

A Modern Biomechanical Assessment of Functional Elbow Motion Utilizing Motion Capture Software

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INTRODUCTION:

The landmark 1981 paper by Morrey et al. used a triaxial electrogoniometer affixed to the arm and forearm to demonstrate that people need 30-130° of elbow flexion and rotation from 50° of supination to 50° of pronation to perform most activities of daily living (ADLs).¹ The present study seeks to address two hypotheses: (1) use of an inertial motion capture system to measure elbow joint angles during ADLs will result in a different range of elbow motion than historic values measured with triaxial electrogoniometer, and (2) the elbow motion required to perform office tasks requires a different functional range of motion compared to previously tested ADLs.

METHODS:

Healthy volunteers without history of elbow-related injuries or surgery were prospectively enrolled at a single institution over a one-month period. Participants were fitted with ten XSens MVN motion capture system sensors, and were calibrated so that real-time motion arcs could be captured using the XSens Analyze software. They were then asked to complete twenty-three movements related to hygiene, activities of daily living, and workplace tasks. Joint angle data were then aggregated to determine mean elbow flexion and pronosupination angles needed to complete each task.

RESULTS:

When assessed with an inertial motion capture system, most hygiene tasks could be achieved within the flexion-extension arc previously described by Morrey et al; however, tasks performed at the center of the body (neck, chest, and sacrum) tended to be performed with greater amounts of supination than previously described (Table 1 and 2). Notably, reaching to the pubis, as a proxy for perineal care, and tying a shoe required the greatest pronation of the hygiene tasks. Performing most office tasks required more elbow pronation than any tasks related to hygiene. Using a computer mouse and reaching for a desk phone both required more elbow extension than what has previously been described as an acceptable range of motion (Figure 1 and 2).

DISCUSSION AND CONCLUSION:

Analysis of elbow kinematics with inertial motion capture yields similar flexion-extension arcs needed for hygiene tasks but demonstrates a greater rotation arc than previously described with triaxial goniometer. Performing office tasks on a desk requires approximately 15-40° of elbow pronation. Results of this study add to the body of evidence helping surgeons make disability determinations, advise patients following elbow trauma, and advocate for assistive devices based on patient and occupational needs.

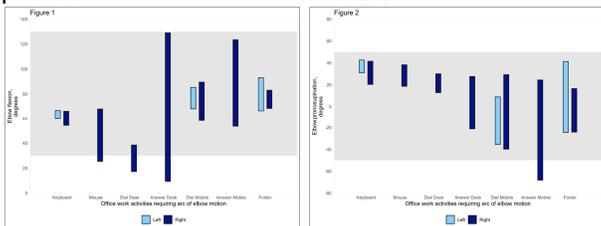


Table 1
Elbow Flexion During Routine Personal Care and Hygiene (Mean and Standard Deviation)

Position	Elbow Flexion (Degrees)		
	Motion Capture	Triaxial Goniometer*	Difference
Head to:			
Vertex	116.1 +/- 9.0	118.6 +/- 6.1	-2.5
Occiput	129.7 +/- 9.1	144.0 +/- 7.0	-14.3
Canthus	126.3 +/- 6.7	-	-
Neck (jugular n)	142.7 +/- 9.0	134.7 +/- 5.2	8.0
Chest (nipple)	132.9 +/- 15.9	120.0 +/- 8.2	12.9
Belt Buckle	98.6 +/- 27.4	100.4 +/- 13.2	-41.8
Scapula	126.0 +/- 23.4	-	-
Sacrum	66.6 +/- 26.5	69.7 +/- 12.4	-3.1
Pubis	17.8 +/- 11.4	-	-
Shoe	6.8 +/- 4.0	16.0 +/- 6.3	-9.2

*Historic values: Morrey et al. JBJS Am. 1981. - denotes tasks not previously tested.

Table 2
Elbow Pronosupination During Routine Personal Care and Hygiene (Mean and Standard Deviation)

Position	Elbow Pronosupination (Degrees)**		
	Motion Capture	Triaxial Goniometer*	Difference
Head to:			
Vertex	-46.3 +/- 16.4	-46.6 +/- 16.0	0.3
Occiput	4.7 +/- 23.3	-2.0 +/- 23.0	6.7
Canthus	-30.7 +/- 21.9	-	-
Neck (jugular n)	-68.8 +/- 17.5	-40.9 +/- 16.3	27.9
Chest (nipple)	-62.0 +/- 15.7	-29.4 +/- 19.2	35.5
Belt Buckle	2.9 +/- 28.6	-11.9 +/- 23.8	13.9
Scapula	-28.0 +/- 47.4	-	-
Sacrum	-64.3 +/- 26.2	-55.8 +/- 20.1	8.5
Pubis	22.8 +/- 19.9	-	-
Shoe	19.2 +/- 17.2	19.0 +/- 17.2	0.2

**Historic values: Morrey et al. JBJS Am. 1981. - denotes tasks not previously tested. **negative values represent hand in a supinated position