NATIONAL ERGONOMICS Conference & ErgoExpo

Using Newly Developed Push-Pull Guidelines to Improve Materials Handling Tasks

THE OHIO STATE UNIVERSITY

Presented by: Gary Allread, PhD, CPE
SRI-Ergonomics

Topics to be Covered

- Why new guidelines were developed
- Work design factors included in guidelines
- How to use online push-pull tool
- Case study
- Recent questions and lessons learned about guidelines

Pushing and Pulling Tasks in Industry

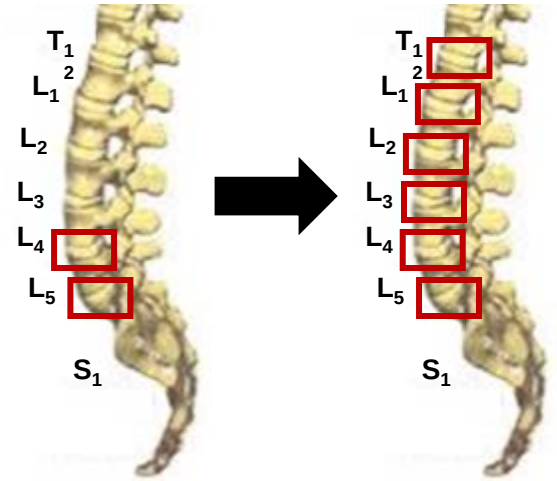
Pushing and Pulling Tasks in Industry

- Are becoming more prevalent
- Account for about 20% of all low-back injuries
- Injury costs associated with these activities are increasing

Biomechanical Impact of Pushing and Pulling

Advances in Understanding and Measuring Spine Loads

- **Loads can now be accurately estimated across the entire lumbar spine**
- **Can determine when an activity is believed to exceed spine tolerance (cause vertebral endplate micro-fractures)**

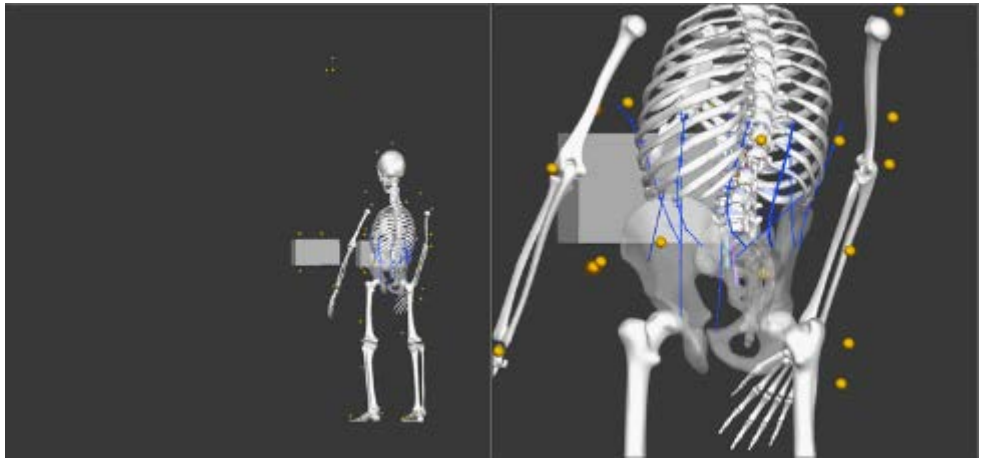


Advances in Understanding and Measuring Spine Loads

- **Pushing and pulling greatly impacts loads at the upper lumbar levels**

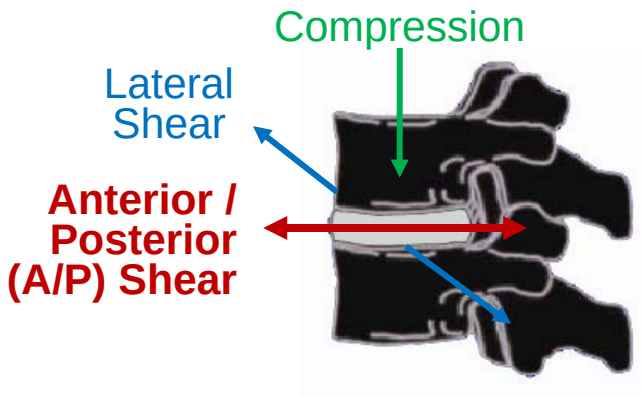
Lumbar Spine Joints

- T_{12}/L_1
- L_1/L_2
- L_2/L_3
- L_3/L_4
- L_4/L_5
- L_5/S_1



Advances in Understanding and Measuring Spine Loads

- **Shear forces (A/P) on lumbar discs are as or more important than compression when assessing risk due to pushing and pulling**



