Wearing Body Armor Changes Shoulder Girdle and Trunk Kinematics During Lifting

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Disclaimer and Non-Disclosure

The statements and opinions expressed during this presentation are those of the authors and do not necessarily reflect the opinions of their employers or any of their affiliated organizations.

- Joseph Kardouni has no conflicts to report
- Sandra John has no conflicts to report
- Emma Williams has no conflicts to report
- Bryan Riemann has no conflicts to report

Background

- Body armor protective equipment often worn by military and law enforcement personnel
- Body armor
  - Load over shoulder girdle
  - 7-9 kg mass
    - Can weigh more with additions
  - Additional mass around torso
- Wearing body armor in an operational environment is associated with back, neck, and upper extremity pain (Konitzer et al. 2008)

Purpose

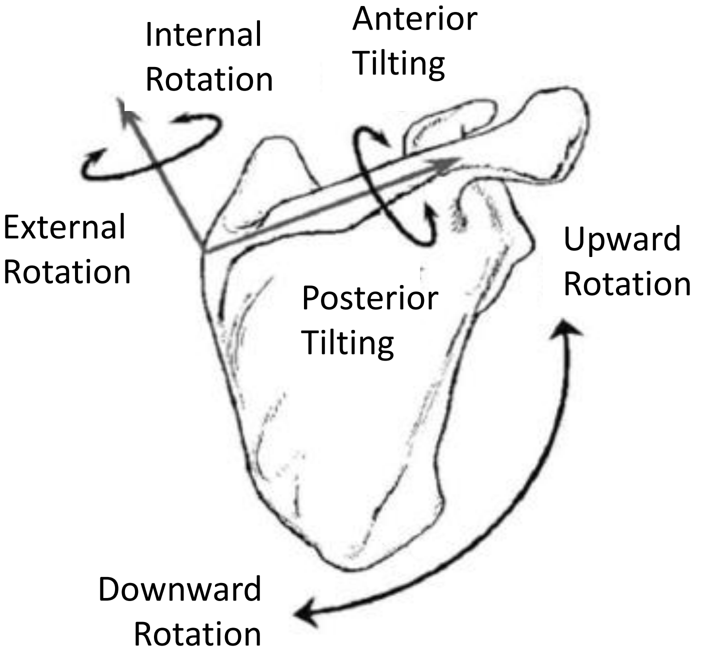
- Examine the effects of body armor on thoracic and shoulder girdle kinematics while lifting an ammunition can to a shelf at shoulder height and while moving the can from the shelf.

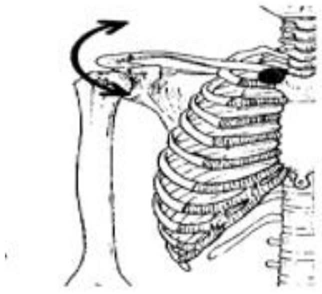
Methods

- Healthy participants
  - n=27 (15 female)
  - Age=24.4 ± 5.1, range 18-37
- Electromagnetic tracking system
  - 6-degrees of freedom
  - Sensors attached over
    - Thoracic spine
    - Scapula
    - Arm (humerus)
    - Forearm

Methods

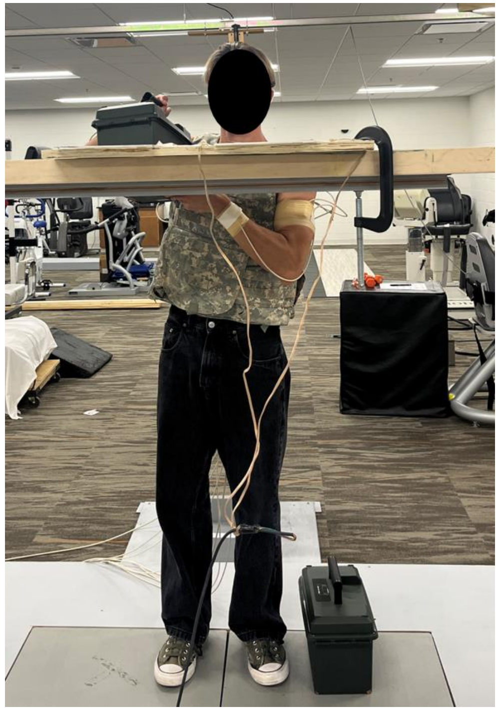
- Dependent variables
  - Thoracic motion
    - Flexion/extension
    - Rotation
    - Lateral flexion (side bending)
  - Scapular rotations
    - Upward/downward rotation
    - Internal/external rotation
    - Posterior/anterior tilting
  - Scapular positions
    - Clavicular elevation/depression
    - Clavicular protraction/retraction





