COLLECTION SAFETY AND ERGONOMICS

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Overview

- Introduction & Background
- Benefits of Ergonomic interventions
- How Ergonomics applies to the waste collection industry
- Relevant ergonomic assessment tools and techniques for waste collection task assessment
- Guidelines for assessment, implementation and management of ergonomics in waste collection
- Summary of findings of EREF funded study: "*An Ergonomic Study of Solid Waste Collection*"

Introduction & Benefits

Manual Waste Collection

Introduction

- Industries in the Waste Management service sector are engaged in:
  - Waste Collection
  - Waste Treatment and Disposal
  - Remediation and Other Waste Management Services

- With the population growing waste management is becoming more and more important

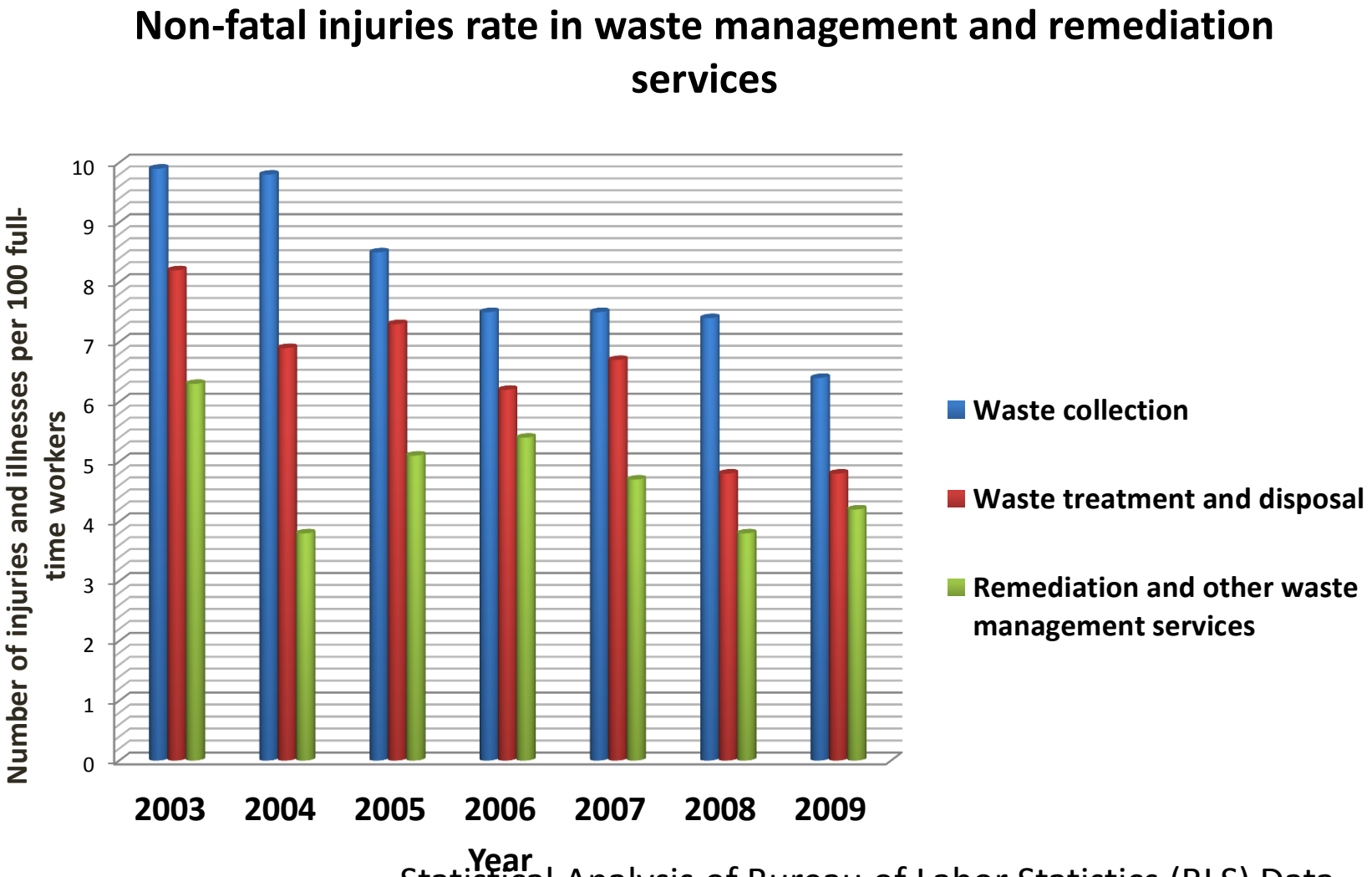
What is Ergonomics?

