

Eight Ways to Assess a Lifting Tool

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Why the interest in lid lifting tools?

- 2003 WA Occupational Injury and Illness rates
 - 9.1 Local government utilities
 - 9.0 Manufacturing
 - 11.1 Construction
- ~20,000 back injuries per year
- Seattle Public Utilities identified lid lifting as a target area to reduce risk and injury
- UW conducted an acceptability and musculoskeletal risk evaluation of 4 vault lid lifting tools



Methods

Tool Selection

1. Examined biomechanics of removing lids
2. UW & SPU team reviewed 16 tools and selected 6
3. Weighed lids & measured force to break impaction
4. 3 tools selected for assessment, plus existing tool



Biomechanics and Weights of Forces of 5 Vault Lids



	Sand catcher	Bicycle grate	Combined sewer	26" sewer lid	Large Inlet Top (LIT)
Full weight	361	122	250	154	130.8
Break impaction	230	65	N/A	88	N/A
Lift 1 end	286				
Drag		53 to 106		138	



L-Hook



Extractor



Bigs



Allegro



Tool Assessment

- 3 workers: small , medium, large
- Use 3 new lifting tools + currently used tool
- Lift 26” lid 4 times with each tool
- Collect objective & subjective measures



Objective Measures (5)

1. Back compression force (3DSSPP)
2. Strength - percent capable (3DSSPP)
3. Force required to use tool (force gauge)
4. Back bending posture (virtual corset)
5. Task time (stop watch)



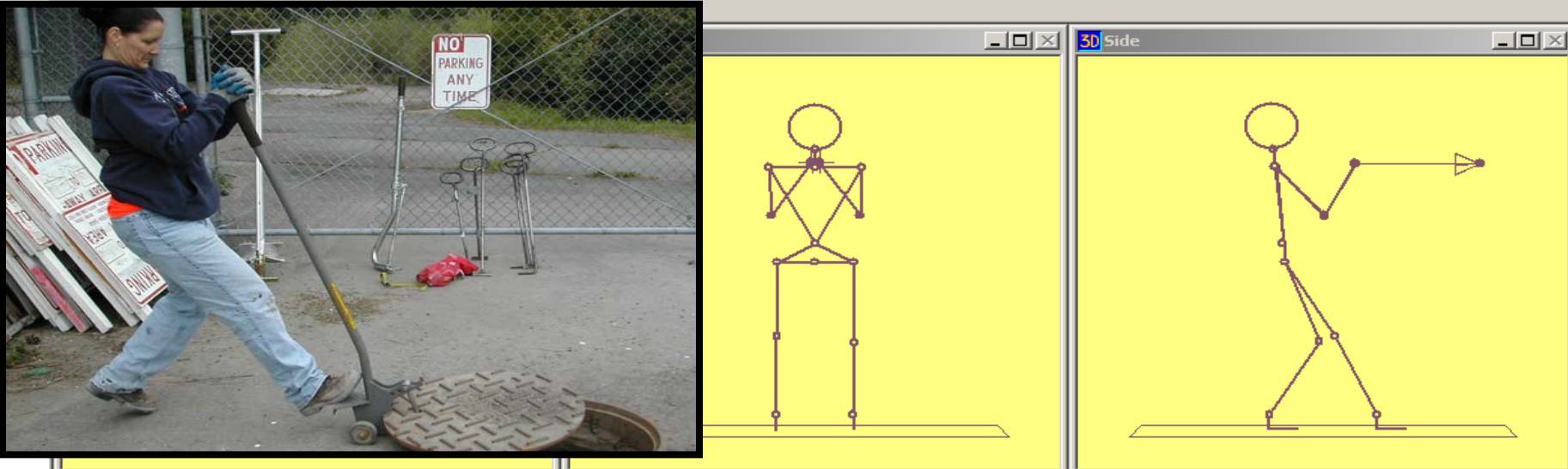
Subjective Measures (3)

6. Tool usability (worker survey)
7. Ranking of all tools (worker survey)
8. Self-reported fatigue (Borg scale)



1 & 2: Back compression & % cap

3D Univ. of Michigan's 3DSSPP v4.32 - 3D_S1_Extractor.tsk



3D Side

3D S1 Extractor

3D Status

Task: S1 Extractor
Gender: Female, Percentile: Data Entry
Ht (in): 64.0, Wt (Lb): 130.0
Hand Forces (Lb) Left: 22.5, Right: 22.5

