Evaluation of the Effectiveness of a Re-designed Pipette for Reducing the Risk Factors for Musculoskeletal Disorders

Ming-Lun (Jack) Lu, Ph.D.
Sunil Sudhakaran, M.S. AEP

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Background

- Part of the NORA Ergonomic Intervention Project for evaluation of effectiveness of engineering interventions
- NIOSH/Duke University collaboration
- Can ergonomic design of pipettes reduce stressors related to upper limb musculoskeletal disorders (MSDs)?

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What is a Pipette?

- A device used to transfer an exactly defined quantity of liquid from one vessel to another, which involves picking up pipette and tip, aspirating, overblowing and ejecting tip (5 major actions)
- Most pipettes used in labs are single-channel and elongated/axial in shape

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Physical Risk Factors for Pipetting

- Highly repetitive thumb exertions for operating pipette plunger and eject trigger as a result of short cycle time (3-10 sec at Duke)
- Postural stresses include awkward and static shoulder elevation, forearm rotation, elbow flexion, and wrist deviation

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Pipetting and MSD's

- The relationship between pipetting and MSD development remains largely unknown
- The literature suggests that prolonged pipetting may increase the risk for upper limb MSD's (Bjorkstn et al, 1994; Fredriksson, 1995; David and Buckle, 1997)

Objective

- To determine whether the re-designed pipette (i.e. ergonomic intervention) significantly reduces the MSD physical risk factors associated with pipetting

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Participants

- 11 female and 1 male full-time pipette users from two clinical labs of Duke University participated in the simulation of pipetting
- Simulation was conducted in their labs

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Pipettes Evaluated

Eppendorf Reference

100-1000 µL volume

Oxford Benchmate II

100-1000 µL volume

VistaLab Ovation BioNature

100-1000 µL volume

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Data Collection

- Thumb and total finger forces using 19 FlexiForce™ sensors
- Outcome variables:
  - Thumb force: force data of 2 sensors
  - Total finger force: sum of force data of all 19 sensors

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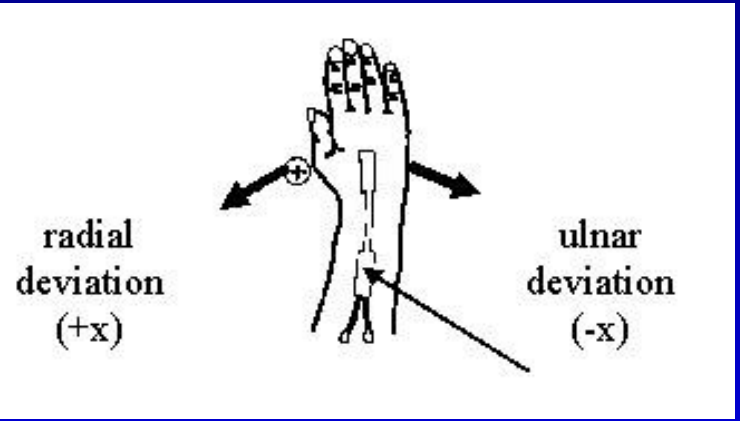
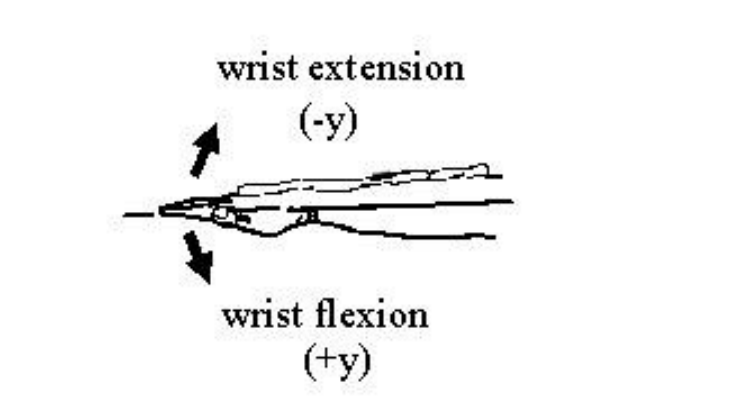
Data Collection (cont.)