- Scientific discipline concerned with the understanding of interactions among humans and other elements of a system.
  - More efficient
  - Safer and healthier work environments
  - Quality enhancement
  - Long term cost savings

Benefits of Ergonomic interventions

- Cost reduction
- Enhancement of worker task performance and safety
- Enhanced task efficiency

Solid Waste Industry



Statistical Analysis of Bureau of Labor Statistics (BLS) Data

Ergonomics and waste collection

Manual Waste Collection

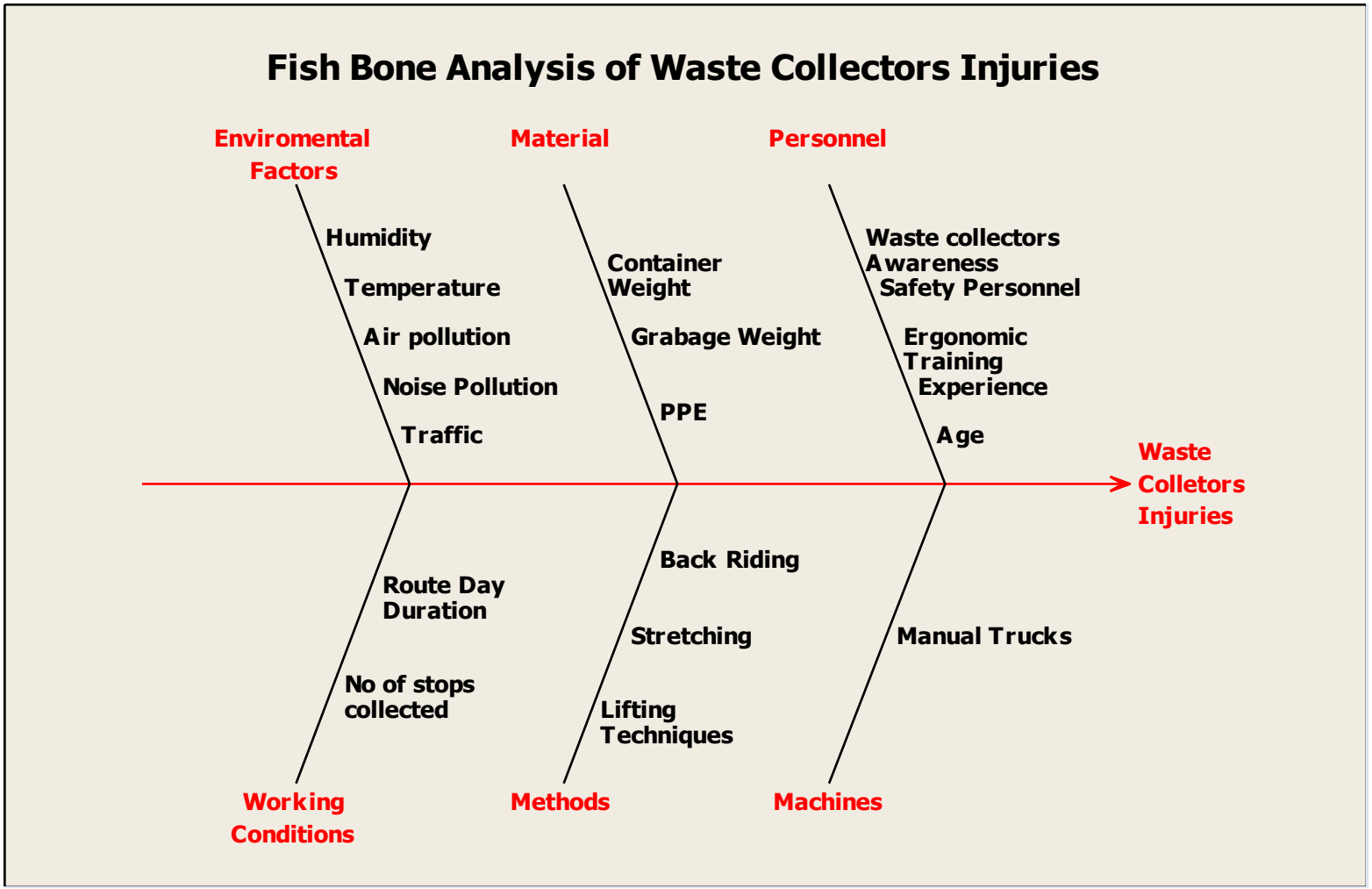
Why Ergonomics in this industry?

