

## Measuring the Impact of Motor Impairments on Reaching Function in Individuals with Chronic Hemiparetic Stroke

Sara A. Freed, SPT, Melissa M. Marwitz, SPT, James P. O'Brien, SPT, Jaylene D. Thompson, SPT, Rebecca Dugan, SPT, Qianyun Meng, SPT, Arek Solawa, SPT, and Amanda Tay, SPT

Faculty Preceptors: Grace C. Bellinger, MS, PhD (Cand.) and Michael D. Ellis, PT, DPT

Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

### Background

- Flexion synergy, weakness, and limited passive range of motion are common impairments following a stroke.
- These impairments are often studied in isolation leaving their relative predictive capacity of reaching function unknown.

### Research Objectives

- Evaluate the relative contribution of the impairments that impact reaching function in individuals with chronic moderate to severe hemiparetic stroke.
- Determine the independent contributions of these variables on reaching function to aid in the prioritization of interventions for this population.

### Participants

- N= 34 (23 males and 11 females;  $58.3 \pm 10.8$  years old;  $11.8 \pm 8.3$  years post-stroke;  $26 \pm 7$  out of 66 arm motor Fugl-Meyer score)
- Participants provided written consent and completed the IRB-approved study



Figure 1: Experimental setup for isometric measurement of shoulder and elbow strength

### Methods

- Movement kinematics and kinetics quantified using a robotic device (Figures 1 & 2)
- Isometric shoulder abduction and elbow extension strength measured through a load cell (Figure 1)
- Passive range of motion for elbow extension measured using goniometry at end-range with overpressure
- Three randomized dynamic protocols completed to quantify reaching function and the emergence and takeover thresholds of flexion synergy (Figure 4)
- Multiple linear regression used to determine the relative contributions of each impairment to reaching function



Figure 2: Experimental setup for dynamic measurement of reaching function and flexion synergy.

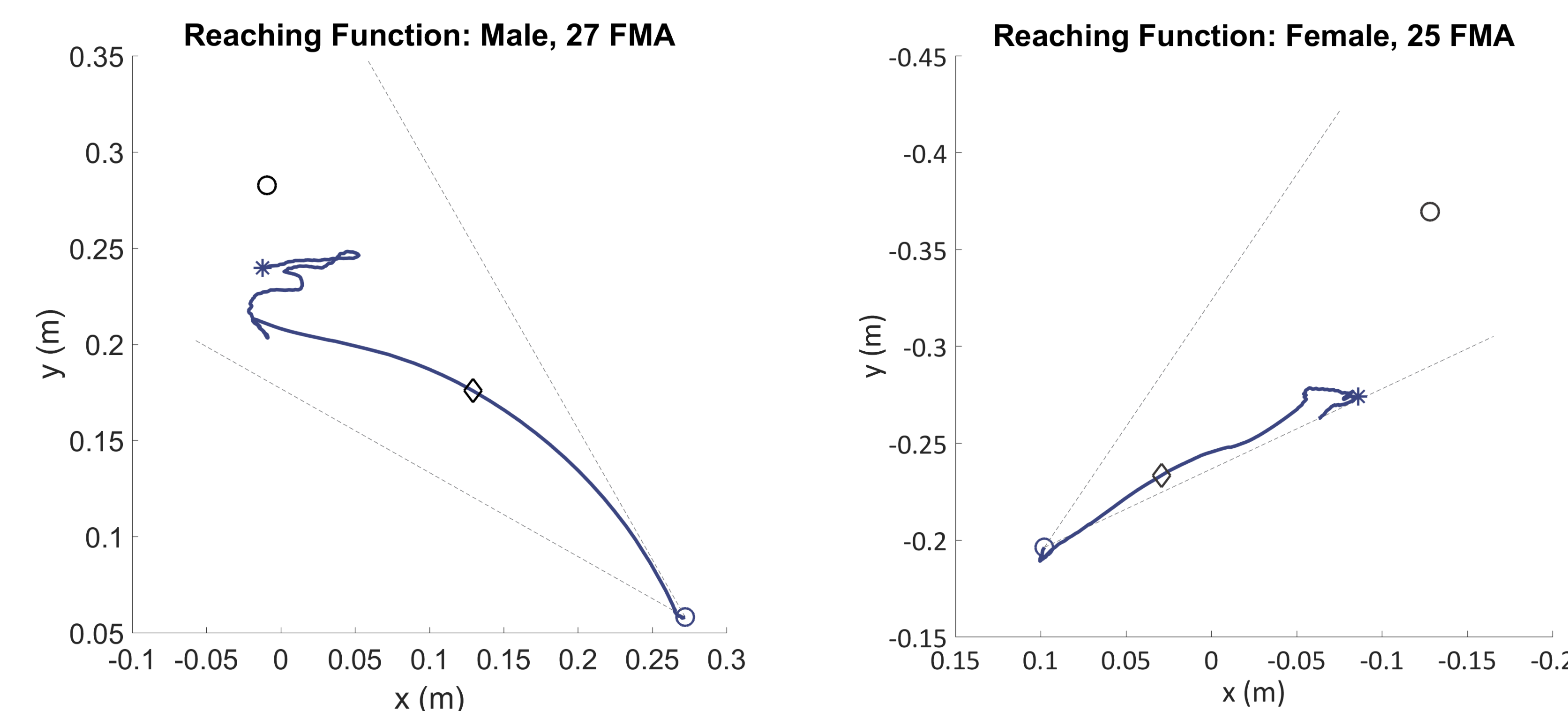


Figure 3: Reaching function was defined as the furthest distance achieved during planar reaches against gravity. The reaching target was standardized by joint angles and resulted in a reach to end range just lateral to the shoulder.

