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Title: Rotator Cuff Strength Ratio and Injury in Glovebox Workers

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Rotator Cuff Strength Ratio and Injury in Glovebox Workers

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Abstract

Background and Purpose

Rotator cuff integrity is critical to shoulder health. Due to the high workload imposed upon the shoulder while working in an industrial glovebox, this study investigated the strength ratio of the rotator cuff muscles in glovebox workers and compared this ratio to the healthy norm.

Methods

Descriptive statistics were collected using a short questionnaire. Handheld dynamometry was used to quantify the ratio of forces produced in the motions of shoulder internal and external rotation.

Results

Results showed this population to have shoulder strength ratios that were significantly different from the healthy norm.

Conclusions

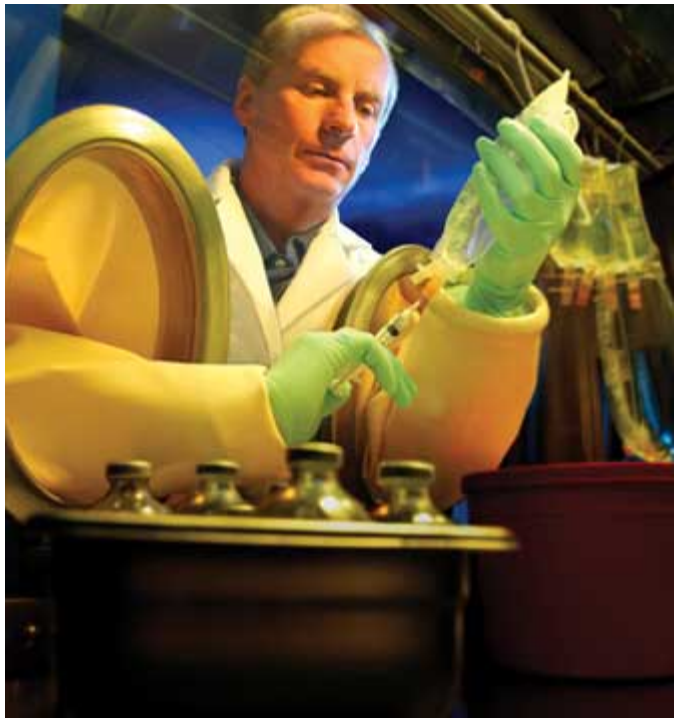
The deviation from the normal ratio demonstrates the need for solutions designed to reduce the workload on the rotator cuff musculature of glovebox workers in order to improve health and safety. Assessment of strength ratios can be used to screen for risk of symptom development.

Background: Industrial Gloveboxes – What Are They?

What is a glovebox?

Background: Industrial Gloveboxes – What Are They Used For?

- **Many industries require the use of a glovebox (GB) to manipulate objects within a contained environment**
  - Pharmaceutical
  - Semi-Conductor
  - Nuclear
  - Other Biochemical Industries

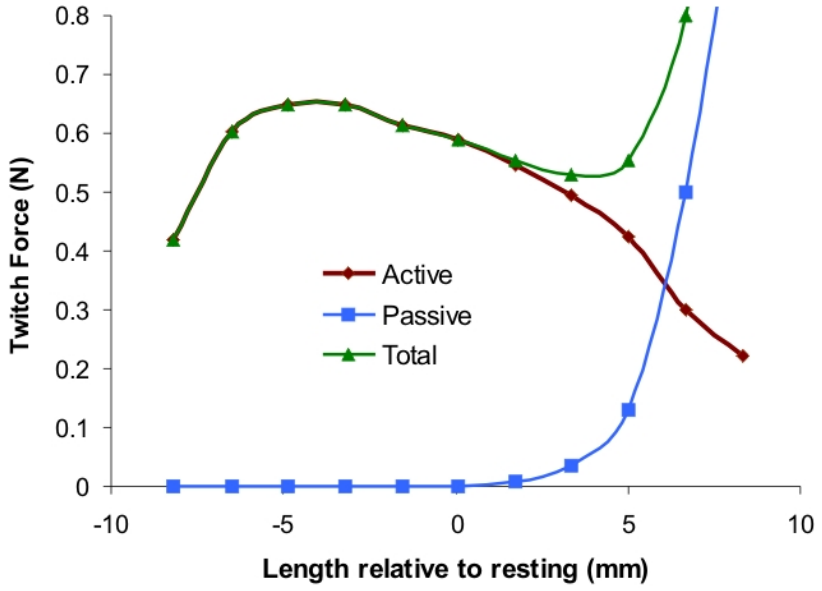


Background: Industrial Gloveboxes – What Is the Problem?