- Wrist posture and forearm rotation using a twin axis electrogoniometer and a torsiometer
- Outcome variables:
  - Wrist ulnar/radial deviation
  - Wrist flexion/extension
  - Forearm pronation/supination

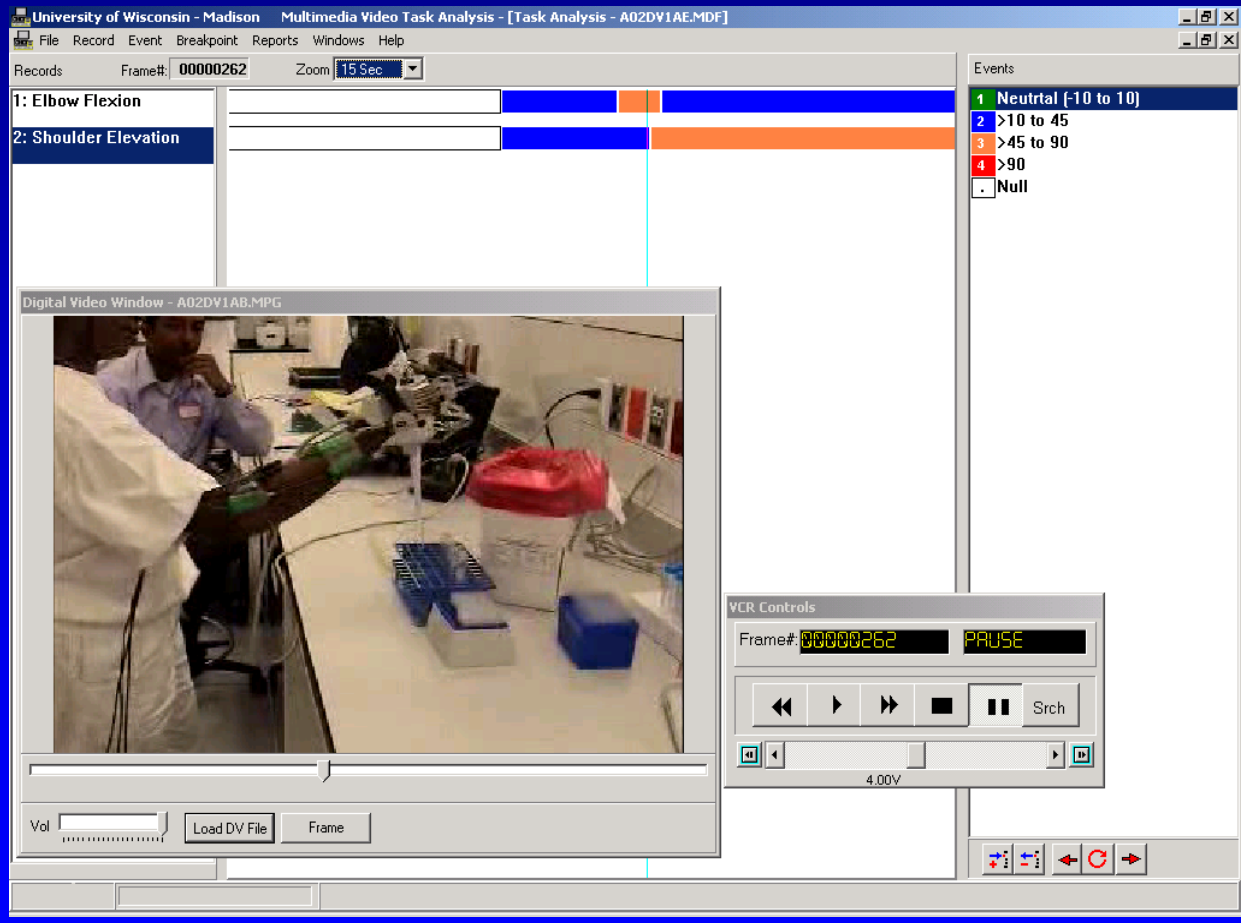


Electrogoniometer



Data Collection (cont.)