Push-Pull Research Recently Published

ERGONOMICS, 2018
VOL. 61, NO. 6, 853–865
https://doi.org/10.1080/00140139.2017.1417643

Taylor & Francis
Taylor & Francis Group

Check for updates

Biomechanically determined hand force limits protecting the low back during occupational pushing and pulling tasks

Eric B. Weston[a,b], Alexander Aurand[a,b], Jonathan S. Dufour[a,b], Gregory G. Knapik[a,b] and William S. Marras[a,b]

[a]Spine Research Institute, The Ohio State University, Columbus, OH, USA; [b]Department of Integrated Systems Engineering, The Ohio State University, Columbus, OH, USA

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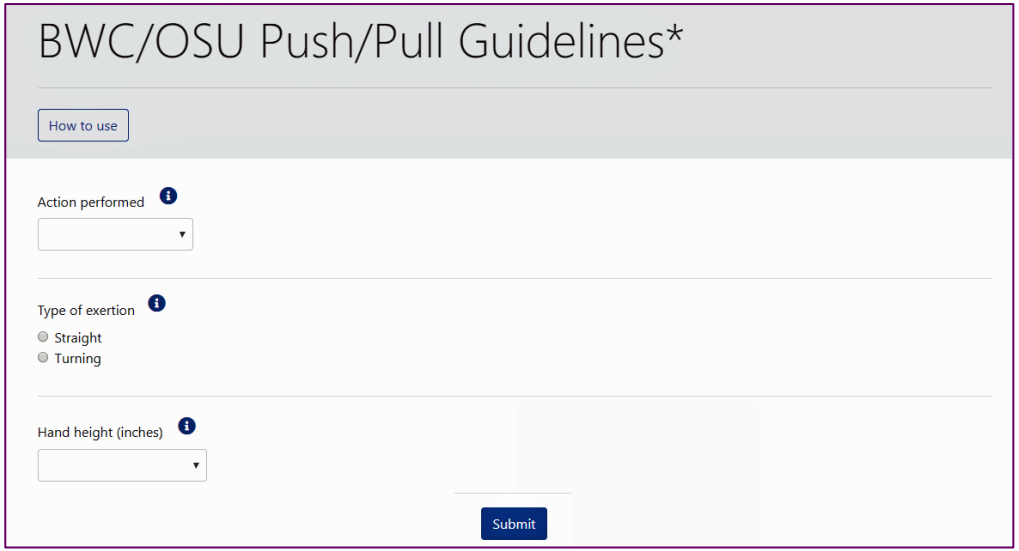
Ohio | Bureau of Workers' Compensation

Using the Push-Pull Guidelines for Design or Evaluation

Using the Online Push-Pull Guidelines

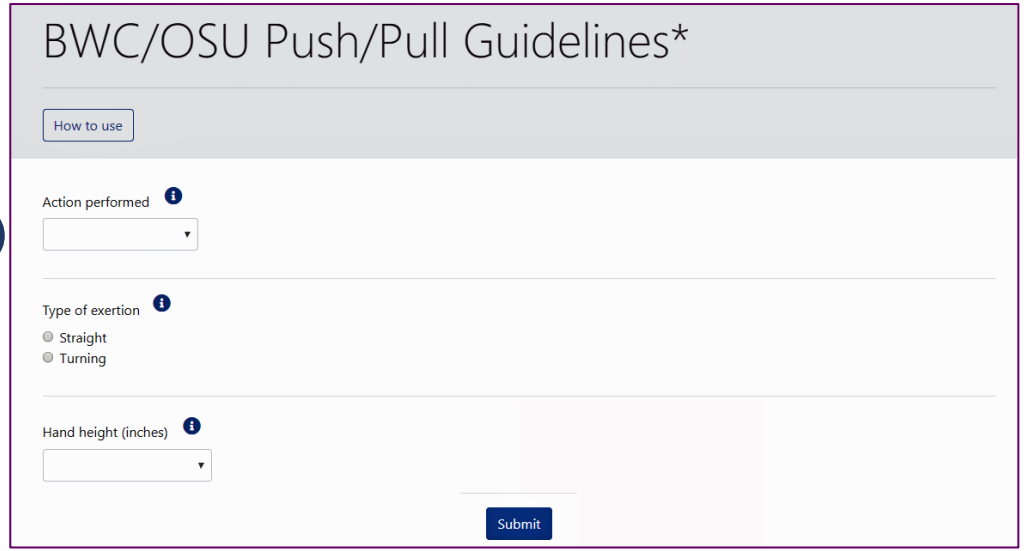
- **Available online**
  - www.bwc.ohio.gov/employer/programs/safety/PushPullGuide/PushPullGuide.aspx
- **Need a force gauge and tape measure**
- **Guidelines designed to be protective for both males and females, across a wide range of employee ages**