- **Ergonomic Hazards – GB work regularly requires:**
  - Maintaining the shoulders in ~90°of flexion
  - Activity at extreme (end) range of motion
  - Heavy lifting (e.g., objects heavier than 15lbs)
  - Repetitive shoulder/elbow/wrist/finger motions

Background: The Rotator Cuff – Length-Tension Relationship

- **Length-Tension Relationship of Muscle Fibers**
  - Explains the high vulnerability of RC muscles during GB work[1,2]
  - Elevators at risk – maintaining shoulders in gloveports in ~90°of flexion[3-5]
  - External Rotators at risk – transferring objects through airlocks/to the next station[1,2]
  - Internal Rotators – hypothesized to be used excessively due to arm positioning[33]



Background: Glovebox Work and Shoulder Injuries

- LANL Ergo Team and Occupational Medicine (Occmed) Clinic monitor GB worker shoulder health
- 23 recordable shoulder injuries between 2004 and 2013
- Shoulder injuries require more time away from work than any other occupational injury[34]
- Rotator cuff repair surgery has a direct and indirect cost of $120,000 to $200,000[38,39]
- Recovery from surgery averages 9 to 18 months[34,38,39]

Background: Strength Ratios and Shoulder Injuries

- Research implicates muscular imbalance in injury development[7-11]
- Studies show healthy shoulders have 1.5:1 ratios of internal rotator strength to external rotator strength[12,21,26-30]
- No previous research has studied strength ratios in GB workers
- Study designed to investigate strength ratios and symptom incidence in a uniquely vulnerable population

- **Hypothesis:** the average strength ratio among GB workers is significantly different from the normal healthy ratio

