# THREE DIMENSIONAL UPPER EXTREMITY KINEMATICS IN A YOUNG ADULT AND PEDIATRIC POPULATION WHILE PERFORMING AN EATING TASK

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## INTRODUCTION

Little is known about upper extremity (UE) biomechanics during activities of daily living (ADLs) in children. In addition, few researchers have examined age-related differences in UE kinematics during such tasks. Establishing a database of UE movement patterns in pediatric and young adult populations is important as it will allow researchers to increase their understanding of UE movement as a function of age. Knowledge of typical UE movement will also be useful for the identification of movement deviations in clinical populations of the same age (e.g. cerebral palsy). Therefore, the purpose of this research was to quantify and compare age-related differences in three-dimensional upper extremity kinematics between a young adult and pediatric group during an eating task.

## METHOD

### Participants
Fifteen young adults (n=15; 5 male, 10 female), aged 18-24 years (mean age: 20.2 years), and fifteen paediatric participants (n=15; 5 male, 10 female) aged 7-9 years (mean age: 8.3 years) participated in the study with consent. Participants were excluded if there was a history of UE disorders such as fractures, major lacerations, or burns. Participants were recruited from the Fredericton area through advertisements and word-of-mouth. The protocol was approved by the University of New Brunswick Research Ethics Committee.

### Instrumentation
An eight-camera Vicon MX motion capture system (Oxford Metrics Ltd., Oxford, UK) was employed to track the three-dimensional trajectories of eighteen (n=18) reflective markers placed on the participants' skin at a sampling frequency of 60 Hz. Rigid body segments included the head, trunk, and the left and right upper arm, forearm, and hand. The marker locations were a modified version of Rab et al. [1].

### Procedures
All data collection occurred in the Motion Analysis Lab at the University of New Brunswick. Participants wore a tank top to allow adhesion of the markers directly to the skin. Each participant was asked to perform an eating task, which involved scooping pudding from a bowl with a spoon. For each participant, trials were completed for both the dominant and non-dominant arms. Three trials were collected for each arm while performing the task. A height adjustable stool and table was used to standardize the starting posture of each participant (knee flexion and elbow flexion at 90 degrees, palms face down on table and shoulder width apart).

### Data Analysis
Coordinate data was exported from Vicon in binary c3d files. Data was then imported into Matlab (Mathworks, Inc) for further processing using custom-made software. Coordinate data was filtered using a second order, zero lag low-pass Butterworth filter at a cutoff frequency of 6Hz. The body was modeled as a series of rigid links joined by 2-3 degree of freedom articulations. The wrist and joint centres were calculated using the midpoint between the ulnar and styloid markers, and lateral and medial epicondyles, respectively. The shoulder joint centre was approximated using de Leva's method [2]. Embedded or local coordinate systems were computed at the joint centre for each segment. Joint angles were then computed from the relative orientations of the embedded coordinate systems using Euler angles. A y-x-z rotation sequence was used, corresponding to flexion/extension,

adduction/abduction, and internal/external rotation. Temporal-spatial variables were also analyzed for all tasks and included cycle time and task phase duration.

For the statistical analyses, independent variables were age group (n=2), and arm (n=2). Dependent variables included range, maximum, and minimum values of Euler angles for the eating task. Two-way ANOVAs were used to test for significant ($p<0.05$) differences in Euler angle data across age groups and dominant/non-dominant arms.

## RESULTS

Significant differences ($p<0.05$) in mean joint angle parameters (max, min, range) were found between age groups for the eating task. No significant differences in mean joint angles were found between the dominant and non-dominant arms. Mean and standard deviations of the selected joint angle parameters for the young adult and paediatric group are provided in Table 1. The young adult had a significantly larger mean maximum elbow flexion (Figure 1) than the paediatric group during phase 1 of the eating task (hand lifts a spoonful of pudding from the bowl to the mouth). The young adult group also had a significantly larger mean maximum elbow flexion angle than the paediatric group during phase 2 of the eating task (return spoon from mouth to bowl). Finally, the young adult had a significantly larger mean range of elbow flexion in phase 2 and a significantly lower mean range of shoulder rotation than the paediatric group during phase 1 of the eating task. On average the percentage of time spent in each phase was similar for the paediatric (phase 1: 56%) and young adult (phase 1: 58%) groups.