- Manual and semi-automated waste collection has many of the known ergonomic risk factors associated with occupational injuries
- Proactive implementation of ergonomic principles in waste collection can mitigate risks and reduce the likelihood of injuries.

Risk Factors in Waste Collection

- Manual material handling (i.e., lifting or pushing)
- Repetition
- Awkward posture
- Task duration
- Contact stress
- Environmental factors
- Vibration

Solid Waste Industry



Applying Ergonomics in Waste Collection

- Address application by the categories that contribute to the occurrence of ergonomic related injuries
  - Environmental factors
  - Manual material handling
    - Waste container weight
    - Container design
  - Task performance process
    - Working conditions
    - Methods

Assessment Tools and Techniques

Manual Waste Collection

Assessment Tools & Techniques

- Environmental factors
- Manual Material Handling
- Task performance process

What is a Task Assessment Tool

- A narrative, quantitative, qualitative or checklist system that provides a standardized evaluation of a job or task
- A tool that can provide specific or general information about a body region or risk factor
- A tool that has been scientifically validated

Purpose of Assessment Tools

- Support an Ergonomics Program
- Clarify ergonomic risks
- Guide to suggested corrective actions
- Provide a level of measurement and monitoring

Environmental Factors

- Humidity
- Temperature
- Air pollution
- Noise pollution
- Vehicular traffic

Humidity & Temperature

- To assess risk of adverse impact associated with extreme temperatures and humidity
  - Perform analysis of Heat Stress Index for given tasks at high risk times of the year
    - i.e. perform an assessment to obtain the Heat Stress Index
  - Extreme cold
    - Implement clothing requirements, processes to reduce exposure and Personal Protective Equipment (PPE)
- Response:
  - Offer a hybrid approach to mitigate the factors that includes process redesign, PPE and other ergonomic interventions

Air Pollution

- Assess level of pollution in the air
  - Exposure to environmental pollutants
  - Exposure to vehicle pollutants
- Response
  - Face masks
  - Altering exposure with process or schedule redesign

Vehicular Traffic

- Primary risk of injury is from vehicle traffic: waste collectors hit by moving cars
- Response
  - Training
  - Process redesign
  - Reflective and bright clothing

Noise Pollution

- Noise evaluation
  - Use a personally worn noise dosimeter to evaluate noise level throughout a task
  - Compare these ratings to OSHA guidelines
- Response
  - Personal Protective Equipment (PPE)
  - Limit exposure

Manual Material Handling

- Primary risk factors in MMH include
  - Container weight
  - Container design
  - Repetition (up to 800 stops in a shift)
  - Height of vehicle when emptying waste container

Recognizing a WMSD Problem

- Assessment and analysis
- OSHA 200/300 logs
- Accident Reports
- Workman's Compensation records
- Employee Surveys
- Visual Cues

