

## Introduction

Asymmetric sit-to-stand (STS) and static standing mechanics may be related to fall risk and function after hip fracture. Even in those individuals who achieve an independent status in rising from STS, asymmetric movement strategies are frequently adopted. Previous research has revealed that the asymmetry is not fully explained by strength deficits alone. Stroke literature suggests that STS asymmetry is a function of perceptual deficits, such as sense of effort, however, this concept has not yet been explored following a hip fracture.

## Case Description

74-year-old female who was 6 months post total hip arthroplasty due to hip fracture sustained following a fall. Her rehabilitation was standard, unremarkable, and her health was otherwise stable. All data collection took place in a motion analysis laboratory.

## Methods



Figure 1. (above) Subject performing right side maximal excursion during a STS

Subject was seated on custom-built platform. Knee extension (KE) maximal voluntary isometric contraction (MVIC) was tested bilaterally. With this same arrangement, a force matching task was performed (Table 1).

3 STS conditions:

1. Natural "self-selected"
2. "50/50 fix" following feedback from "self-selected" performance
3. "Maximal excursion" (Figure 1)

Force matching task: while standing, the subject was asked to shift a self-selected amount of weight toward one side, return to upright neutral, and then replicate the exact same load on the contralateral side (Figure 2).

Perception was assessed using a custom-built Visual Analog Scale (VAS) device.