Methods

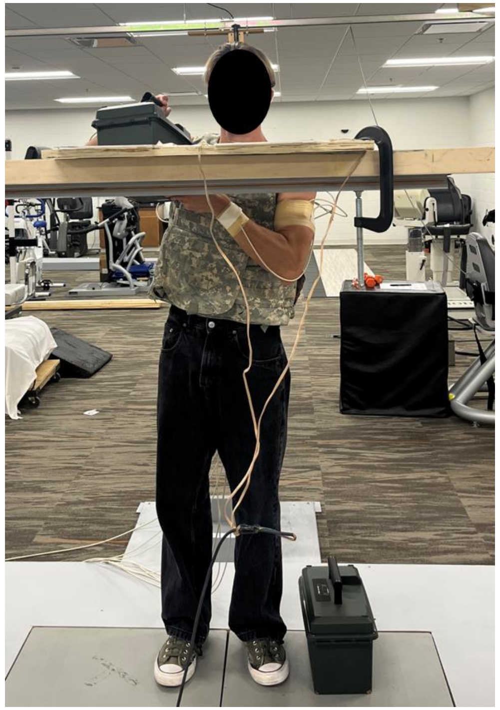
- Ammunition can lifting task
  - Feet shoulder-width apart
  - Can lateral to foot
  - Lift 12.5 kg ammunition can with right hand
  - Place onto shelf at shoulder (clavicle) height
  - 5 repetitions
  - Two Conditions: with Body Army, without Body Armor
- Ammunition can lowering task
  - Lift and lowered to the floor using their right hand
  - 5 repetitions
  - Two Conditions: with Body Army, without Body Armor
- Rest
  - 3 minutes between tasks
  - 1 minute between repetitions



Methods

- Kinematic data
  - Examined at:
    - Shoulder (glenohumeral) height during lifting
    - Immediately upon lifting from shelf
    - Shoulder (glenohumeral) height during lowering
  - Task (lift/lower) and Condition (BA/without BA) were randomized
  - Average of middle 3 repetitions
  - Right arm only for this analysis

- Paired t-test comparisons; Hegdes d
  - Shoulder (glenohumeral) height lifting
  - Immediately at lift off
  - Shoulder (glenohumeral) height lowering



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Lifting Task

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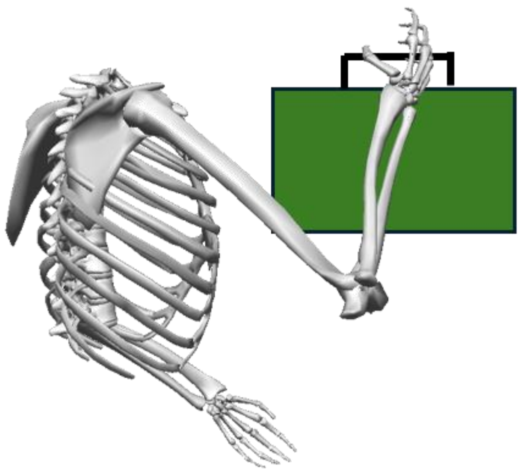
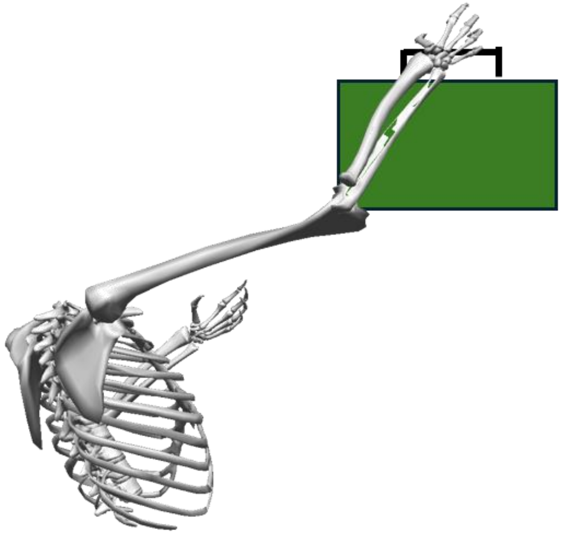
Results: Lifting at Shoulder Height



	Kinematic Variable	Body Armor	Without Body Armor	Difference	p	Hedges d
↑	**Scapular IR**	**3.5°**	**-0.6°**	**4.1 ± 5.8**	**0.001***	**0.46 M**
	Scapular UR	15.6°	15.0°	-0.6 ± 8.0	0.711	0.06
↓	**Scapular PT**	**-3.2°**	**1.1°**	**-4.3 ± 7.1**	**0.004***	**0.63 M**
↓	**Clavicular Elevation**	**8.5°**	**11.0°**	**-2.5 ± 3.0**	**<0.001***	**0.53 M**
↑	**Clavicular Protraction**	**2.7°**	**-1.4°**	**4.2 ± 3.2**	**<0.001***	**0.87 L**
↓	**Thoracic Extension**	**1.4°**	**7.8°**	**-6.5 ± 6.8**	**<0.001***	**0.60 M**
	Thoracic Rotation	-39.4°	-35.6°	-3.8 ± 12.9	0.144	0.25
↓ Left	**Thoracic Side Bend**	**4.2°**	**8.7°**	**-4.5 ± 7.2**	**0.003***	**0.46 M**