Manual Material Handling

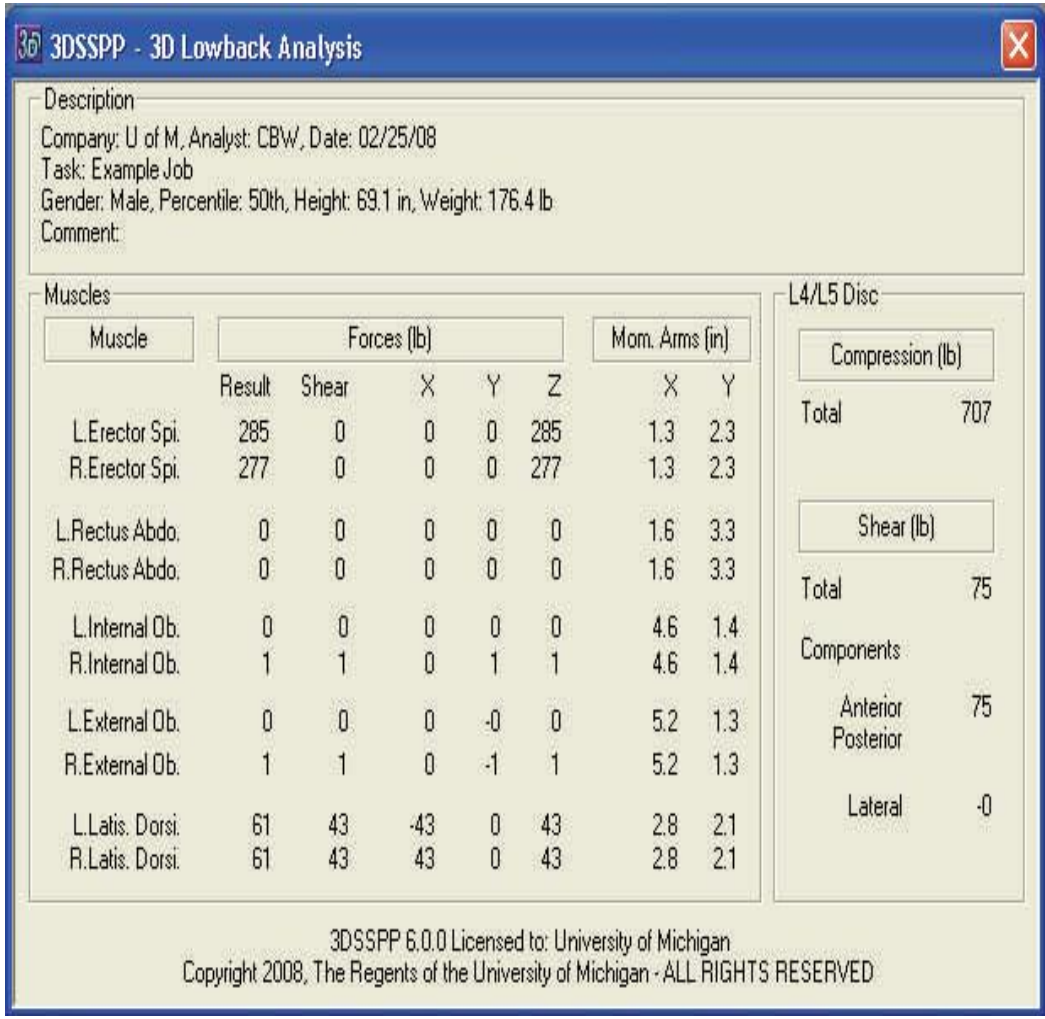
- Assessment tools
  - Quantitative and qualitative tools
  - Subjective Assessment
  - Checklists
  - Software
    - 3DSSPP
    - JACK

3DSSPP

- 3DSSPP software predicts static strength requirements for tasks such as lifts, presses, pushes, and pulls.
- The program provides an approximate job simulation that includes posture data, force parameters and male/ female anthropometry.
- Output includes the percentage of men and women who have the strength to perform the described job, spinal compression forces, and data comparisons to NIOSH guidelines.
- Various reports are provided

3D LOW BACK ANALYSIS REPORT

- Lists the L4/L5 disc compression force and can be compared to the NIOSH Back Compression Design Limit (BCDL) of 3400 newtons (or 770 pounds)
- List Back Compression Upper Limit (BCUL) of 6400 newtons (or 1430 pounds.)