- Shoulder elevation using video data analyzed with Multimedia Video Task Analysis™ software
  - Outcome variable: shoulder elevation greater than 45°



Experimental Design

- Repeated measure on four independent variables (pipette type, task, volume, position)
- Randomized complete-block design for the four independent variables (3 types of pipettes, 2 hands/1 hand, 200μL/1000μL, standing/seated)
- A total of 24 trials (3 pipettes × 2 tasks × 2 volumes × 2 positions) were completed by each participant

Sample Trials

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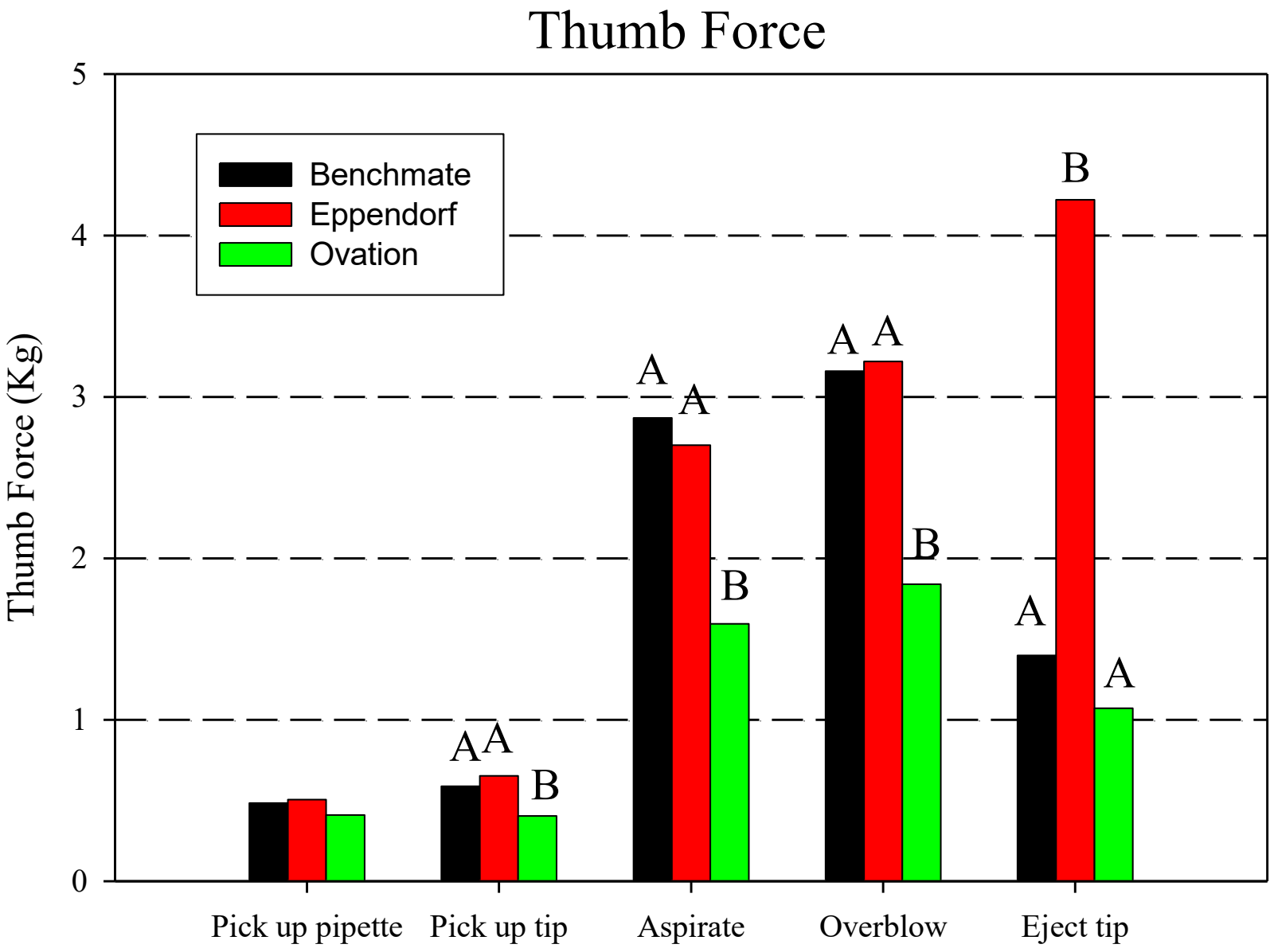
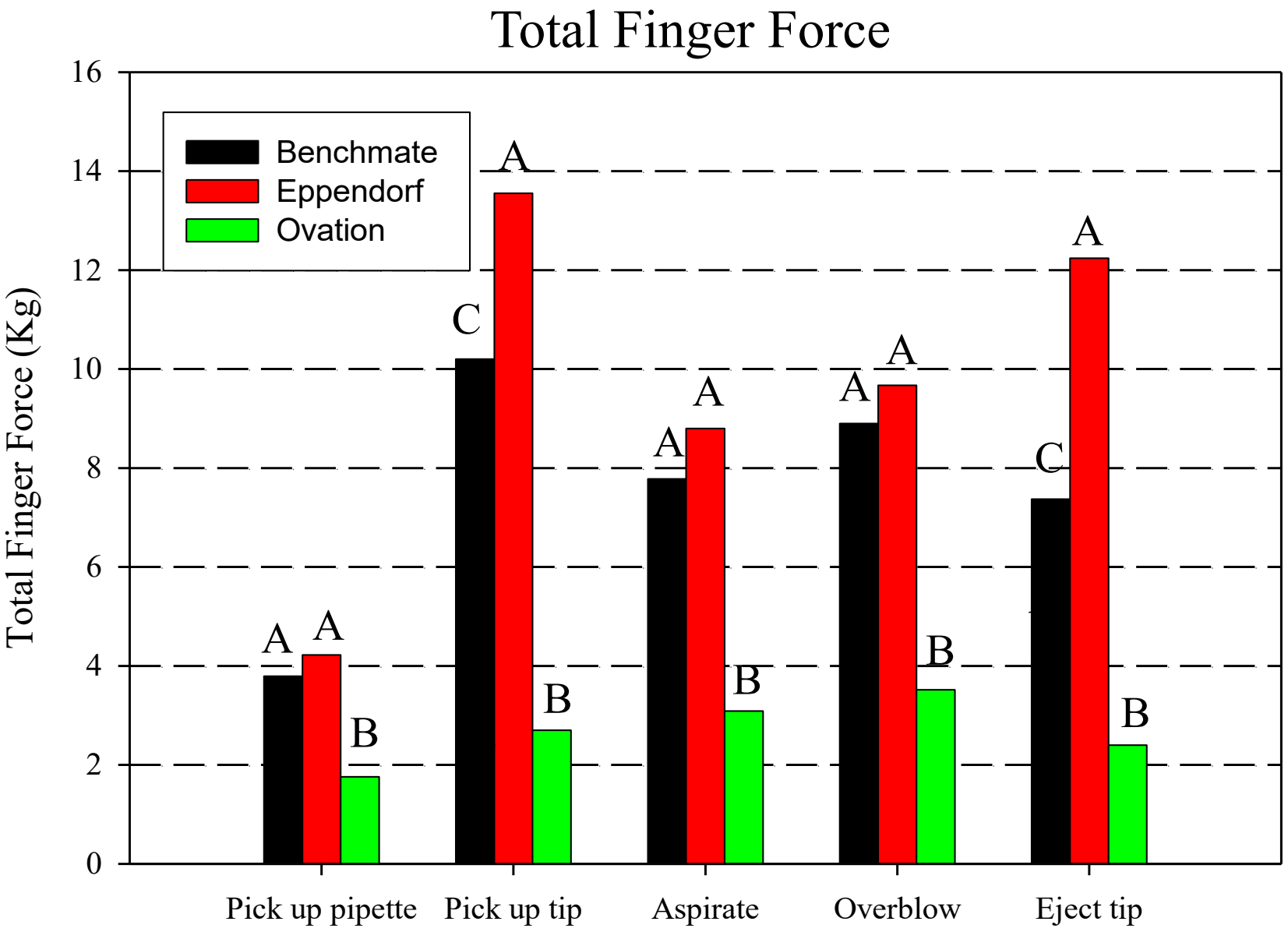
Data Analysis