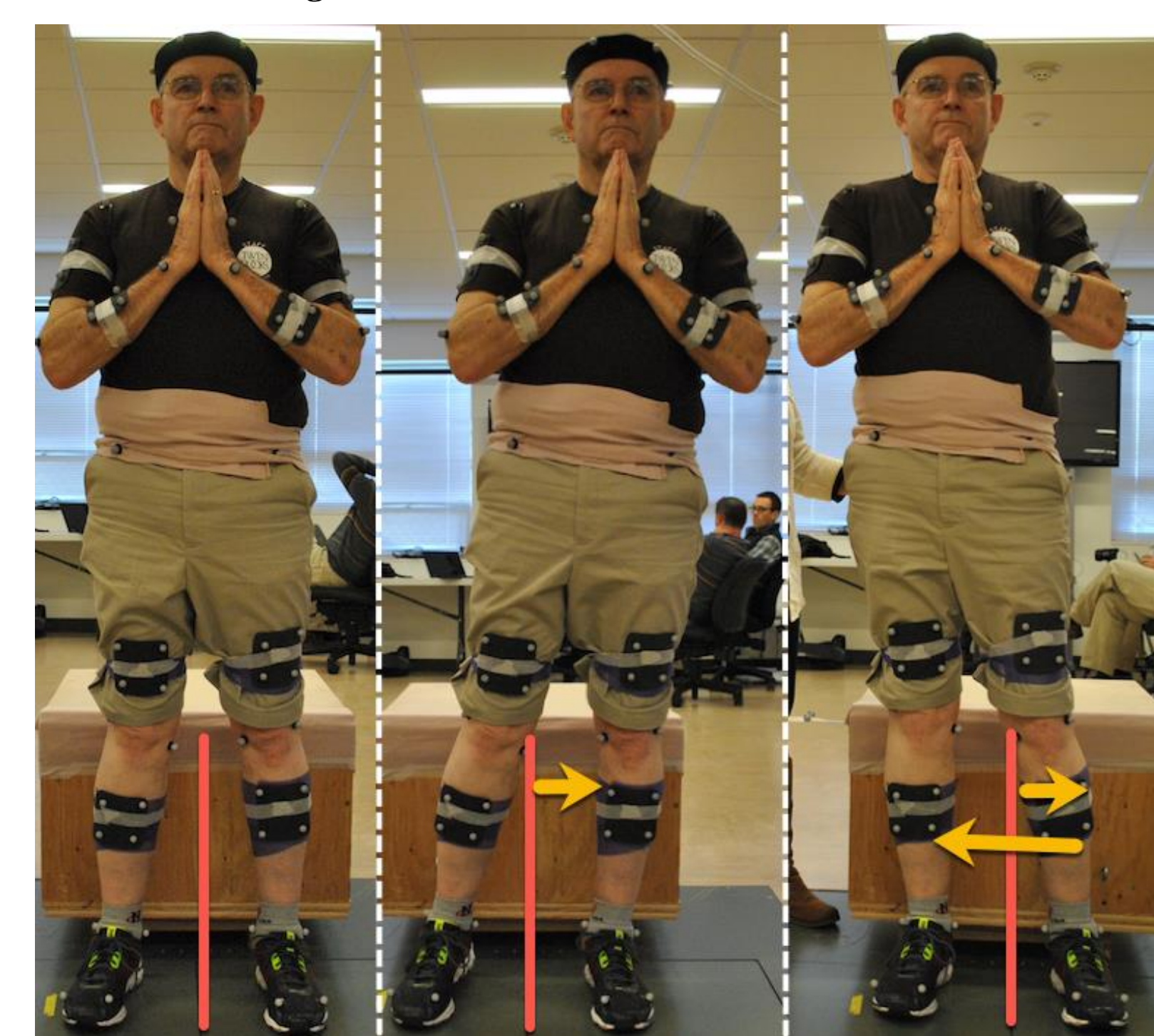


Figure 2. (left) Example of a subject performing the lateral weight-shift matching task. In this case, after the person loaded his left side, he attempted to replicate the exact same load on the right side.

Table 1. Summary of isometric knee extension torque

LE	KE force (mean % BW)		
	ok	fx	Δ
KE MVIC	17.9	17.6	0.3
Match a self-selected KE using fx-side as the standard	12.8	10.6	Over-shot by 2.2
Match a self-selected KE using ok-side as the standard	8.6	10.9	Over-shot by 2.3

Abbreviations: KE, knee extension; BW, body weight; LE, lower extremity; ok, non-fractured LE; fx, fractured LE; Δ, difference between LEs; MVIC, maximum voluntary isometric contraction

Table 2. Summary of STS, with perceptual ratings

LE	VAS rating of STS loading (% max)		Actual STS peak vGRF (% BW)		Actual vGRF of static standing after (mean % BW)	
	ok	fx	ok	fx	ok	fx
STS self-selected	65	35	60 <sup>3</sup> (*green)	48 <sup>3</sup> (*red)	68 <sup>3</sup> (**green)	31 <sup>3</sup> (**red)
STS trying 50/50 fix	(50)	(50)	53 <sup>3</sup>	55 <sup>3</sup>	55 <sup>3</sup> (++green)	44 <sup>3</sup> (++red)
STS max excursion to ok LE side	80	20	87 <sup>5</sup>	37 <sup>5</sup>	66 <sup>5</sup>	33 <sup>5</sup>
STS max excursion to fx LE side	40	60	38 <sup>5</sup>	60 <sup>5</sup>	48 <sup>5</sup>	50 <sup>5</sup>

Abbreviations: STS, sit-to-stand; VAS, visual analog scale; max, maximum; BW, body weight; vGRF, vertical ground reaction force; LE, lower extremity; ok, non-fractured LE; fx, fractured LE  
Key: superscript <sup>3</sup> = see Figure 3; \*green = see the \* icon near the figure's green line