3DSSPP - 3D Lowback Analysis

Description

Company: U of M, Analyst: CBW, Date: 02/25/08
Task: Example Job
Gender: Male, Percentile: 50th, Height: 69.1 in, Weight: 176.4 lb
Comment:

Muscles

Muscle	Forces (lb)					Mom. Arms (in)	
	Result	Shear	X	Y	Z	X	Y
L.Erector Spi.	285	0	0	0	285	1.3	2.3
R.Erector Spi.	277	0	0	0	277	1.3	2.3
L.Rectus Abdo.	0	0	0	0	0	1.6	3.3
R.Rectus Abdo.	0	0	0	0	0	1.6	3.3
L.Internal Ob.	0	0	0	0	0	4.6	1.4
R.Internal Ob.	1	1	0	1	1	4.6	1.4
L.External Ob.	0	0	0	-0	0	5.2	1.3
R.External Ob.	1	1	0	-1	1	5.2	1.3
L.Latis. Dorsi.	61	43	-43	0	43	2.8	2.1
R.Latis. Dorsi.	61	43	43	0	43	2.8	2.1

L4/L5 Disc

Compression (lb)

Total 707

Shear (lb)

Total 75

Components

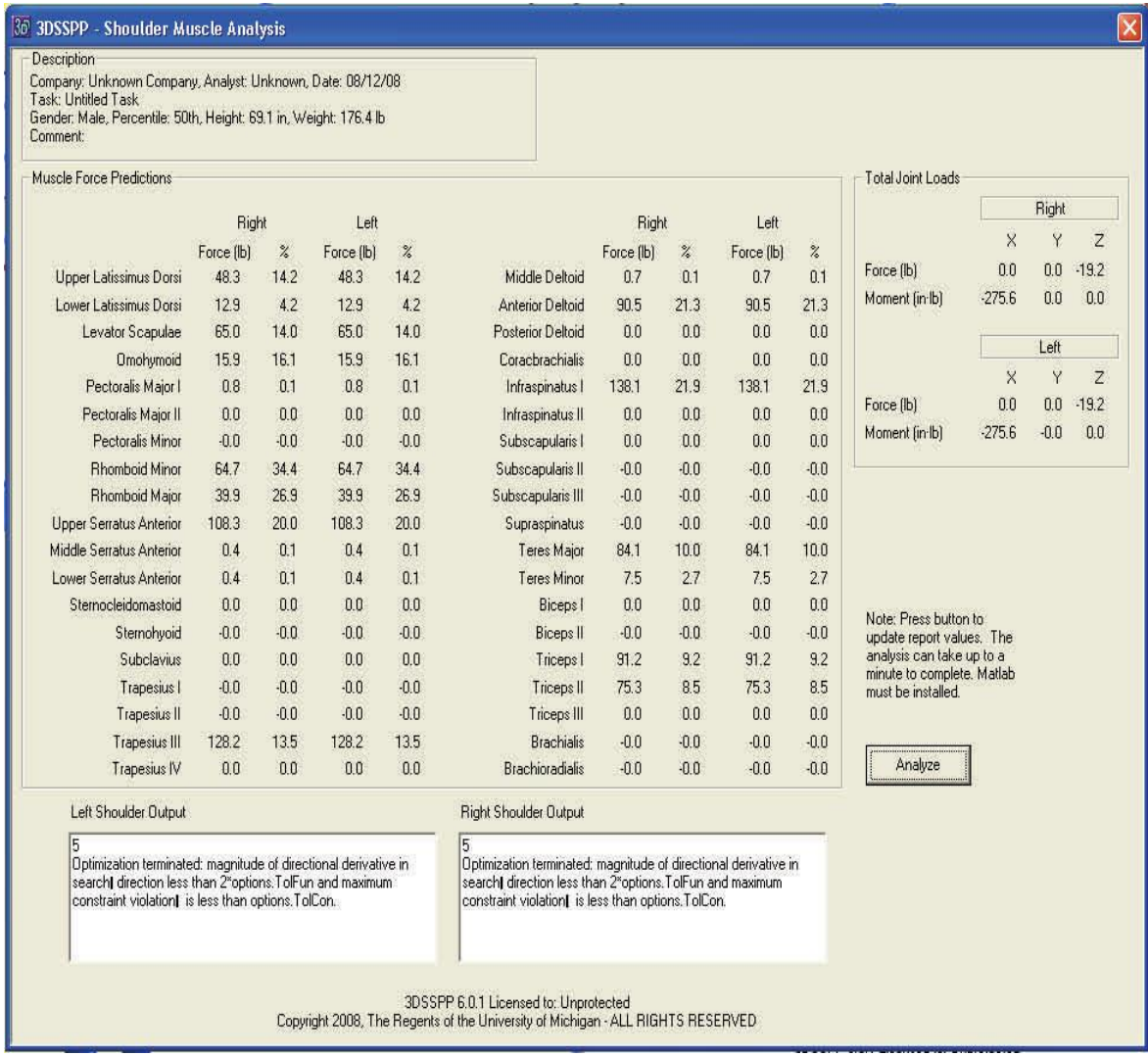
Anterior Posterior 75

Lateral -0

3DSSPP 6.0.0 Licensed to: University of Michigan

SHOULDER MUSCLE MODEL REPORT

- The shoulder muscle model report outputs the results of the shoulder muscle model.
- The model analyzes the left and right shoulder independently.



3DSSPP - Shoulder Muscle Analysis

Description
Company: Unknown Company, Analyst: Unknown, Date: 08/12/08
Task: Untitled Task
Gender: Male, Percentile: 50th, Height: 69.1 in, Weight: 176.4 lb
Comment:

Muscle Force Predictions

	Right		Left	
	Force (lb)	%	Force (lb)	%
Upper Latissimus Dorsi	48.3	14.2	48.3	14.2
Lower Latissimus Dorsi	12.9	4.2	12.9	4.2
Levator Scapulae	65.0	14.0	65.0	14.0
Omohymoid	15.9	16.1	15.9	16.1
Pectoralis Major I	0.8	0.1	0.8	0.1
