Quantification of associated reactions during walking in people with associated reactions due to acquired brain injury

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Introduction

Hemiplegic upper limb associated reactions (ARs) are common during effortful activities such as walking, in people with acquired brain injury (ABI). They adversely impact function and quality of life. Given that ARs may affect all upper limb joints, composite scores derived using three-dimensional motion analysis (3DMA) may be able to condense kinematic data from multiple joint axes into a single score as a criterion-reference, ecologically valid AR outcome measure.

Scan me for associated reaction examples

Aims

To apply composite scores to quantify AR upper limb movement abnormality during walking in people with ABI and evaluate their; i) known-groups and convergent validity; ii) test re-test reliability, and, iii) responsiveness to the effort-dependent and speed-related AR changes.

Methodology

Forty-two adults with ABI and ARs during walking and 36 healthy controls (HC) underwent 3DMA assessment of their self-selected and fast walking speeds. Composite scores quantified the affected upper limb's kinematic abnormality. The Arm Posture Score arithmetic mean version (APSam) and 1.96 standard deviation reference-range scaled versions; the Kinematic Deviation Score mean (KDSm) and worst score (KDSw) were evaluated for association with each other and subjective abnormality rating (Pearson's 'r' correlation), test-retest reliability (intra-class correlation coefficient (ICC)), and ability to quantify speed-related changes in abnormal upper limb movement (% change scores, Cohen's *'d'* effect size (ES).