Research: Methods

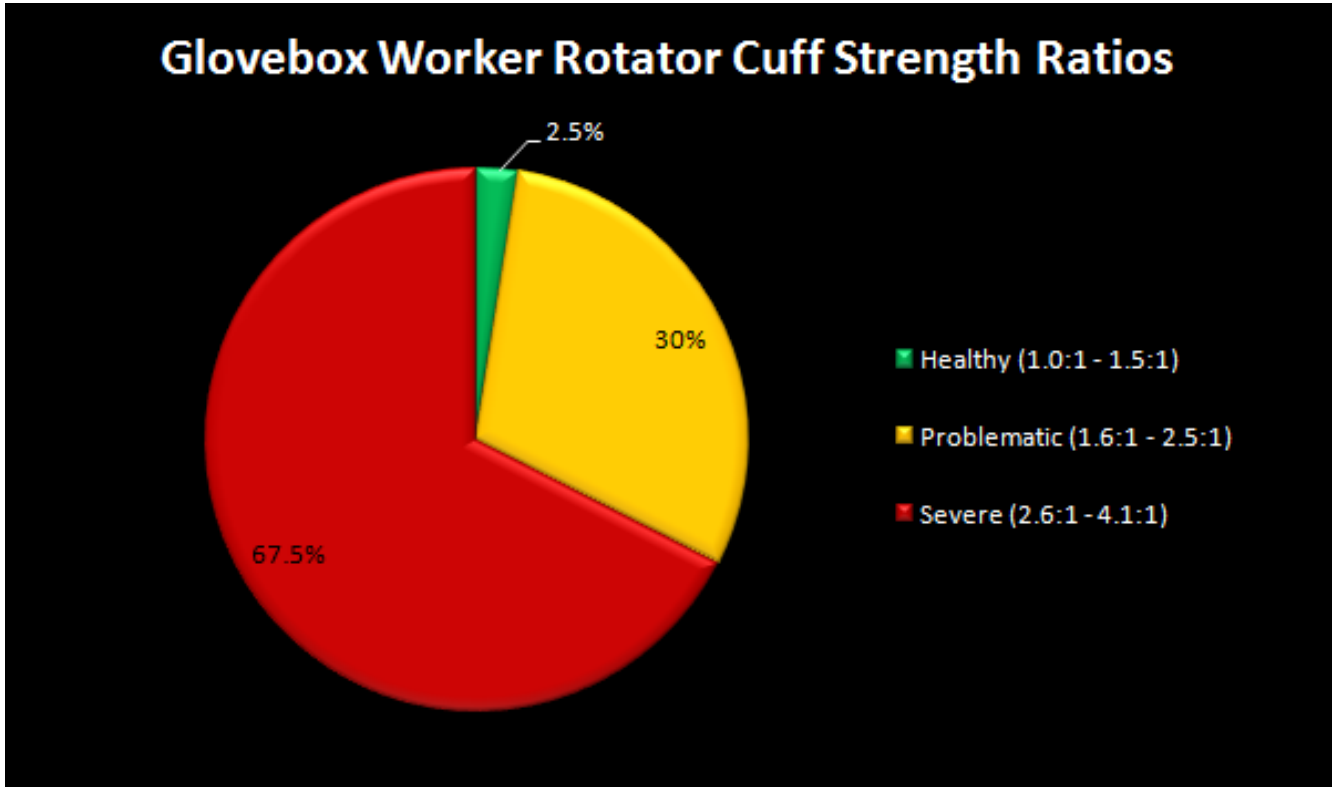
- **Study design was presented to and approved by the LANL Human Subjects Research Review Board (HSRRB)**
- **Informed consent was obtained from each subject prior to participation**
- **Strength testing using hand-held dynamometry**
  - Internal and external rotator strength measured in English pounds (lbs)
  - Both motions measured 3 times on each arm[13]
  - 2 seconds to build contraction, 3 seconds to sustain contraction[13,26]
  - 30 seconds of rest between consecutive trials[19]
  - Testing alternated between unilateral internal and external rotation
- **Questionnaire**
  - Age
  - Years worked in a glovebox
  - Time worked in a glovebox per day
  - Shoulder symptom(s) (i.e., physical pain, tingling, or numbness)

Research: Procedure

- ErgoFET 300 Hand-Held Dynamometer (HHD)
- Same practitioner administered all tests[12-19]
- Subjects in standing position
- 90º elbow flexion and 30º scaption[15,20-25]
- Researcher stabilized subject's arm[12-19]
- Researcher resisted rotation via application of HHD to distal surface of forearm[12-19]

Results

- GB worker strength ratios differ significantly ($p < 0.0001$) from healthy norm of 1.5
- Range: 1.5:1 to 4.1:1
- Mean: 2.7:1
- Median: 2.6:1
- 2% of workers have healthy 1.5 ratio
- 33% of workers have ratios over twice healthy norm



Results (continued…)

- 50% of workers report shoulder symptoms
- Most symptomatic workers exhibit higher strength ratios
- Ratio of 2.5:1 identified as cut-off point for increased symptom risk