- The mean values of the force and goniometry outcome variables were calculated for each action
- Percent time for shoulder elevation greater than 45° for each action was calculated with MVTA for each action
- All outcome variables are calculated for the following actions:
  - Pick up pipette
  - Pick up tip
  - Aspirate
  - Overblow
  - Eject tip
- ANOVA for each outcome variable each action was tested using PROC MIXED in SAS



Different letters indicate a significant difference ($p<0.05$)



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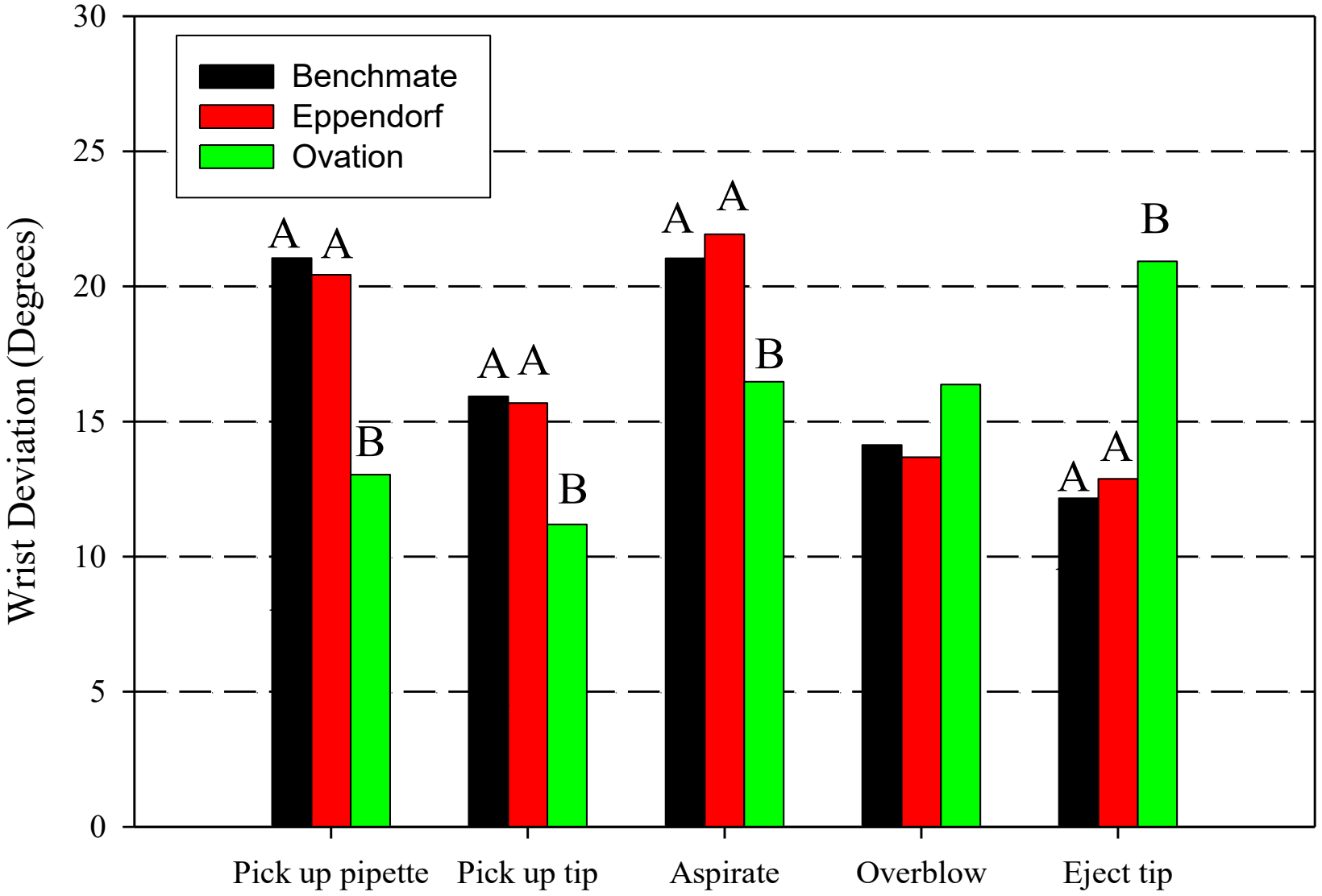
Wrist Deviation