1a) Arm Posture Score arithmetic mean **(APSam)**
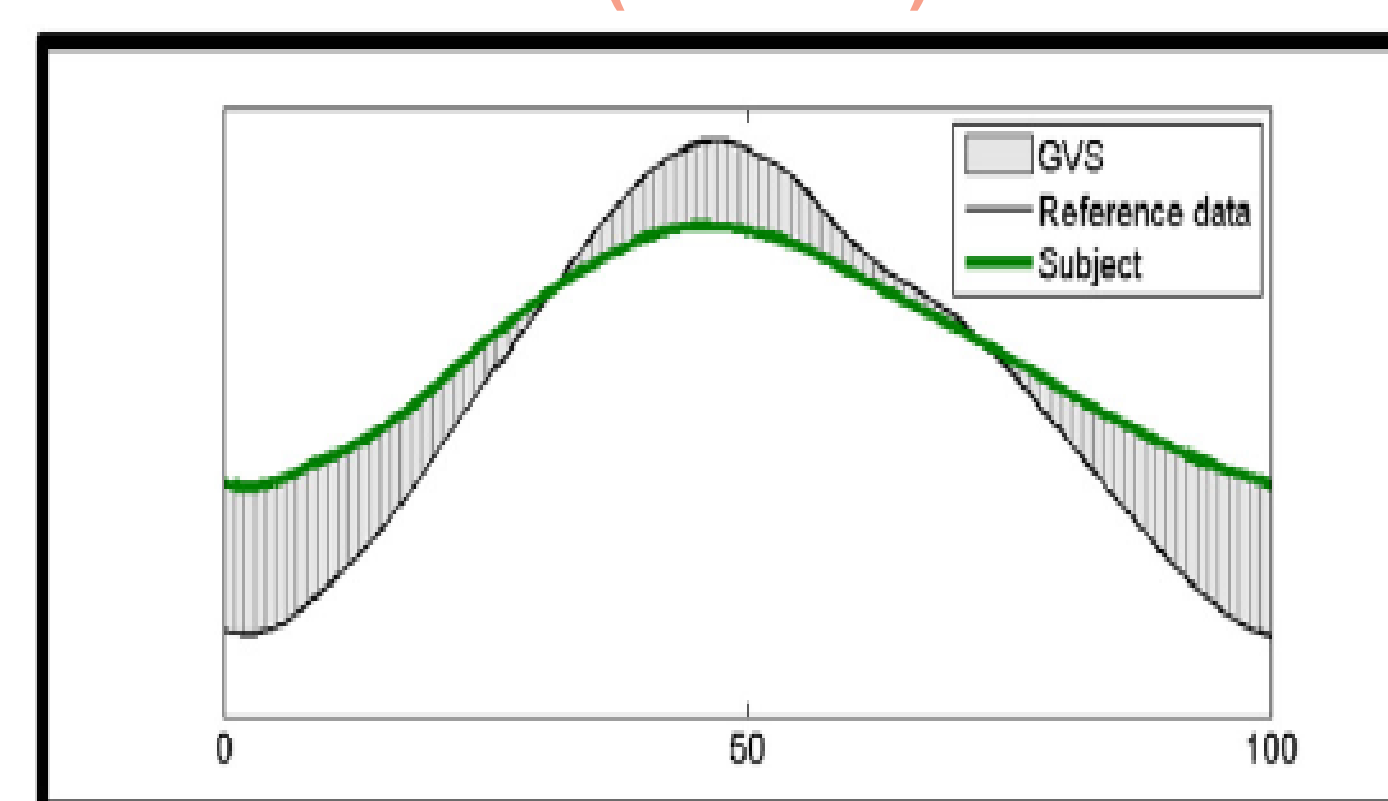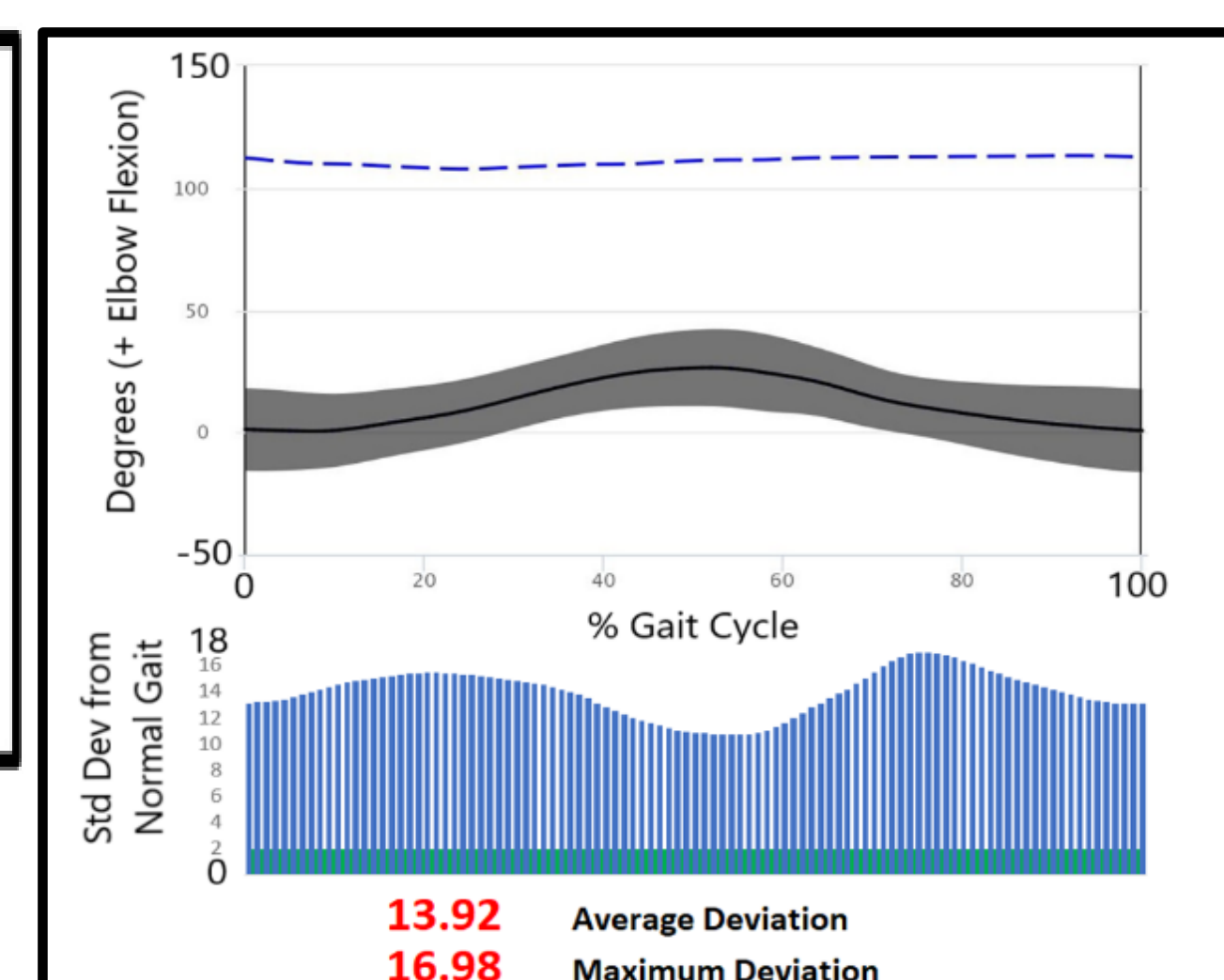
1b) Kinematic Deviation Score **(KDSm & KDSw)**

Figure 1. Schematic illustration of the joint axes calculation for; a) the APSam); and, b) the KDS.