IR=Internal Rotation, UR=upward rotation, PT=posterior tilt

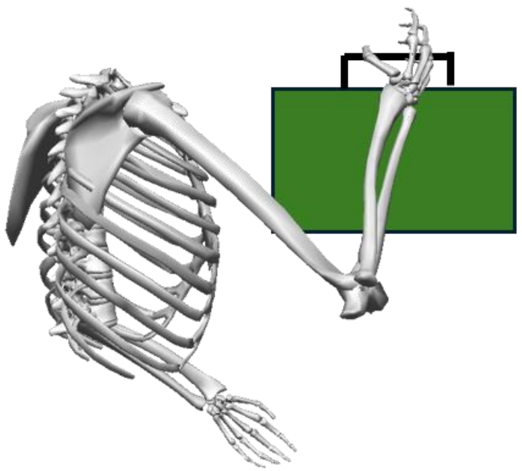
Results: Lifting Can From Shelf



	Kinematic Variable	Body Armor	Without Body Armor	Difference	p	Hedges d
↓	**Scapular IR**	**5.8°**	**10.9°**	**-5.1 ± 7.1**	**<0.001***	**0.50 M**
	Scapular UR	27.8°	25.3°	2.5 ± 8.0	0.216	0.16
	Scapular PT	-3.1°	0.1°	-3.1 ± 9.1	0.084	0.36
↓	**Clavicular Elevation**	**15.6°**	**20.1°**	**-4.6 ± 2.9**	**<0.001***	**0.91 L**
↑	**Clavicular Protraction**	**4.0°**	**2.6°**	**1.3 ± 2.9**	**0.023***	**0.26 S**
↓	**Thoracic Extension**	**9.0°**	**10.9°**	**-1.8 ± 3.1**	**0.005***	**0.30 S**
	Thoracic Rotation	-4.8°	-2.8°	-1.9 ± 6.5	0.138	0.25
	Thoracic Side Bend	10.0°	11.5°	1.5 ± 4.3	0.078	0.26

IR=Internal Rotation, UR=upward rotation, PT=posterior tilt

Results: Lowering at Shoulder Height



	Kinematic Variable	Body Armor	Without Body Armor	Difference	p	Hedges d
	Scapular IR	-0.1°	-1.5°	1.4 ± 5.1	0.177	0.15
	Scapular UR	19.2°	18.7°	0.5 ± 8.2	0.761	0.05
↓	**Scapular PT**	**-1.0°**	**2.5°**	**-3.5 ± 5.8**	**0.004***	**0.49 M**
↓	**Clavicular Elevation**	**12.2°**	**14.7°**	**-2.5 ± 2.9**	**<0.001***	**0.52 M**
↑	**Clavicular Protraction**	**0.2°**	**-2.3°**	**2.6 ± 2.0**	**<0.001***	**0.87 L**
	Thoracic Extension	2.0°	1.2°	-0.8 ± 6.6	0.525	0.43 L
	Thoracic Rotation	-44.3°	-42.9°	1.4 ± 7.3	0.339	0.25
↓ Left	**Thoracic Side Bend**	**1.4°**	**4.0°**	**-2.6 ± 5.7**	**0.026***	**0.23 S**

IR=Internal Rotation, UR=upward rotation, PT=posterior tilt

Limitations

- Participants not accustomed to wearing body armor
- Proportion of female participants greater than military averages
- Current analysis focused on functional targets and did not include humeral angles
  - Further analysis of data possible

Conclusions

- Wearing body armor altered shoulder and trunk kinematics
  - Thoracic kinematics
    - Trunk extension and opposite side bending decrease
    - Response to the additional trunk mass and keeping center of gravity within the base of support; less relative cantilever effect from ammo can
  - Scapular kinematics
    - During lifting shoulder and arm moving toward the target for ammo can placement
      - Decreased posterior tilt (PT) and elevation (CE)
      - Increased internal rotation (IR) and protraction (CP)
      - Increased IR and SP may be compensatory for decreased CE and PT
    - During lowering, there was no difference in IR at shoulder height
    - At liftoff, IR was less while wearing body armor
      - May be related to tactile stimulus prior to load
      - Greater magnitude of protraction at higher elevation

Possible Implications

- Changes in movement patterns suggest that wearing body armor may lead to dyskinetic scapular movement
  - Specifically related to changes in Internal Rotation and Protraction
- Understanding that personnel unaccustomed to wearing body armor or loads over the trunk may experience movement changes
  - Not just increased load on the lower extremities
- Consider training needs
  - Acclimation to wearing loads (often addressed through “train as you fight”)
  - Neuromotor adaptation/training
  - Tissue adaptation to altered load and stresses

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Questions

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