Pectoralis Major II	0.0	0.0	0.0	0.0
Pectoralis Minor	-0.0	-0.0	-0.0	-0.0
Rhomboid Minor	64.7	34.4	64.7	34.4
Rhomboid Major	39.9	26.9	39.9	26.9
Upper Serratus Anterior	108.3	20.0	108.3	20.0
Middle Serratus Anterior	0.4	0.1	0.4	0.1
Lower Serratus Anterior	0.4	0.1	0.4	0.1
Sternocleidomastoid	0.0	0.0	0.0	0.0
Sternohyoid	-0.0	-0.0	-0.0	-0.0
Subclavius	0.0	0.0	0.0	0.0
Trapesius I	-0.0	-0.0	-0.0	-0.0
Trapesius II	-0.0	-0.0	-0.0	-0.0
Trapesius III	128.2	13.5	128.2	13.5
Trapesius IV	0.0	0.0	0.0	0.0

	Right		Left	
	Force (lb)	%	Force (lb)	%
Middle Deltoid	0.7	0.1	0.7	0.1
Anterior Deltoid	90.5	21.3	90.5	21.3
Posterior Deltoid	0.0	0.0	0.0	0.0
Coracbrachialis	0.0	0.0	0.0	0.0
Infraspinatus I	138.1	21.9	138.1	21.9
Infraspinatus II	0.0	0.0	0.0	0.0
Subscapularis I	0.0	0.0	0.0	0.0
Subscapularis II	-0.0	-0.0	-0.0	-0.0
Subscapularis III	-0.0	-0.0	-0.0	-0.0
Supraspinatus	-0.0	-0.0	-0.0	-0.0
Teres Major	84.1	10.0	84.1	10.0
Teres Minor	7.5	2.7	7.5	2.7
Biceps I	0.0	0.0	0.0	0.0
Biceps II	-0.0	-0.0	-0.0	-0.0
Triceps I	91.2	9.2	91.2	9.2
Triceps II	75.3	8.5	75.3	8.5
Triceps III	0.0	0.0	0.0	0.0
Brachialis	-0.0	-0.0	-0.0	-0.0
Brachioradialis	-0.0	-0.0	-0.0	-0.0

Total Joint Loads

	Right		
	X	Y	Z
Force (lb)	0.0	0.0	-19.2
Moment (in-lb)	-275.6	0.0	0.0

	Left		
	X	Y	Z
Force (lb)	0.0	0.0	-19.2
Moment (in-lb)	-275.6	-0.0	0.0

Note: Press button to update report values. The analysis can take up to a minute to complete. Matlab must be installed.