Table 3. Summary of matching trials, with perceptual ratings

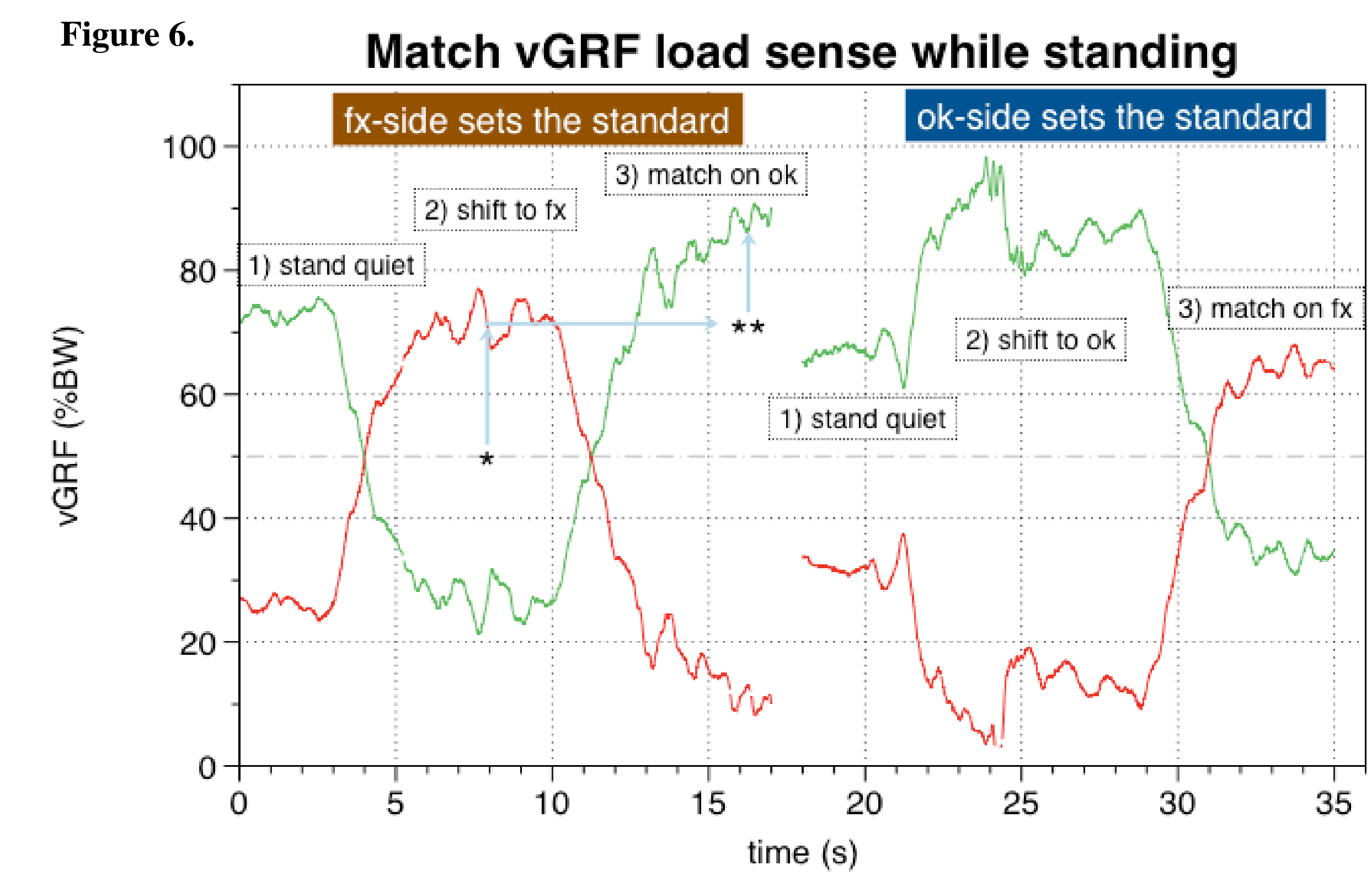
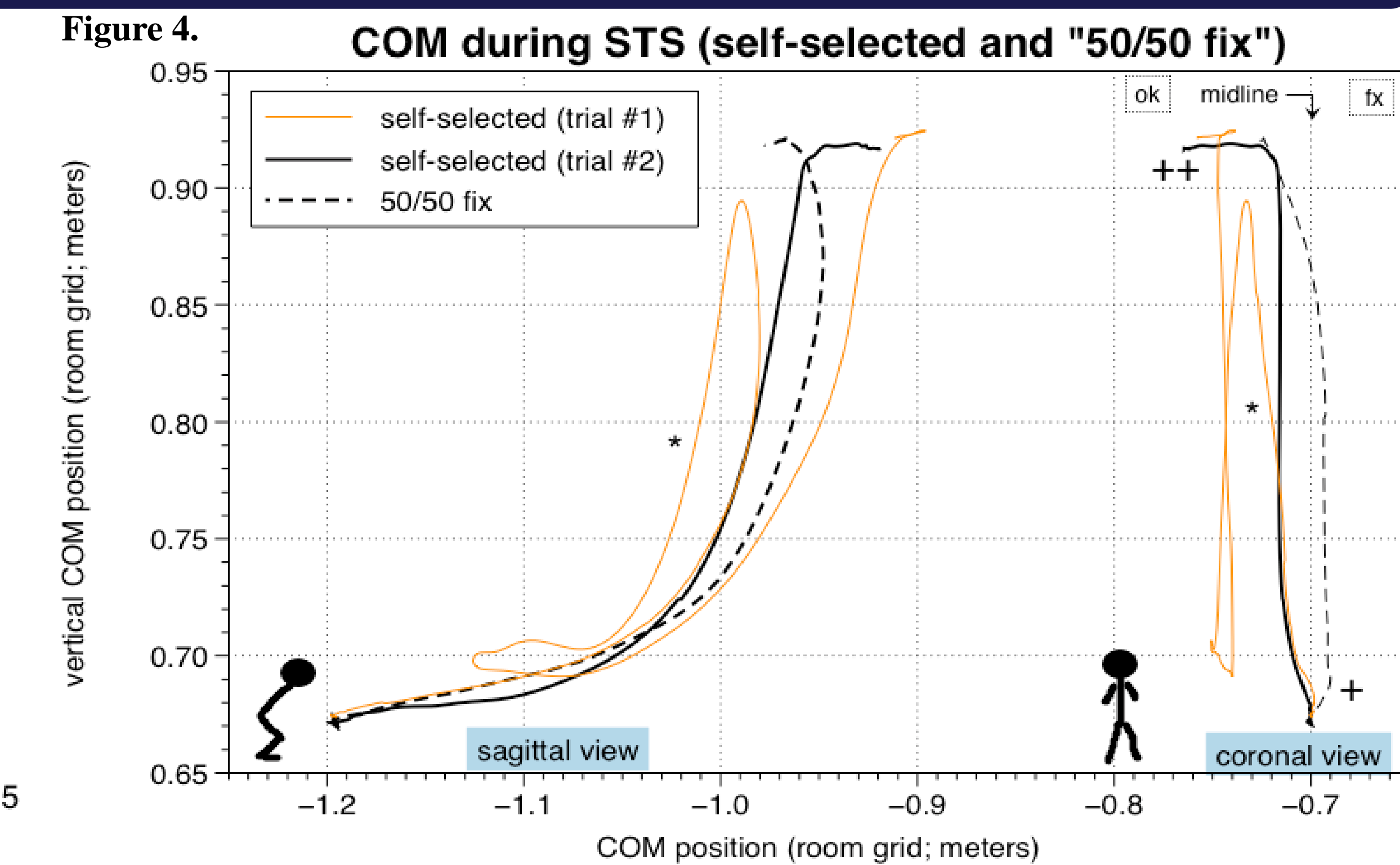
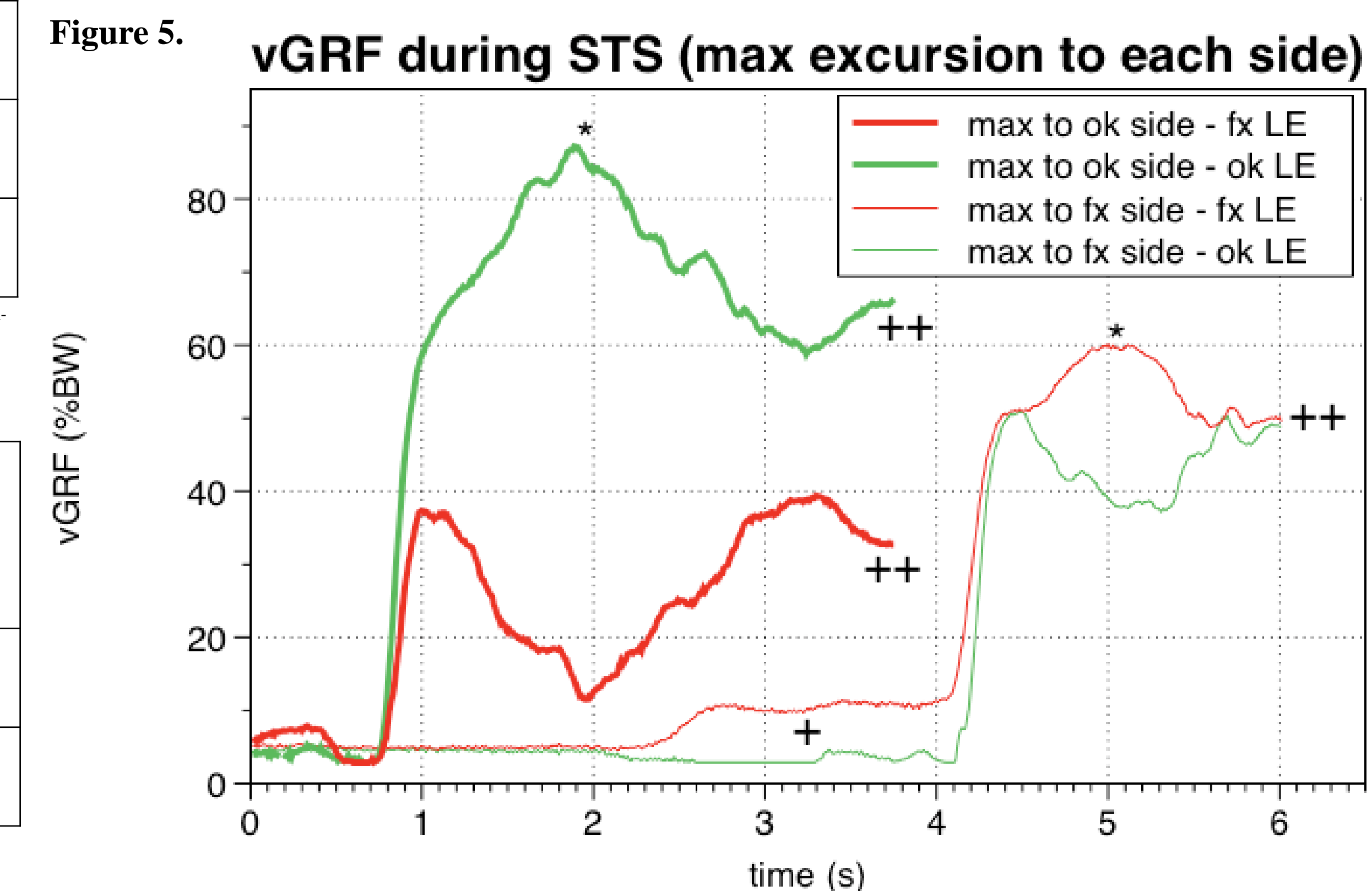