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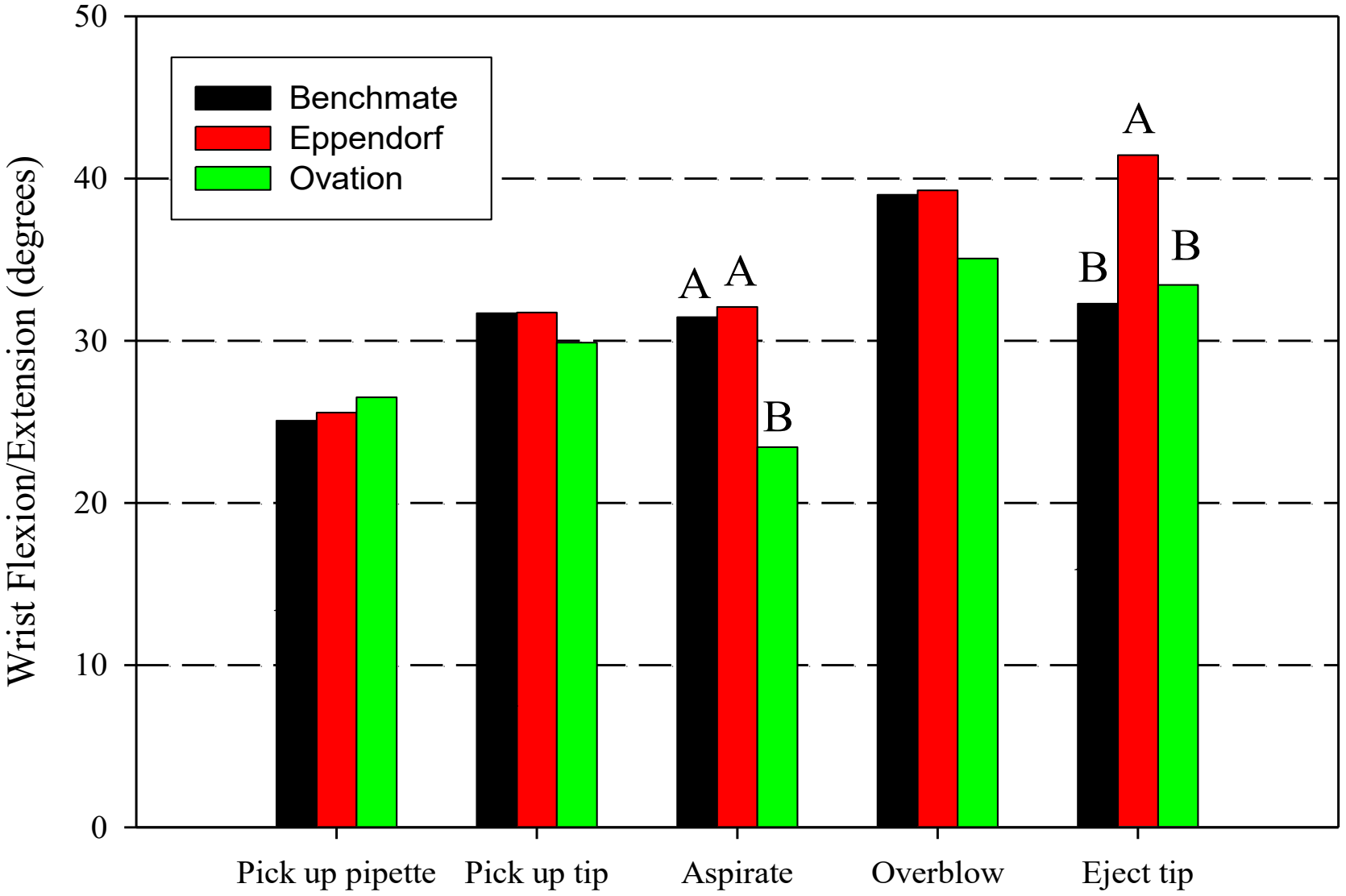
Wrist Flexion/Extension