Results

i) **Validity:**

Known groups: The KDSm under-classified AR abnormality, whereas the KDSw captured the majority of ABI participants.

Convergent: Very strong correlations existed between composite scores (r ≥ 0.80). All scores had moderate-strong correlations with subjective AR ratings (r = 0.54 - 0.79).

ii) **Test retest reliability:**

All three composite scores had very strong test-retest reliability, irrespective of speed (ICCs > 0.81).

iii) **Responsiveness:**

The APSam demonstrated a 16% (ES = 0.76) walking speed-related increase in upper limb abnormality from self-selected to fast walking speed, whilst decreases were demonstrated in the KDSm 26% (ES = 0.90) and KDSw 35% (ES = 0.96).
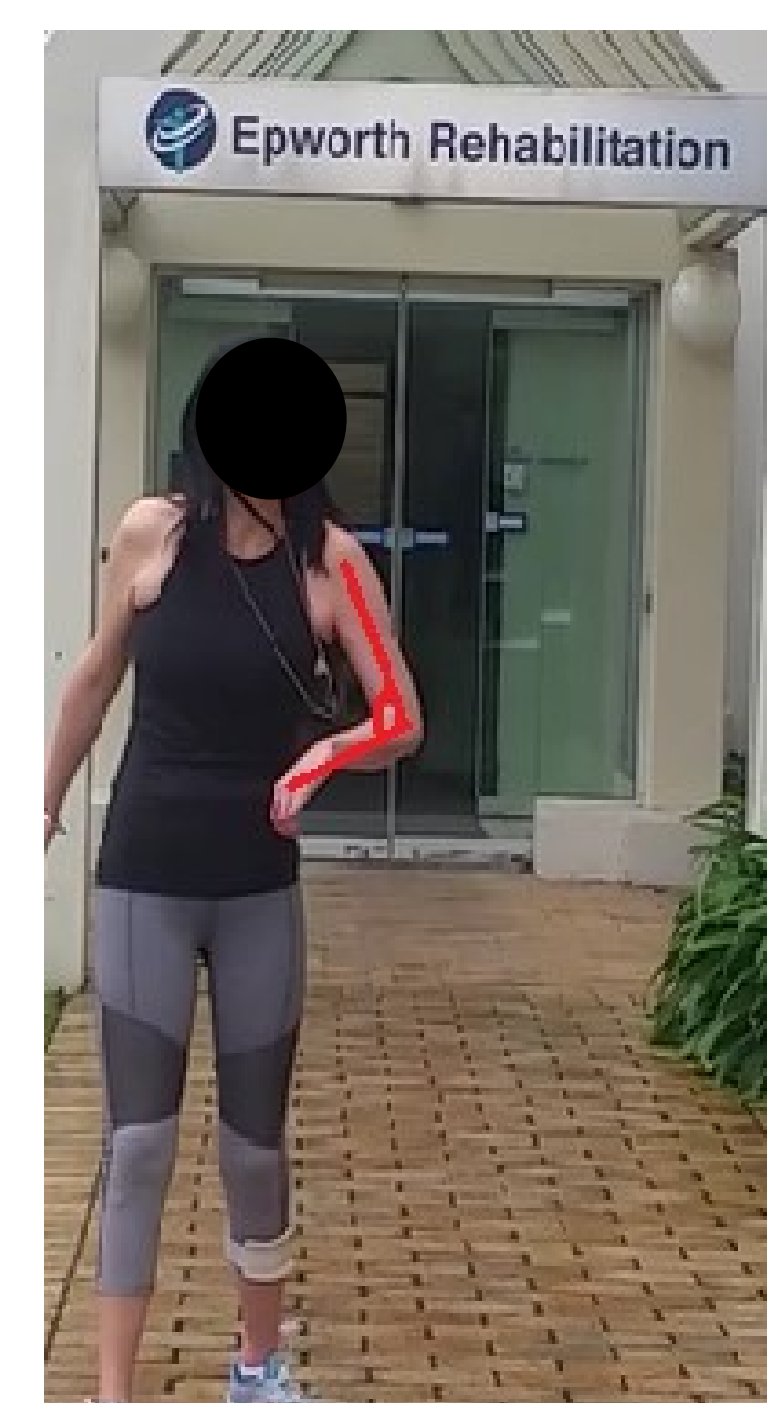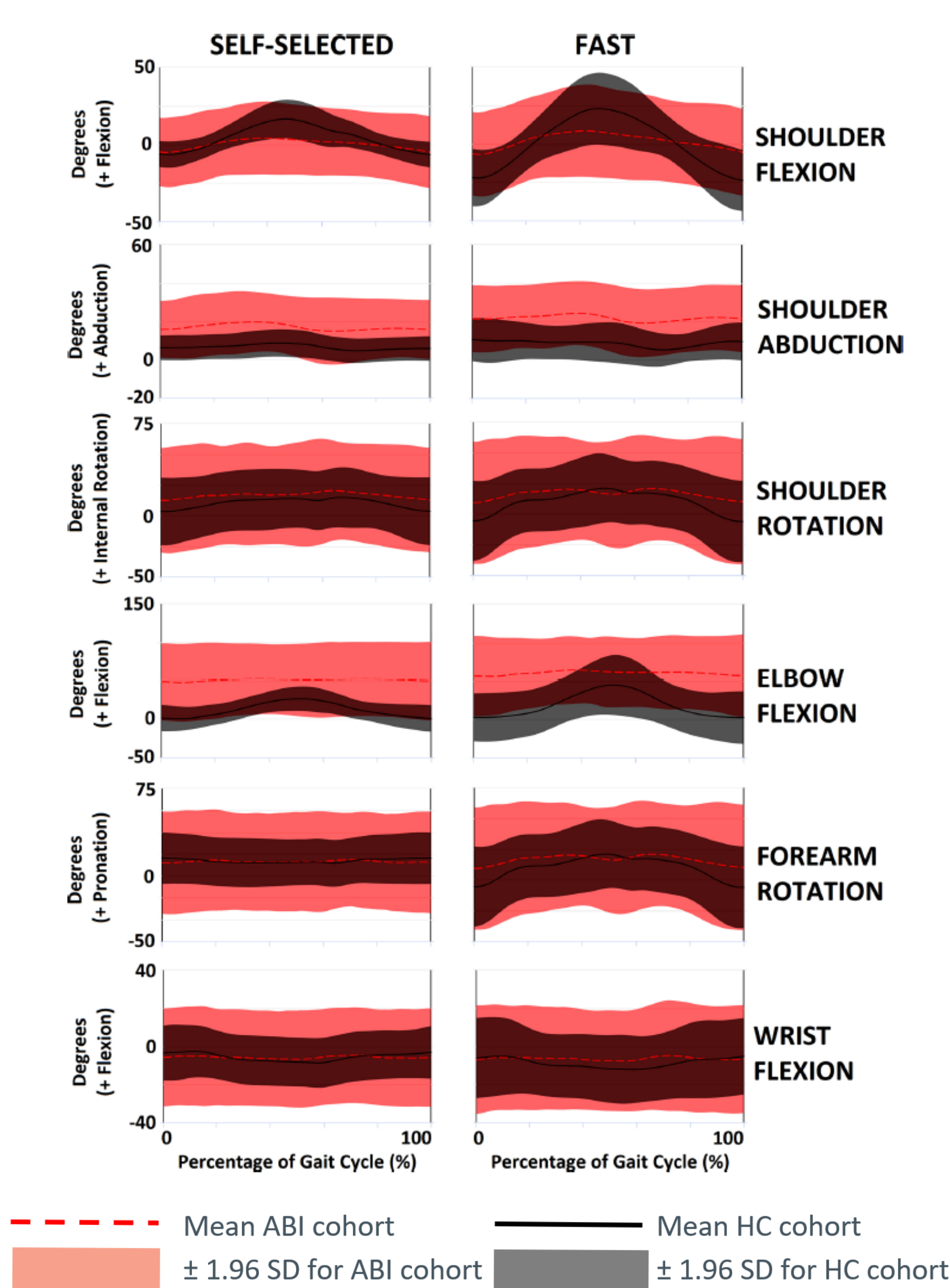

ABI participant with a left upper limb AR

Figure 2. Kinematic graphs illustrating upper limb joint axes change from self-selected to fast walking speeds.

Replicated 3DMA skeleton

Conclusions

The APSam, KDSw, and number of abnormal joint axes comprehensively assess the whole upper limb AR, accurately classifies abnormality, and quantifies severity. This study illustrated notable presence of ARs at self-selected walking speed and small effort-dependent increase at fast speeds. However, when scaled to HC variability, the fast walk kinematics became less abnormal due to increased HC movement variability.

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