Table 1: Strength Ratios of Symptomatic Workers

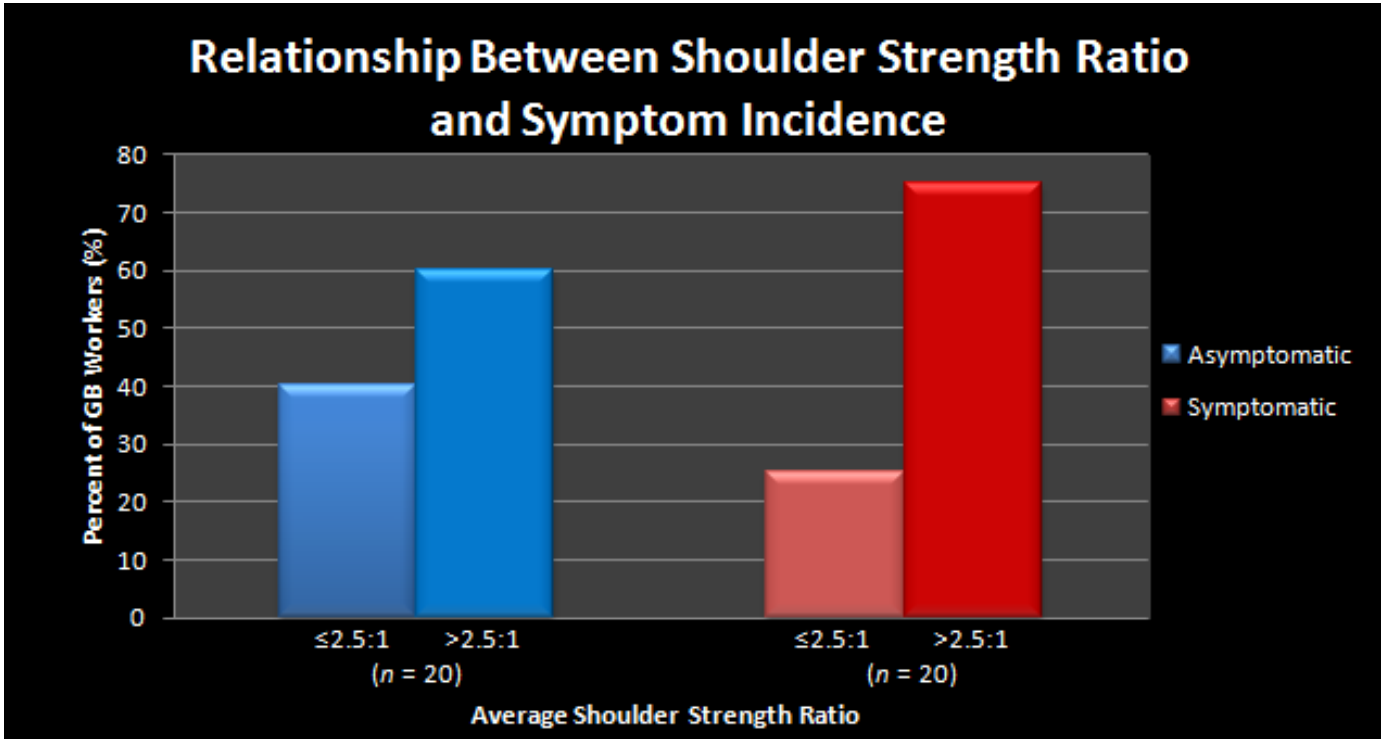
Shoulder Strength Ratio	1.0:2.5:1	2.6-4.1:1
Percent of Symptomatic GB Workers	25% (*n* = 5)	75% (*n* = 15)

Table 2: Strength Ratios of Asymptomatic Workers

Shoulder Strength Ratio	1.0:2.5:1	2.6-4.1:1
Percent of Asymptomatic GB Workers	40% (*n* = 8)	60% (*n* = 12)