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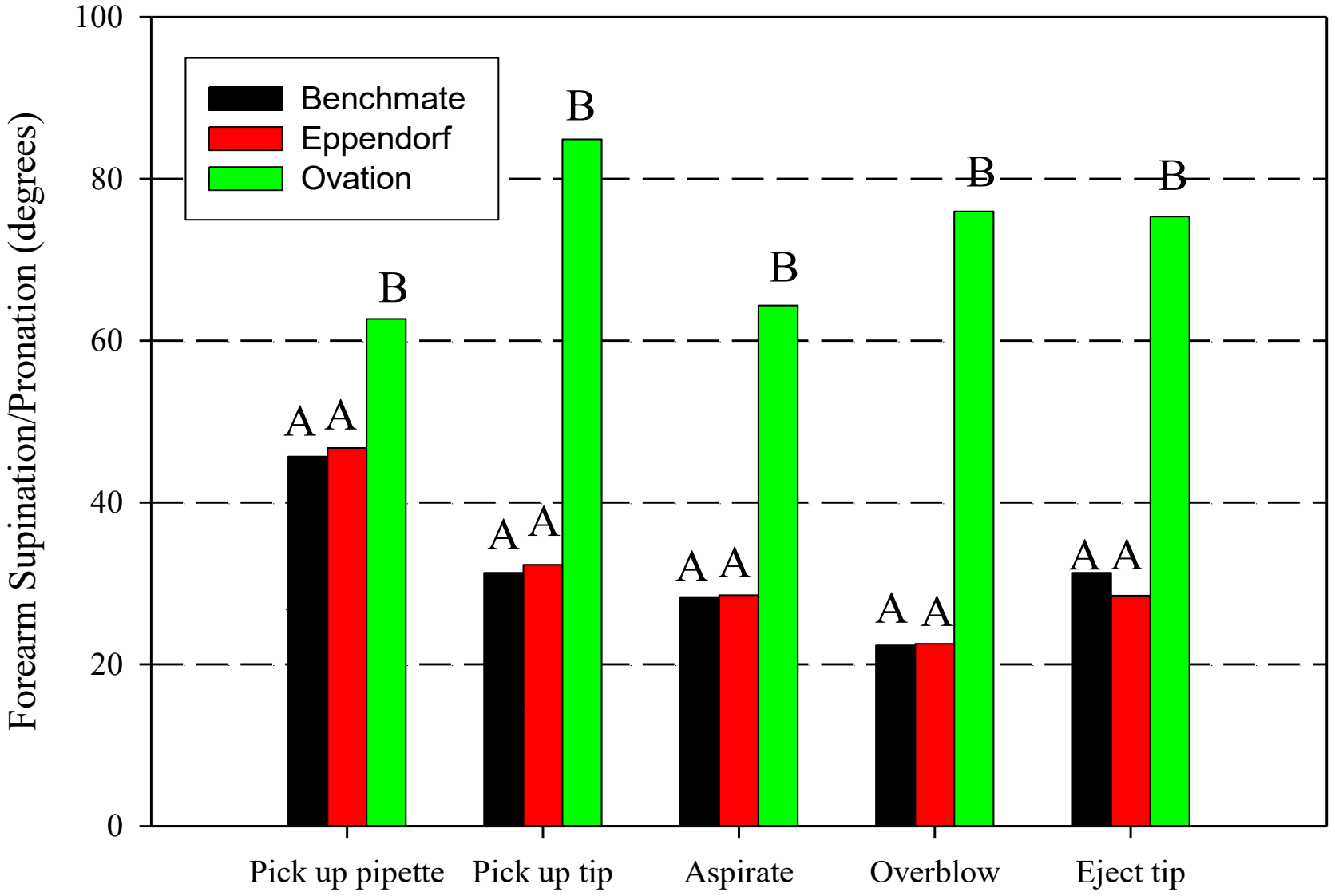
Forearm Rotation