Using the Online Guidelines
Home Page



www.bwc.ohio.gov/employer/programs/safety/PushPullGuide/PushPullGuide.aspx

Using the Online Guidelines
Input 1 → Action Performed



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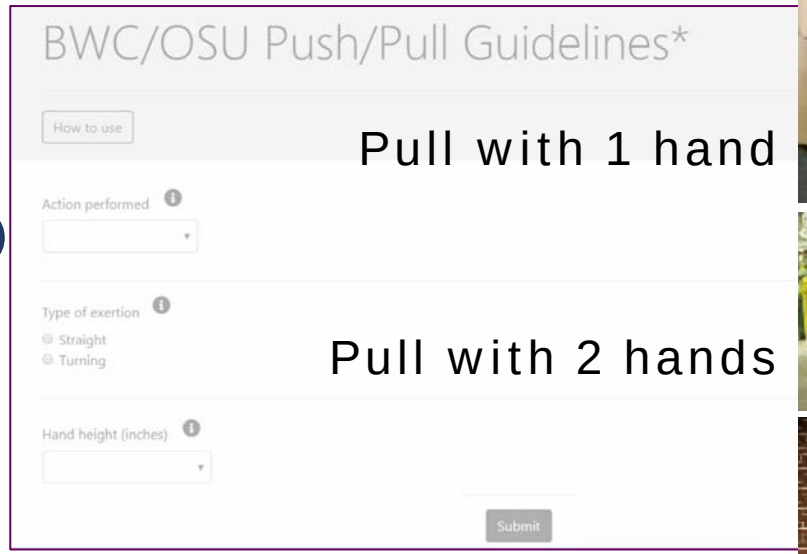
Input 1 → Action Performed