Analyze

Left Shoulder Output

5
Optimization terminated: magnitude of directional derivative in search| direction less than 2*options.TolFun and maximum constraint violation| is less than options.TolCon.

Right Shoulder Output

5
Optimization terminated: magnitude of directional derivative in search| direction less than 2*options.TolFun and maximum constraint violation| is less than options.TolCon.

3DSSPP 6.0.1 Licensed to: Unprotected
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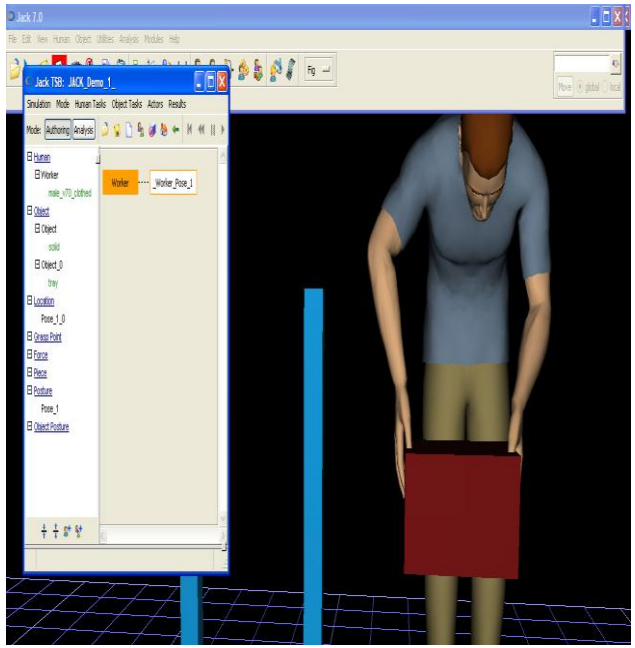
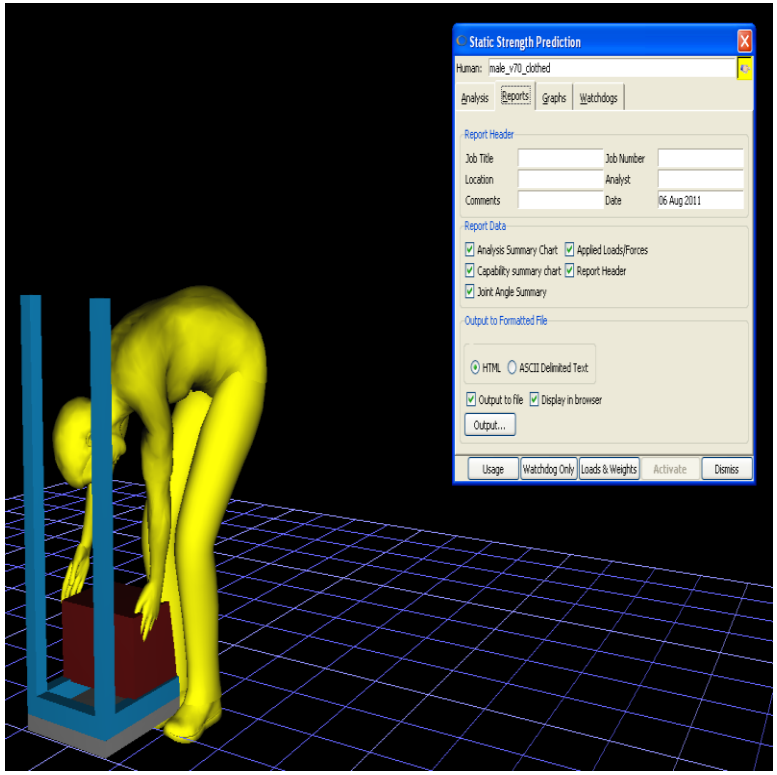
JACK