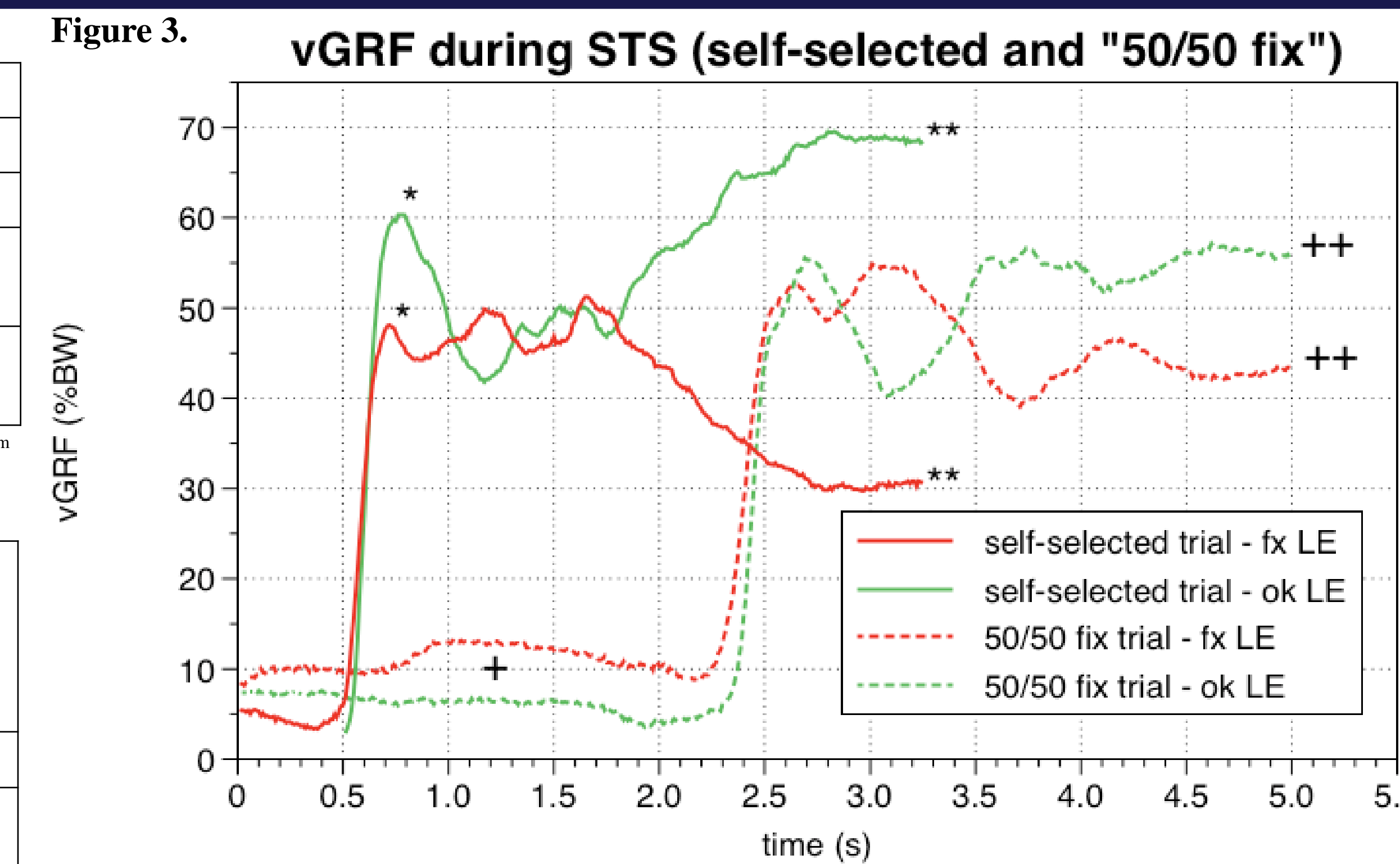
Task: match a self-selected standing lateral shift using...	vGRF of initial shift (% BW)	vGRF of shift match (% BW)	Success of vGRF match (% BW)	VAS rating of shift match (% max)
...fx LE as standard	71 <sup>6</sup> (*)	89 <sup>6</sup> (**)	Over-shot by 18%	84
...ok LE as standard	87	65	Under-shot by 22%	72