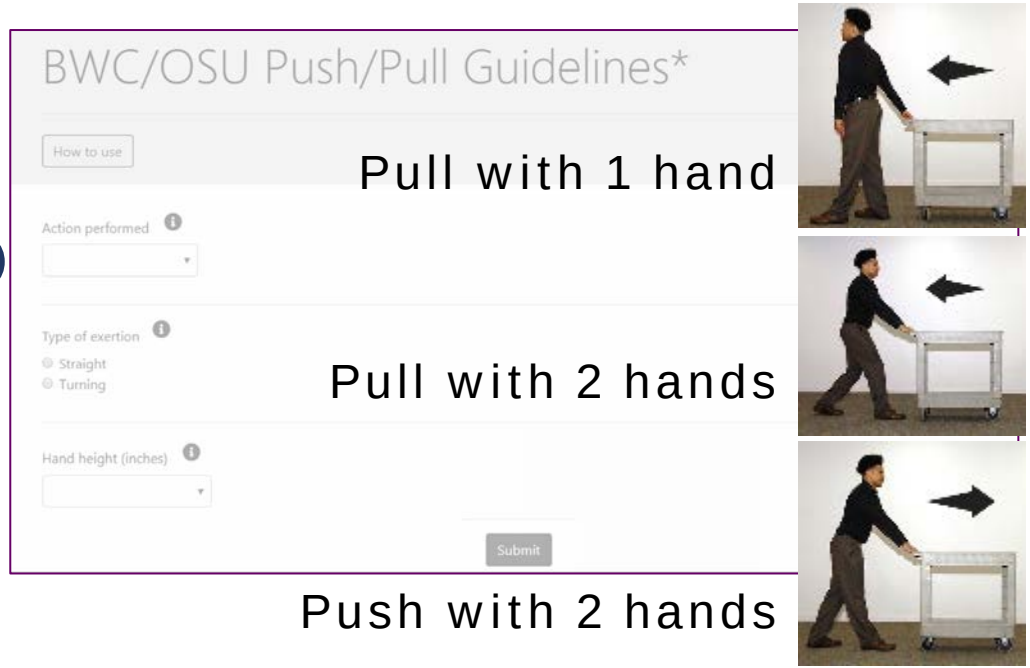
1

Pull with 1 hand

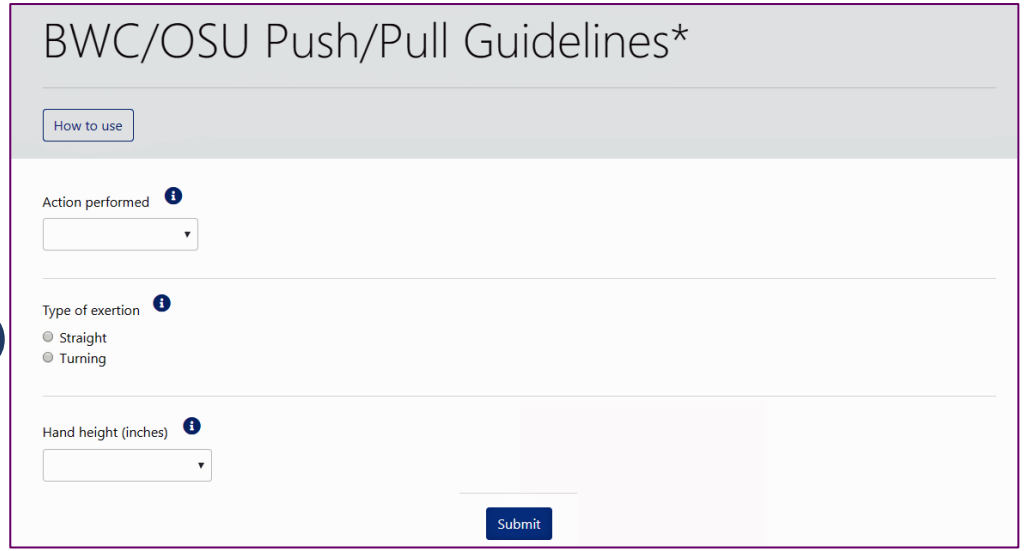
Pull with 2 hands

Push with 2 hands

Using the Online Guidelines
Input 1 → Action Performed

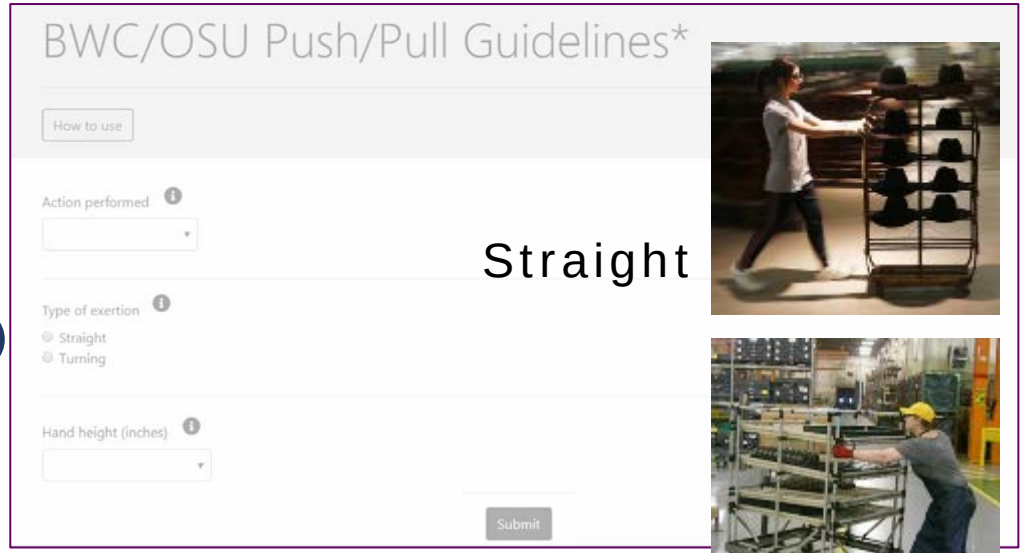


Using the Online Guidelines
Input 2 → Type of Exertion



2

Using the Online Guidelines
Input 2 → Type of Exertion

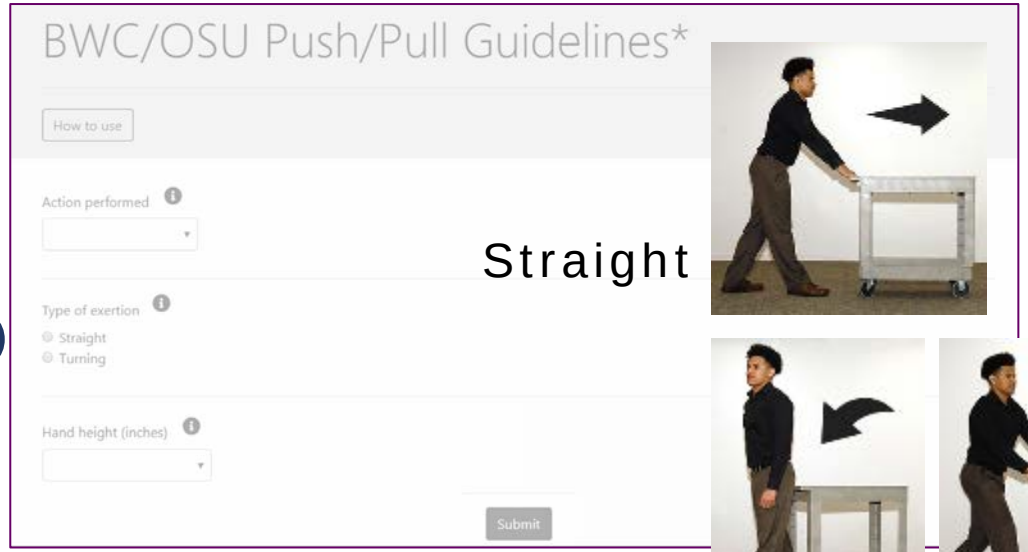


2

Straight