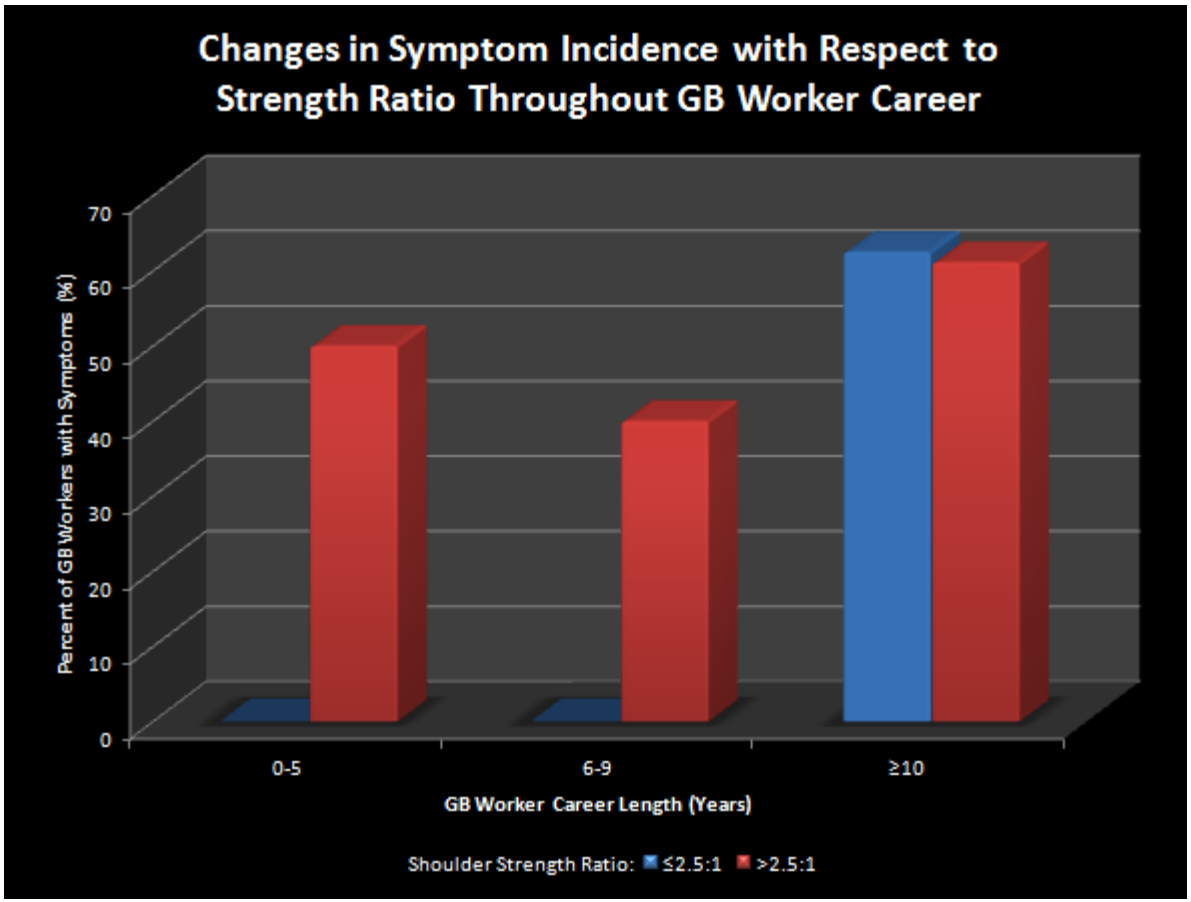
Results (continued…)

- 75% of symptomatic workers have ratios > 2.5:1
- 60% of asymptomatic workers have ratios >2.5:1
  - Indicative of need for preventative screening



Results (continued…)

- Symptom incidence increases with age and career length
- Weak correlation between increasing strength ratios and age/career length
- Symptom incidence directly related to strength ratios up to career length of 10 years



Conclusions

- GB worker shoulder strength ratios differ significantly from healthy norm
- Only 2% of workers have healthy 1.5 ratio
- Over 33% of workers have strength ratios greater than twice healthy ratio
- 50% of workers are symptomatic
- 60% of asymptomatic workers are at high risk
- Symptom incidence influenced by strength ratios up to career of 10 years
- Ratio assessment can screen for risk
- Controls needed to improve abnormal strength ratios

Solutions

- **Multifaceted approach to address severe strength imbalance in GB workers**
  - Administrative Controls:
    - Ratio assessment as a screening tool
    - Weight lifting limit (American Glovebox Society recommends 15lbs)
    - Mandatory rotator cuff strengthening program
  - Engineering Controls:
    - Equipment that reduces external rotation at end range of motion (e.g., new airlock tray)
    - Provision of assistive lifting devices

Take Home Message

- Drastic and prevalent shoulder strength imbalance among GB workers
- High (50%) incidence of shoulder symptoms among GB workers
- Direct relationship between abnormal ratios and symptom development
- Immediate and specific actions needed to correct problem

References

Please see handout for full list of referenced sources.

Questions