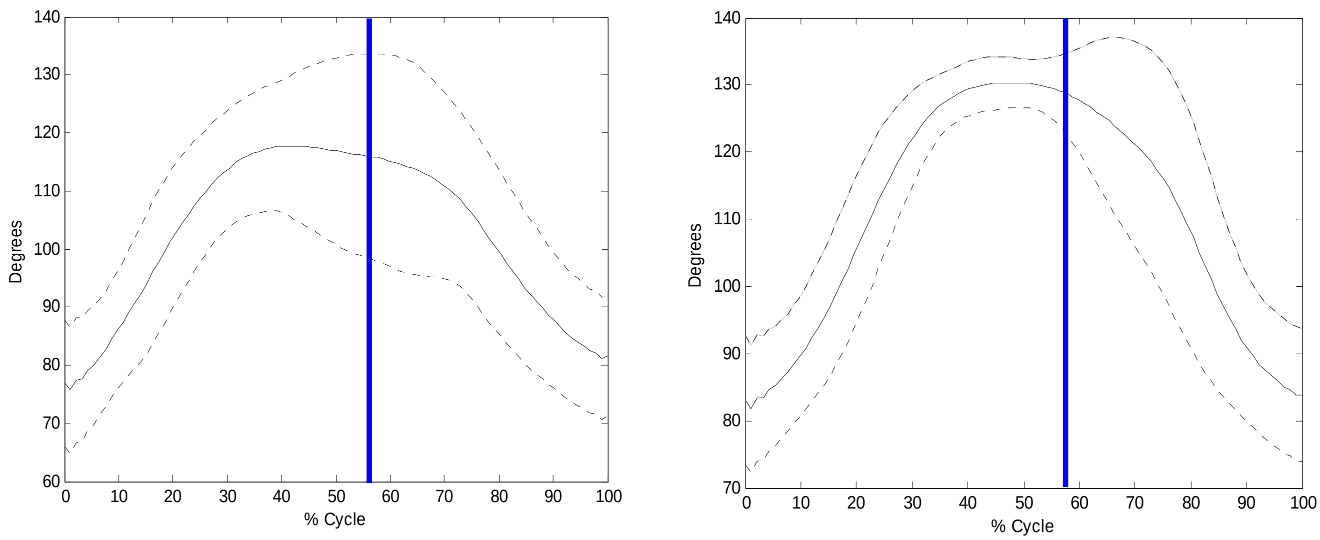


**Figure 1.** Mean ± 1 SD for elbow flexion for the eating task (A) Paediatric Group, (B) Young Adult Group (blue line represents the end of phase 1 and the beginning of phase 2).

## DISCUSSION

The purpose of this study was to examine the age-related differences in three-dimensional upper extremity kinematics between a young adult and pediatric group while performing an ADL. Results showed significant differences in joint angle parameters between age groups for the eating task. The young adult group had significantly increased elbow flexion angles and range of motion, and decreased shoulder range of motion (rotation) compared to the paediatric group. An examination of all joint rotations revealed that compared to the paediatric group, the young adult group typically completed the eating task using less shoulder abduction and

**Table 1:** Descriptive data for angle parameters during the eating task for the young adult and paediatric group

| Group | Angle Parameter (Degrees) | Phase 1 | | Phase 2 | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| Paediatric | Max Elbow Flexion | **116.41** | 11.27 | **114.92** | 11.86 |
| Young Adult | | **128.22** | 5.78 | **126.89** | 5.81 |
| Paediatric | Range of Elbow Flexion | 51.43 | 12.8 | **35.32** | 14.49 |
| Young Adult | | 55.71 | 12.18 | **45.93** | 10.84 |
| Paediatric | Min Elbow Rotation | -37.44 | 21.23 | -29.14 | 24.07 |
| Young Adult | | -52.02 | 20.2 | -44.6 | 19.75 |
| Paediatric | Range Elbow Rotation | 64.98 | 17.29 | 75.53 | 18.22 |
| Young Adult | | 56.01 | 21.1 | 75.93 | 13.68 |
| Paediatric | Max Shoulder Flexion | 65.21 | 18.69 | 63.93 | 18.16 |
| Young Adult | | 66.59 | 21.44 | 66.25 | 21.22 |
| Paediatric | Range of Shoulder Flexion | 31.61 | 14.67 | 23.91 | 10.47 |
| Young Adult | | 27.49 | 9.29 | 20.84 | 7.97 |
| Paediatric | Range of Shoulder Abduction | 14.49 | 6.8 | 9.02 | 5.61 |
| Young Adult | | 10.03 | 6.57 | 7.4 | 4.61 |
| Paediatric | Range of Shoulder Rotation | **19.82** | 7.88 | 20.17 | 11.1 |
| Young Adult | | **13.98** | 5.29 | 13.88 | 7.8 |

**Significant differences between groups (*p*<0.05) are in bold**

more shoulder, elbow, and wrist flexion. In contrast, the paediatric group demonstrated less flexion across the joints and greater shoulder abduction. Therefore, age-related differences may exist in terms of the techniques used to complete the eating task. Differences in task experience and anthropometrics likely contributed to the differential movement patterns across the two age groups.

Previous studies examining upper extremity kinematics during eating tasks have reported higher mean maximum elbow flexion angles compared to the present study [3-5]. It is likely that differences in task definitions and protocol were responsible for these differences. For example, Mackey et al. [4] did not use a spoon for the hand to mouth task, which may have increased their mean maximum elbow flexion measurement. In addition, only two studies could be identified in which participants were of similar age [3,5].

Differences in UE kinematics between pediatric and young adult age groups demonstrate the importance of using age-matched control groups in clinical studies. Future work will focus on increasing sample sizes, validating findings, and establishing a control database for clinical applications.

## ACKNOWLEDGEMENTS

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## REFERENCES

[1] G. Rab, K. Petuskey, and A. Bagley, “A method for determination of upper extremity kinematics,” *Gait & Posture*, vol. 15, pp. 113-119, 2002.
[2] P. de Leva, “Joint center longitudinal positions computed from a selected subset of chandler's data,” *Journal of Biomechanics*, vol. 29, pp. 1231-123.
[3] D.J. Magermans, E. Chadwick, H. Veeger, and F. VanderHelm, “Requirements for upper extremity motions during activities of daily living”, Clinical Biomechanics, vol. 20, 591-599, 2005.

[4] A. Mackey, S. Walt, and N. Stott, “Deficits in upperlimb task performance in children with hemiplegic cerebral palsy as defined by 3-dimensional kinematics,” Archives of Physical Medicine and Rehabilitation, vol.87, pp. 207-215, 2006.
[5] I. Murray, and G. Johnson, “A study of the external forces and moments at the shoulder and elbow while performing everyday tasks,” Clinical Biomechanics, vol.19,586-594.