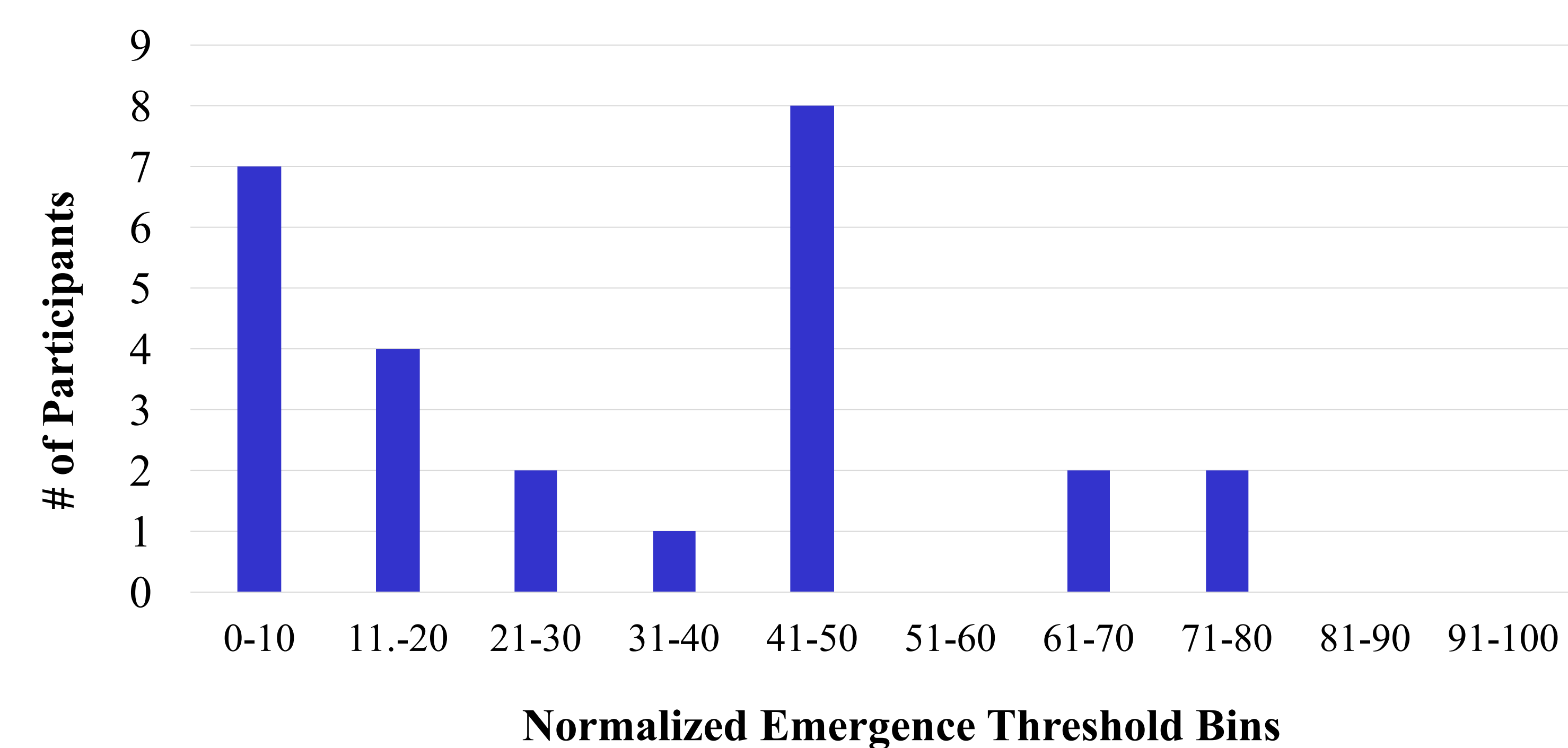


Figure 4: Histogram of the sample indicating the count of individuals at different levels of expression of flexion synergy as measured by the "Emergence Threshold." A lower number (0-10) indicates more severe expression of flexion synergy.

