

Upper Extremity Symmetry Differences among Healthy Subjects Performing Activities of Daily Living

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INTRODUCTION: Hand laterality (handedness) significantly influences Activities of Daily Living (ADL). Various conditions such as stroke and cerebral palsy can cause asymmetry in hand skills, potentially impacting the performance of ADLs. This study investigates the use of a 3D motion analysis submovement decomposition method in detecting hand asymmetries in healthy individuals during tasks that simulate everyday activities.

METHODS: Using a motion capture system, we recorded the movements of 25 healthy subjects performing ADLs at a frequency of 100Hz. We positioned 21 markers on the upper extremities and torso to capture the three-dimensional positions of shoulder, elbow, and wrist joints. Subjects performed three tasks: stacking six blocks, transferring a large ring from one hand to another and placing it on a contralateral cone, and reaching out to push a button to the front and ipsilateral side of the torso. Each task was performed three times with both the self-reported dominant and non-dominant hands. We processed positional data, removed noise, and established x (anterior-posterior), y (medial-lateral), and z (superior-inferior) planes. After obtaining velocities, we marked trial start and end using wrist velocity criteria and decomposed each trial into submovements. From here, the absolute values of the mean velocities, as well as the average submovement lengths, were extracted and aggregated—with higher average velocities and longer submotion lengths indicating more fluid and efficient motion. Differences in velocity means and submotion length between dominant and non-dominant limbs were then identified using paired t-tests.

RESULTS: Figure 1 illustrates the distribution of dominant and non-dominant limb submovement mean velocities in ring placement and block stacking tasks using a parallel coordinate line segment plot. Each task is decomposed into x, y, and z axes plots. Figure 2 further examines these tasks by depicting average submotion length in the same axes. Corresponding t-statistics and p-values are displayed above the plots. Below this, Table 1 contains the set of t-statistics and p-values for the same wrist sensor across activities and features.

DISCUSSION AND CONCLUSION: Our study suggests ring placement exhibits more significant hand asymmetry than block stacking in healthy subjects, especially in the superior-inferior and anterior-posterior plane. Using Sensor A on the lateral wrist as an illustrative example, we can observe how block and ring placement tasks differ in terms of dominant to non-dominant laterality. At a glance, a stronger downward trend for both mean submovement velocity (Figure 1) and length (Figure 2) is clear in the superior-inferior and anterior-posterior planes with ring placement compared to the block stacking task, and this observation persists in their respective t-statistic and p-scores in Table 1. In the medial-lateral plane, both tasks exhibit relatively minimal asymmetry. From here, we plan to further investigate asymmetry across the remaining sensors and ADL, ultimately to provide context for better assessing musculoskeletal interventions.

Figure 1: Block (top) vs Ring Stacking Laterality in Mean Submovement Velocity (x,y,z)

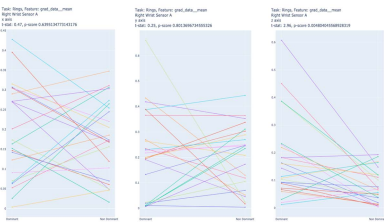
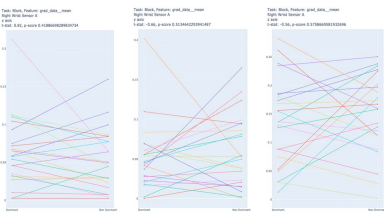


Figure 2: Block (top) vs Ring Stacking Laterality in Mean Submovement Length (x,y,z)

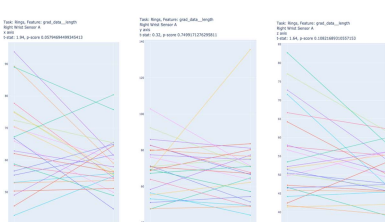
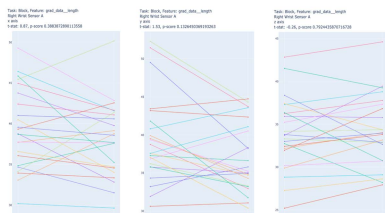


TABLE 1: Dominant vs. Non Dominant, Velocity and Submotion Length, Wrist Sensor A

Feature 1: Mean Velocity		
Task 1: Block Stacking		
	t-statistic	p-score
x (anterior-posterior)	0.8160	0.4189
y (medial-lateral)	-0.6588	0.5134
z (superior-inferior)	-0.5636	0.5759
Task 2: Ring Placement		
	t-statistic	p-score
x	0.4715	0.6395
y	0.2530	0.8013
z	2.9635	0.0048
Feature 2: Submovement Length		
Task 1: Block Stacking		
	t-statistic	p-score
x	0.8711	0.3883
y	1.5321	0.1326
z	-0.264	0.7924
Task 2: Ring Placement		
	t-statistic	p-score
x	1.9446	0.0579
y	0.3207	0.7499
z	1.6381	0.1082