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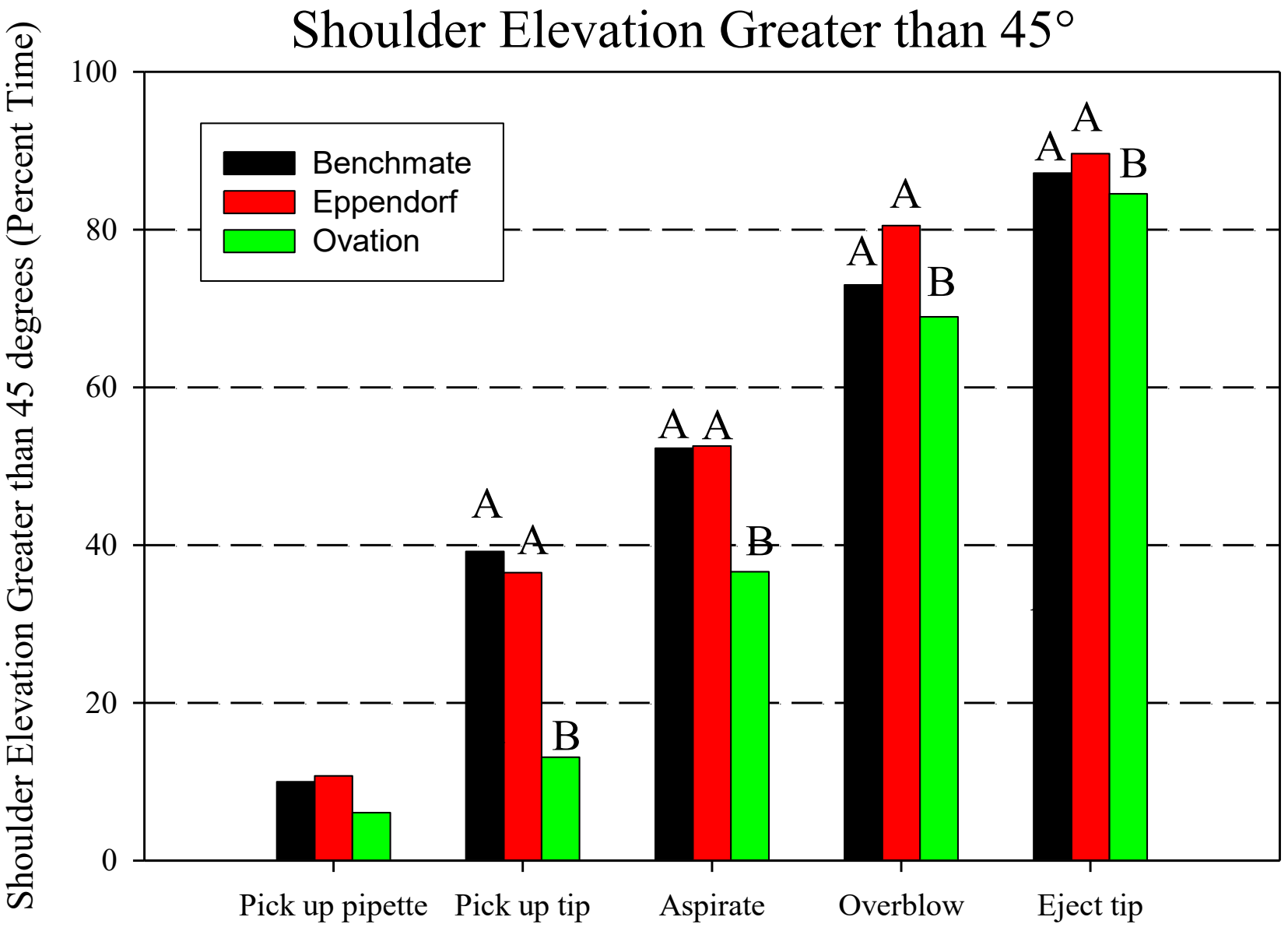

Different letters indicate a significant difference ($p<0.05$)

Other Significant Effects on the Outcome Variables

	Pick up pipette	Pick up tip	Aspirate	Overblow	Eject tip
Forearm rotation	None	Position	None	None	None
Wrist flex/Ext	Position	Position	Position	None	Position Task
Wrist deviation	Position	None	Position	None	Position
Shoulder elevation	Position	Position	Position Task	None	Position
Thumb force	None	None	None	None	None
Total finger force	None	None	None	None	None

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Discussion

- The Ovation pipette significantly reduced the thumb force and total finger force for every action of pipetting.
- The Ovation pipette significantly reduced wrist deviation and shoulder elevation for the majority of the actions of pipetting; however, it only significantly reduced wrist flexion/extension for aspiration.
- The ovation pipette required more forearm rotation (mainly pronation) than the other traditional pipettes. Forearm rotation with low force is less likely to cause hand/wrist MSD's, as compared to wrist deviation, flexion and extension.

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Conclusion

- The re-designed, low force pipette showed a significant reduction in the most important MSD risk factors for pipetting, as compared to two other traditional axial-design pipettes

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