Turning

Using the Online Guidelines
Input 2 → Type of Exertion

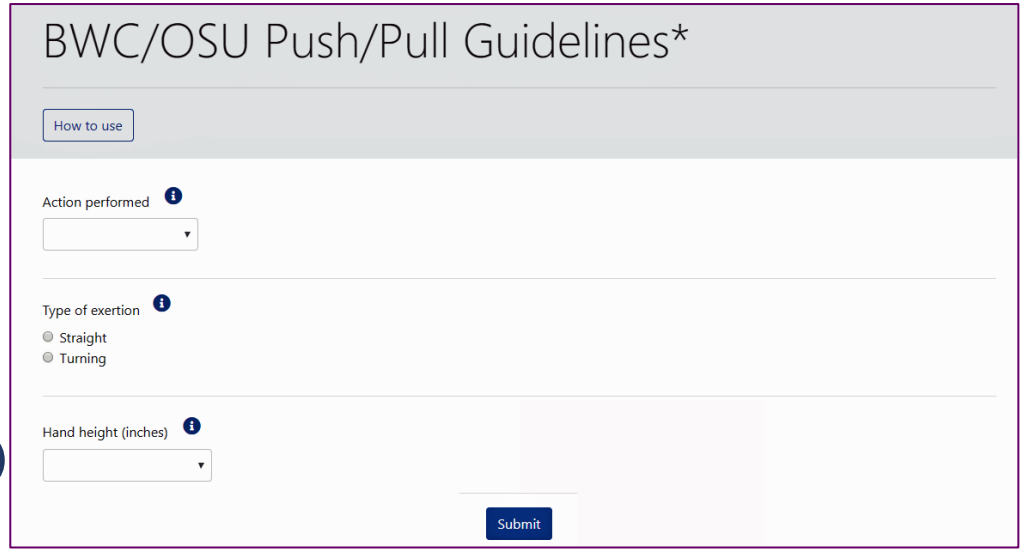


2

Straight

Turning

Using the Online Guidelines
Input 3 → Hand Height



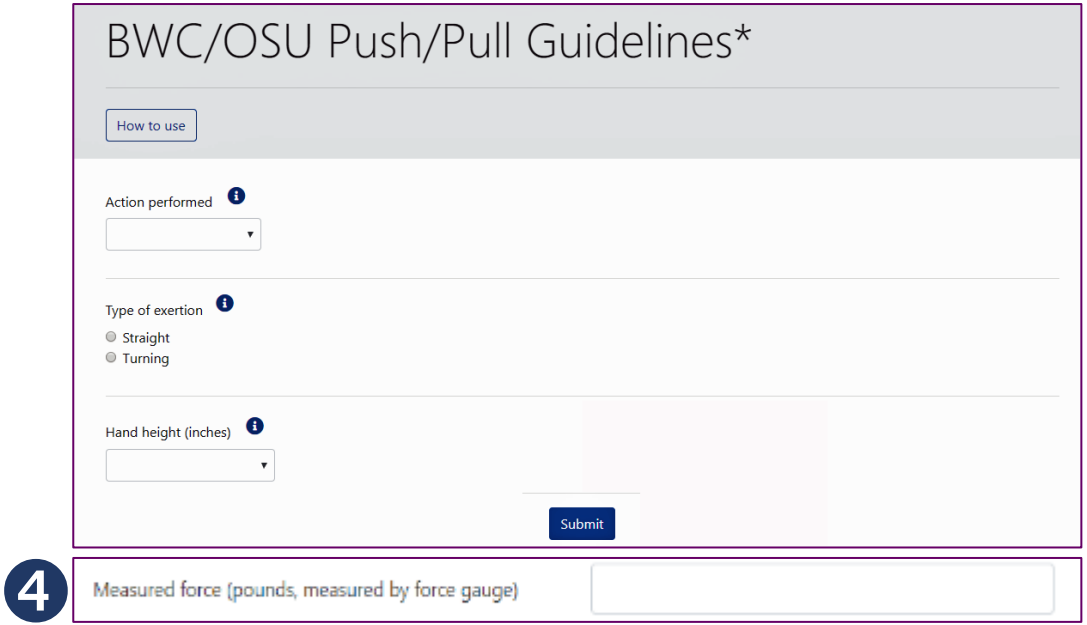
3

Using the Online Guidelines
Input 3 → Hand Height

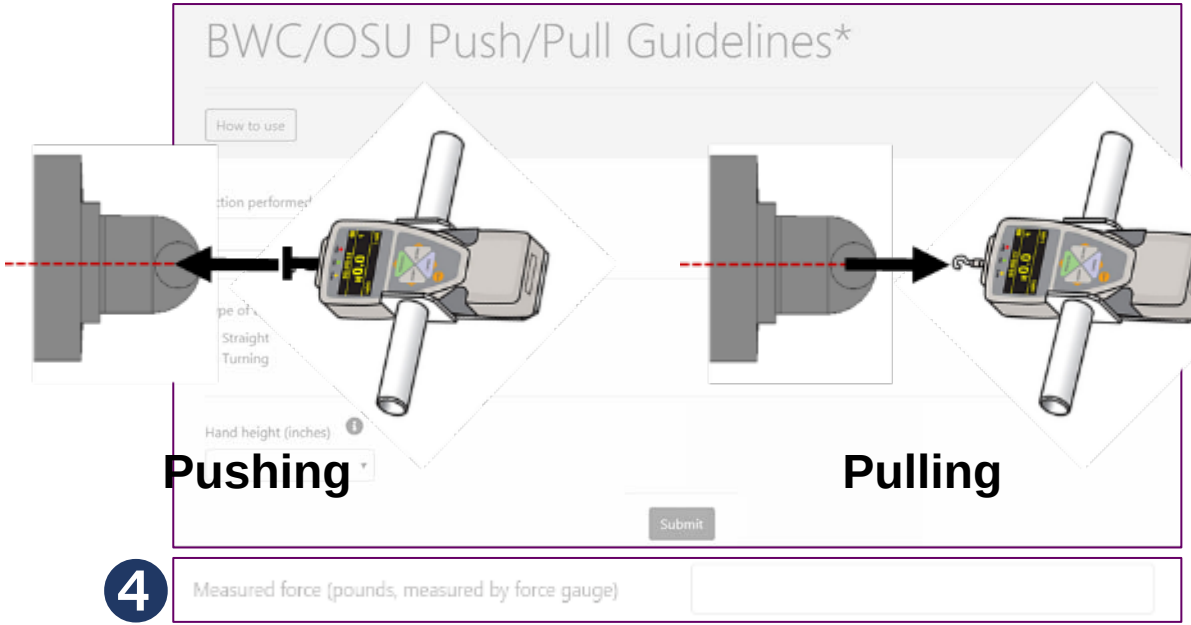
3

Range: 32” - 48”

Using the Online Guidelines
Input 4 → Force



Using the Online Guidelines