Abbreviations: vGRF, vertical ground reaction force; BW, body weight; VAS, visual analog scale; LE, lower extremity; ok, non-fractured LE; fx, fractured LE  
Key: superscript <sup>6</sup> = see Figure 6; \* = see the \* icon on figure

**Figure 3:** After feedback was provided for the self-selected trial, the subject was able to improve their static standing asymmetry from 37% (self-selected) to 11% (50/50 fix trial). The subject used a pre-load strategy for the fx LE during the 50/50 STS trial.

**Figure 5:** With maximum excursion to each side during STS, the difference in peak vGRF for these separate conditions was 27% (87% ok side and 60% fx side). Notably, data for maximum excursion towards the fx side showed a pre-load strategy and that symmetry in static standing was achieved.

## Results



**Figure 4:** The COM data for self-selected (trial #1) STS shows a failed attempt to stand immediately followed by a compensatory strategy to bring COM more anteriorly and towards the unaffected side. The data in the coronal view for each of the conditions shows the subject's inability to maintain COM at midline in static standing.

**Figure 6:** Using each side as a reference for matching sense of load in standing, the subject demonstrated inability to accurately match the target references for each trial. Force plate data plotted here suggests that the subject's sense of effort was a main contributor for their attempts to complete the task.

## Discussion

These findings offer support to the clinically important concept that strength deficits alone do not fully explain loading asymmetry after hip fracture. Despite our subject's ability to accurately perceive movement and torque disparities, she was still unable to spontaneously correct loading asymmetries without feedback prior to practicing the task. That practice likely required her to make complex perceptual adjustments to recalibrate force generation using sense of effort. Considering these findings, perceptual matching tasks may be a useful clinical tool for recalibrating loading asymmetries during STS in patients post hip fracture.