Hand Location (in)	Left	Right	Trunk and Legs Locked
Horizontal:	5.1	5.2	
Vertical:	49.1	49.1	
Lateral:	-0.7	0.7	

Strength Percent Capable
Elbow: 83 Hip: 56
Shoulder: 91 Knee: 77
Torso: 93 Ankle: 82








Coef. of Friction: 0.348
Balance Status
CP Bal: Un-Acceptable
SE Bal: Acceptable

3D Low Back Compression: 311 (Lb)

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1: Back Compression Forces

	Worker #1 Small; Female	Worker #2 Medium; Male	Worker #3 Large; Male
Extractor	311	228	 *
Bigs			242
Allegro			633
L Hook	514		

Boldface = worker with lowest BC per tool; * = tool with lowest BC per worker; ^ = tool with highest BC per worker



2: Percentage of Population Capable

	Worker # 1 (Small female)				Worker # 3 (Large male)			
	Extractor	Bigs	Allegro	L Hook	Extractor	Bigs	Allegro	L Hook
Elbow	83	■	■	■	99	100	99	85
Shoulder	91	96	87	■	99	99	80	75
Torso	93	94	88	92	99	99	90	90
Hip	■	99	75	88	■	96	80	82
Knee	77	93	99	96	86	100	92	99
Ankle	82	97	91	100	99	100	80	99

Boldface values indicate most limiting tool and body part combination.



3: Forces to operate



Allegro - 37 pounds



Bigs - 39 pounds



Extractor - 45.5 pounds



L-Hook - 99 pounds



4: Back bending angles

(degrees of back bending)

	90th Percentile	Min	Max	Median
Allegro	92.8	0.0	122.3	27.2
Bigs	61.4	0.0	120.9	19.7
Extractor	54.8	1.4	111.1	19.2
L Hook	53.9	1.4	111.1	17.3



5: Speed of Use

Tool	Total Time	Speed Per Lid
L-hook	0:03:03	1 per 45 sec
Extractor	0:04:26	1 per 66 sec
Bigs	0:05:14	1 per 78 sec
Allegro	0:05:18	1 per 79 sec























6: Tool Usability Rating

	Ease of Use (3 questions)	Tool Design (5 questions)	Combined Rating (8 questions total)
Bigs	5.3	5.4	
L Hook	5.0	5.1	
Extractor	3.7	4.2	
Allegro	1.8	4.7	



7: Overall Tool Ranking

CATEGORY	RANKING OF “BEST” (1) TO “LEAST FAVORABLE” (4)			
	1	2	3	4
Ease of use	 (1.7)	 (2.0)	 (2.3)	 (4.0)
Body position when using each tool	 (1.7)	 (2.0)	 (2.7)	 (3.7)
Overall tool design	 and  (tie) (2.0)	 (2.3)	 (3.7)	
Speed of use	 and  (tie) (2.0)	 (2.3)	 (3.7)	
Overall preference	 (1.7)	 and  (tie) (2.3)	 (3.7)	



8: Worker Fatigue During Tool Use

	Back	R shoulder	L shoulder	R hand/ wrist	L hand/ wrist	Overall Body	Ave Diff by Tool
Extractor	0.2	0.2	0.3	0.2	0.2	0.3	0.2
Bigs	-0.2	0.0	0.0	0.0	0.2	0.0	0.0
Allegro	1.5	1.2	1.2	1.3	1.2	1.2	1.3
L-Hook	-0.2	0.2	0.2	0.2	0.5	-0.3	0.2
Ave by body part	0.3	0.4	0.4	0.4	0.5	0.3	



Summary of 8 Lifting Assessments

	Force to operate	Fatigue	Back compres- sion	% Strength capable	Task time	Eval- uation rating	Ranking	Back Bending	Overall
Bigs	1	1	1	1	3	1	1	3	1.5
Extractor	2	2	2	2	2	3	2	2	2.1
L-Hook	3	2	3	3	1	2	3	1	2.3
Allegro	4	4	4	4	4	4	4	4	4.0



Evaluating Lifting Aids

- Consider both objective and subjective measures
- Worker participation in lifting aid selection and usability evaluation
- Consider range of applications and worker-types