Input 4 → Force (Straight)



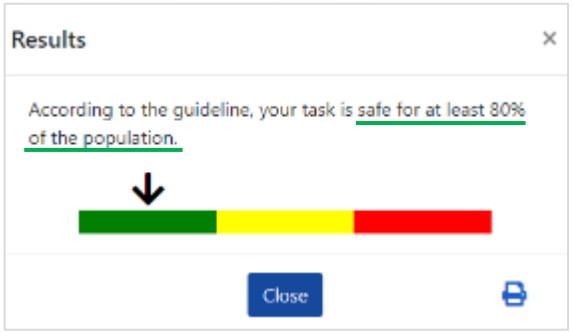
Single-axis force gauge

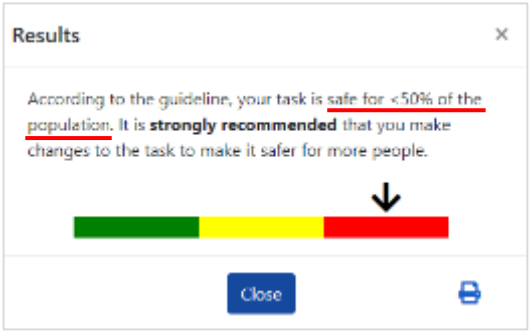
Using the Online Guidelines
Input 4 → Force (Turning)

- **Assume user's hands are placed about shoulder-width apart**
- **These guidelines:**
  - Accommodate hand distances of 12" - 36"
  - Are not applicable for significantly wider or narrower hand distances

