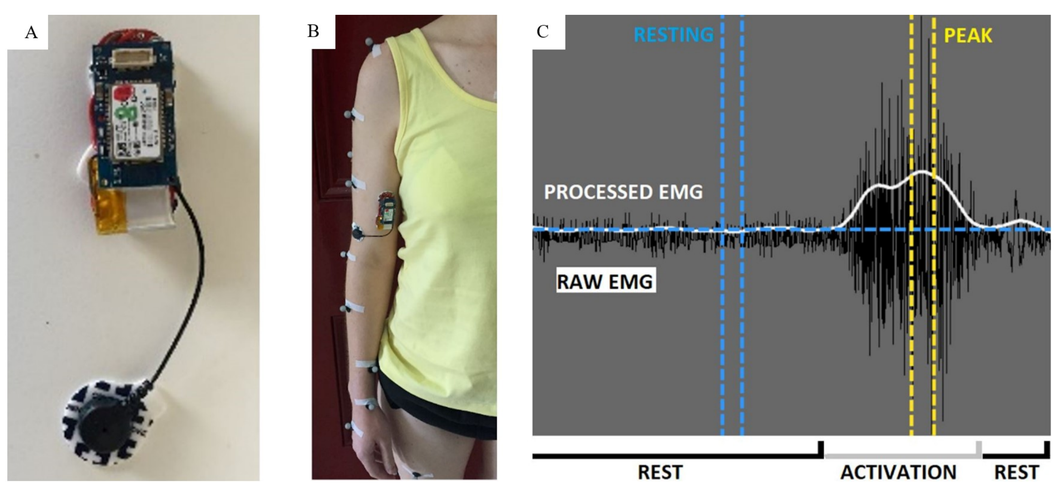


**Figure 2.**
**a) Myoware sEMG device**
**b) Participant wearing sEMG device**
**c) Raw and processed sEMG waveform output**

## Conclusions

Seated contralateral MVIC tests correlate only weak-to-moderately to AR walking kinematics and moderately with biceps brachii activation during walking indicating limited ecological validity. Moderate relationships exist between sEMG and kinematics indicating they may provide different information regarding ARs.

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