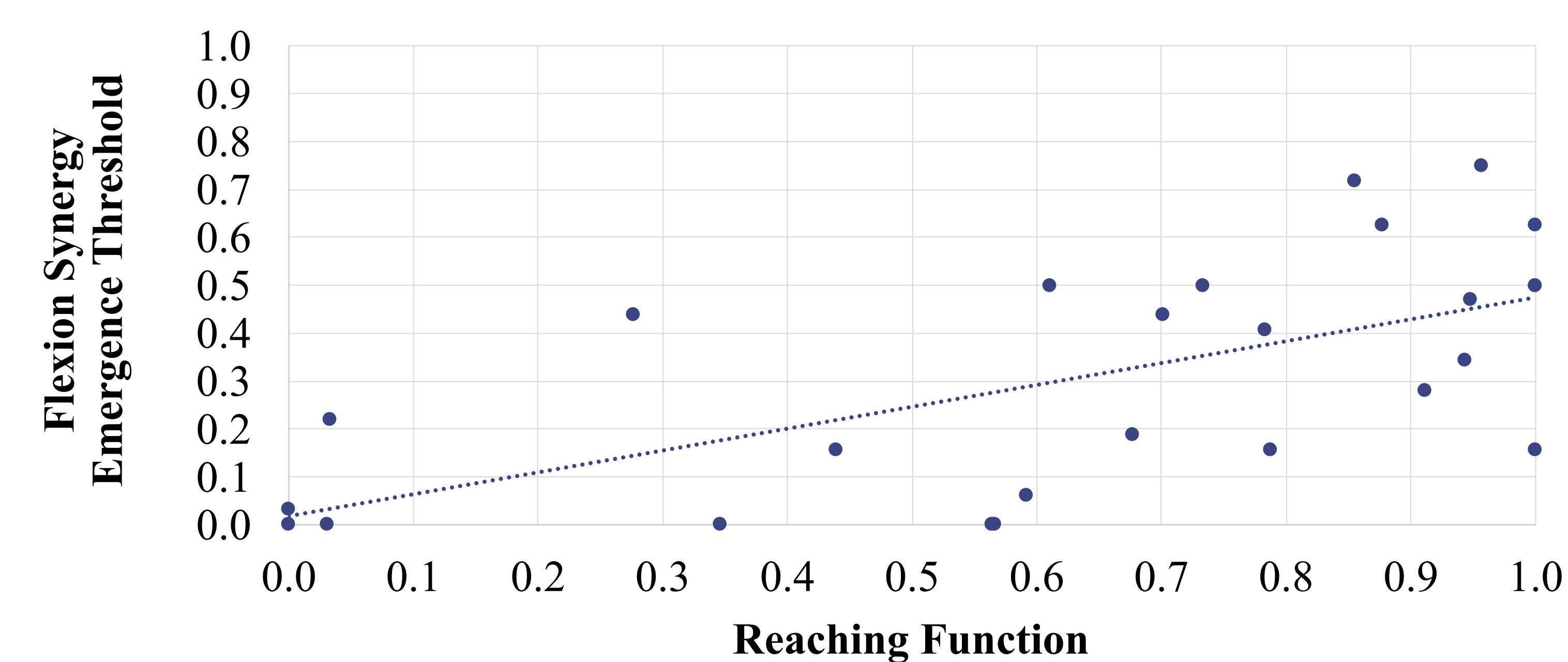


Figure 5: Scatter plot of normalized reaching function by flexion synergy emergence threshold. Regression line is shown for illustrative purposes.  $r = 0.63$ ,  $p = 0.001$ .

### Results

- Original model: significant regression equation was found ( $F(5,20) = 4.18$ ,  $p = 0.009$ ) with  $R^2$  of 0.511.
- Reaching function (Mean  $\pm$  SD;  $0.61 \pm 0.36$ ) was significantly correlated with flexion synergy emergence ( $0.31 \pm 0.24$ ,  $r = 0.63$ ,  $p = 0.001$ ), shoulder abduction strength ( $0.56 \pm 0.19$ ,  $r = 0.39$ ,  $p = 0.023$ ), and elbow extension strength ( $0.44 \pm 0.19$ ,  $r = 0.41$ ,  $p = 0.017$ ).
- Passive range of motion and flexion synergy takeover did not have significant correlations ( $p > 0.05$ ) with reaching function.
- Flexion synergy emergence was the only significant regressor with a standardized beta coefficient of 0.585 ( $p = 0.007$ ).
- Second model with non-correlated regressors removed: significant regression equation was found ( $F(3, 22) = 6.858$ ,  $p = 0.002$ ) with  $R^2$  of 0.483.
- Flexion synergy emergence was the only significant regressor with a standardized beta coefficient of 0.521 ( $p = 0.005$ ).

### Conclusions

- The findings of this study indicate that impairments such as strength and passive range of motion may not contribute to reaching dysfunction to the same extent as flexion synergy.
- The substantial contribution of flexion synergy to reaching function suggests that prioritizing flexion synergy impairment is likely to have the greatest impact when attempting to restore reaching function in chronic moderate to severe stroke.

### Limitations

- This study included a specific sample population which was limited to individuals with enough function in the affected arm to elevate against gravity to shoulder height in order to quantify reaching function.
- The study was also limited to a sample with moderate to severe generalized impairment as measured by the arm motor Fugl-Meyer score.