4 Measured force (pounds, measured by force gauge)

Guideline Outputs





Case Study

Case Study

Handle Height *	Percent of Population Protected	Two-Handed Pushing Hand Force Limit (lbf)
32”	More than 80%	48
	50-80%	58
	Less than 50%	62
35”	More than 80%	51
	50-80%	60
	Less than 50%	64
40”	More than 80%	54
	50-80%	61
	Less than 50%	64
45”	More than 80%	64
	50-80%	72
	Less than 50%	76
48”	More than 80%	68
	50-80%	77
	Less than 50%	80

*** Subset of available handle height data**

← **Load of 80 plates**

- **Task data:**
  - Two-handed push
  - Hands: 35” above floor

- **Measured forces:**
  - 55 lbf (80 plates / 1,200 lbs.)
  - 49 lbf (54 plates / 864 lbs.)
  - 43 lbf (40 plates / 600 lbs.)

Q. How many plates can be pushed safely?

Case Study

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	50-80%	61
	Less than 50%	64
45”	More than 80%	64
	50-80%	72
	Less than 50%	76
48”	More than 80%	68
	50-80%	77
	Less than 50%	80

*** Subset of available handle height data**

Load of 40-54 plates

- **Task data:**
  - Two-handed push
  - Hands: 35” above floor

- **Measured forces:**
  - 55 lbf (80 plates / 1,200 lbs.)
  - 49 lbf (54 plates / 864 lbs.)
  - 43 lbf (40 plates / 600 lbs.)

Q. How many plates can be pushed safely?

Ergo Option #1
Load Fewer Plates

Case Study

Handle Height *	Percent of Population Protected	Two-Handed Pushing Hand Force Limit (lbf)
32”	More than 80%	48
	50-80%	58
	Less than 50%	62
35”	More than 80%	51
	50-80%	60
	Less than 50%	64
40”	More than 80%	54
	50-80%	61
	Less than 50%	64
45”	More than 80%	64
	50-80%	72
	Less than 50%	76
48”	More than 80%	68
	50-80%	77
	Less than 50%	80

*** Subset of available handle height data**

Load of 80 plates

- **Task data:**
  - Two-handed push
  - Hands: 35” above floor

- **Measured forces:**
  - 55 lbf (80 plates / 1,200 lbs.)
  - 49 lbf (54 plates / 864 lbs.)
  - 43 lbf (40 plates / 600 lbs.)

Q. How many plates can be pushed safely?

Ergo Option #2
Raise Cart Handles

Questions and Lessons Learned About Guidelines

Recent Questions

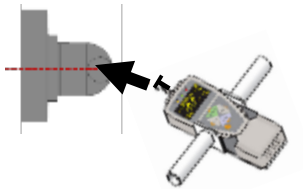
Q. **Why isn’t task frequency included in the guidelines?**

A. Guidelines are based on if the specific push-pull action exceeds what the spine can tolerate without damage, not cumulatively

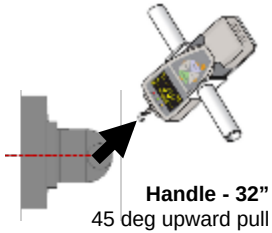
Recent Questions

Q. **What do you do when forces aren't applied to handles horizontally?**

A. Guideline results have been adjusted to account for this, and horizontal forces are easier to measure



Handle - 48"
20 deg upward push



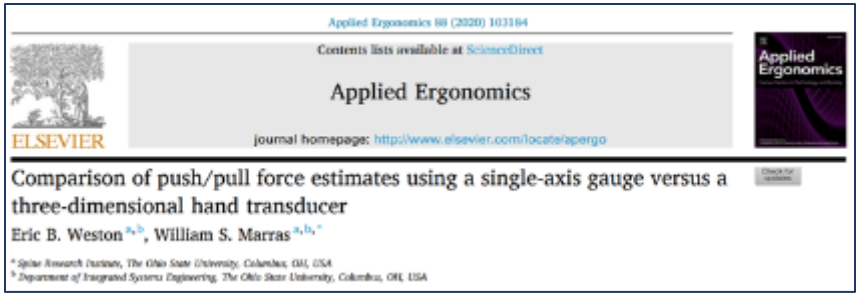
Handle - 32"
45 deg upward pull

Lessons Learned

- **Guidelines for turning exertions are confusing; forces are difficult to measure**
  - Force measurement may require help (one to measure; one to guide)
  - Guidelines based on common distances between hands (~shoulder width apart); guidelines adjusted to account for torque
  - Best to take multiple readings

Lessons Learned

- **Accurate measurements:**
  - Can be obtained using a single-axis force gauge (they closely mirror those from a 3D hand transducer)
  - Occur when recorded at a “fast” pace (moving 1 m in 3 sec); this closely resembles the speed individuals choose to push-pull in industry



Take-Home Messages

Take-Home Messages

- **Guidelines:**
  - Are based on biomechanical spine tolerances
  - Can be used for both task design and assessment
  - Are available as a free, easy-to-use web tool
  - Allow one to consider several options for task improvement
  - Apply to a wide range of push-pull tasks, but there are exceptions

Questions?

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Ergonomics versus Performance in Casters

Presented by: Rob Jorden

Ergonomic Considerations

- **5 Factors of casters on ergonomic performance:**
  - Ease of Rolling (push force required)
  - Height of the work surface (caster height influences)
  - Sound levels in the work place
  - Safety of parked carts and work platforms (locking systems)
  - Ability to control carts and stop quickly (braking systems)

Non-Ergonomic Performance Considerations

- Load Capacity
- Floor Pressure
- Speed Handling
- Environmental Considerations
- Cost

Ease of Rolling

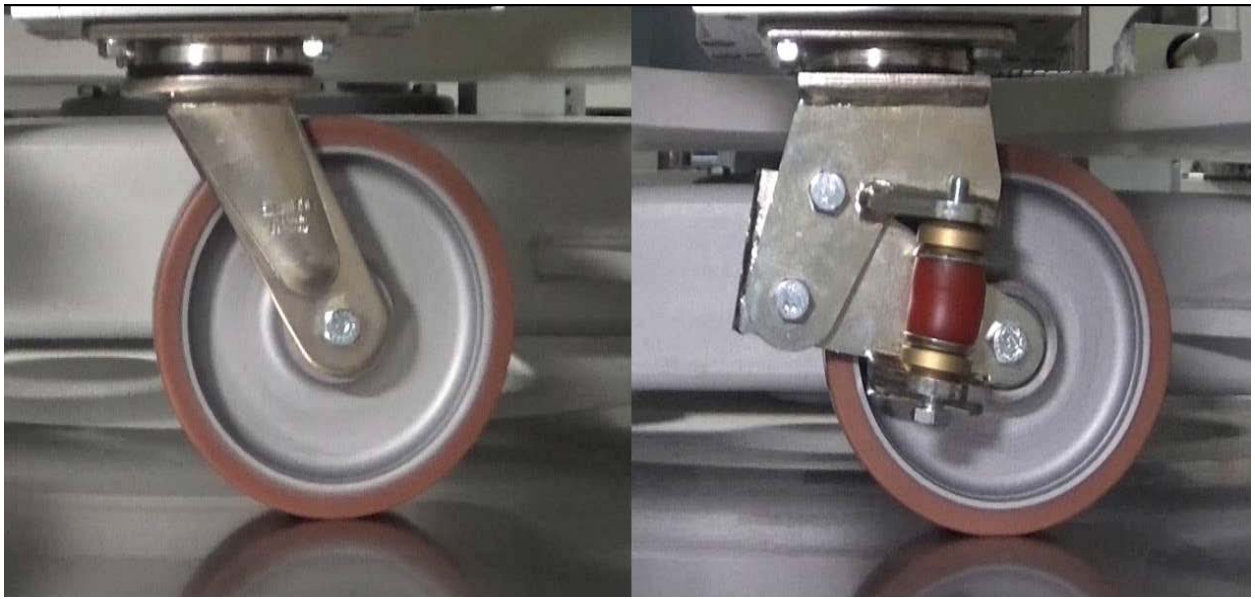
- **Things that enhance ease of rolling:**
  - Larger wheels (which increase the work height, increased cost)
  - Harder wheels (which increase noise and floor damage potential)
  - Wheel geometry (which increase floor damage potential)

Controlling the Work Height

- **Important for lifting height or working height.**
- **Larger casters will roll easier and usually cost more.**
- **Smaller casters are harder to roll usually.**

Sound Level in the Workplace

- **Things that reduce sound levels:**
  - Softer wheels (harder to roll, lower capacities)
  - Shock absorbing casters (very high costs)

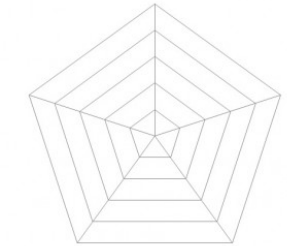


Safety Factors

- **Braking and Locking systems add a lot of cost.**
- **Braking systems are rare, either deadman brakes or active brakes, but allow quick stoppage and control of loads.**
- **Locking systems are often poorly used, e.g. in towing situations or not used at all.**

Trade offs

- There is no ideal caster
- Finding the right balance for the end user is important
- Priorities change over time
- Consider use of a radar graph



Finding a Solution

- **Prioritize ergonomics and performance characteristics**
- **Research your options**
- **Test and Evaluate**
- **Include operators and end users**

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