- A simulation tool that utilizes virtual humans to perform biomechanics and ergonomic analyses.
- Enables sizing of human models to match worker populations and testing of designs for multiple factors including:
  - Injury risk
  - User comfort
  - Reachability
  - Energy expenditure
  - Fatigue limits
- A Siemens product



JACK Task Analysis Toolkit

- NIOSH and RULA Analysis
- Fatigue Analysis
- Lower Back Analysis
- Static Strength Prediction



MMH Assessment Tools

- Various MMH tools exist for assessment
- Lifting and MMH
  - NIOSH Lifting Guideline
  - Liberty Mutual Table
  - Job Severity Index
- Upper extremity
  - Rapid Upper Limb Assessment Tool (RULA)
- Full body
  - Rapid Entire Body Assessment Tool (REBA)

Task Performance Process

- Primary risk factors in task performance
  - Awkward joint posture in the upper extremity and torso
  - Loading on joints of the lower extremity when moving on and off of vehicle

Ergonomics Program Development

Manual Waste Collection

OSHA ERGONOMICS GUIDELINE

- The OSHA Ergonomics Guideline can be used as a model to implement an ergonomics program in a waste collection environment

Where is the Ergonomics Program

- Stand-alone: large companies
  - Union supported in some cases
- Medical departments
- Safety Departments
- Human Resources
- Training Department
- Industrial Hygiene Department

Elements of a Complete Ergonomics Program

- Management leadership and employee participation
- Ergonomic risk information and reporting
- Job hazard analysis and control
- Training
- Ergonomic risk management
- Program evaluation

Management Leadership and Employee Participation

- Active and demonstrated concern for employee ergonomic risks
  - Examine existing policies and practices
  - Develop an ergonomic program that will address the needs, risks and constraints of your organization
    - Assign and communicate responsibilities
    - Provide those persons with authority a knowledge of prevention approaches
    - Commit resources to support the plan
  - Communicate periodically with employees about the program

Management Leadership and Employee Participation (Cont.)

- Employee Participation
  - Give employees an introduction and access to the details of the ergonomics program
  - Provide employees with a procedure for reporting ergonomic risks factors, signs and symptoms
  - Promptly responses to reports by employees
  - Communicate periodically with employees about the program (i.e., Ergonomic updates in regularly scheduled Safety meetings)

Hazard Information and Reporting

- Provide information on prevention and reduction techniques for ergonomic related injuries to current and new employees
- Develop and train employees on the reporting system for them to report and get responses on ergonomic concerns

Job Hazard Analysis and Control

- Analyze the elements of the waste collection tasks to identify "ergonomic risk factors"
  - May also use existing research (i.e. EREF funded UCF study)
- Implement controls to help eliminate or reduce ergonomic hazards
- Consider an incremental abatement process

Ergonomic Training

- Provide training to employees on CTD hazards
  - Employees need to know how to:
    - Recognize
    - Protect
  - Supervisors need to know how to:
    - Set up and manage an ergonomics program
    - Eliminate and evaluate hazards
- Provide training and information
  - Management training
  - Employee training

Ergonomic Risk Management

- Process for regular review of the following
  - High risks task activities
  - Ergonomic related injuries
- Prompt response to employees when ergonomic risks are reported to prevent conditions from worsening
- Determine a series of approaches to respond to reported risks (i.e. depending or degree of risks)
- Develop response strategy
  - Task performance process
  - Personal protective equipment
  - Incremental modifications

Implementation

- Involve key stakeholders in the development of an implementation plan
- Engage employees at all levels
- Consider linking ergonomics program to other safety and health initiatives or programs

Program Evaluation

- Program evaluation
  - Are ergonomic risks being reduced
  - Economic Impact on workers compensation claims
  - Employee perception of the program
  - Overall impact of program

University of Central Florida EREF Funded Research Project

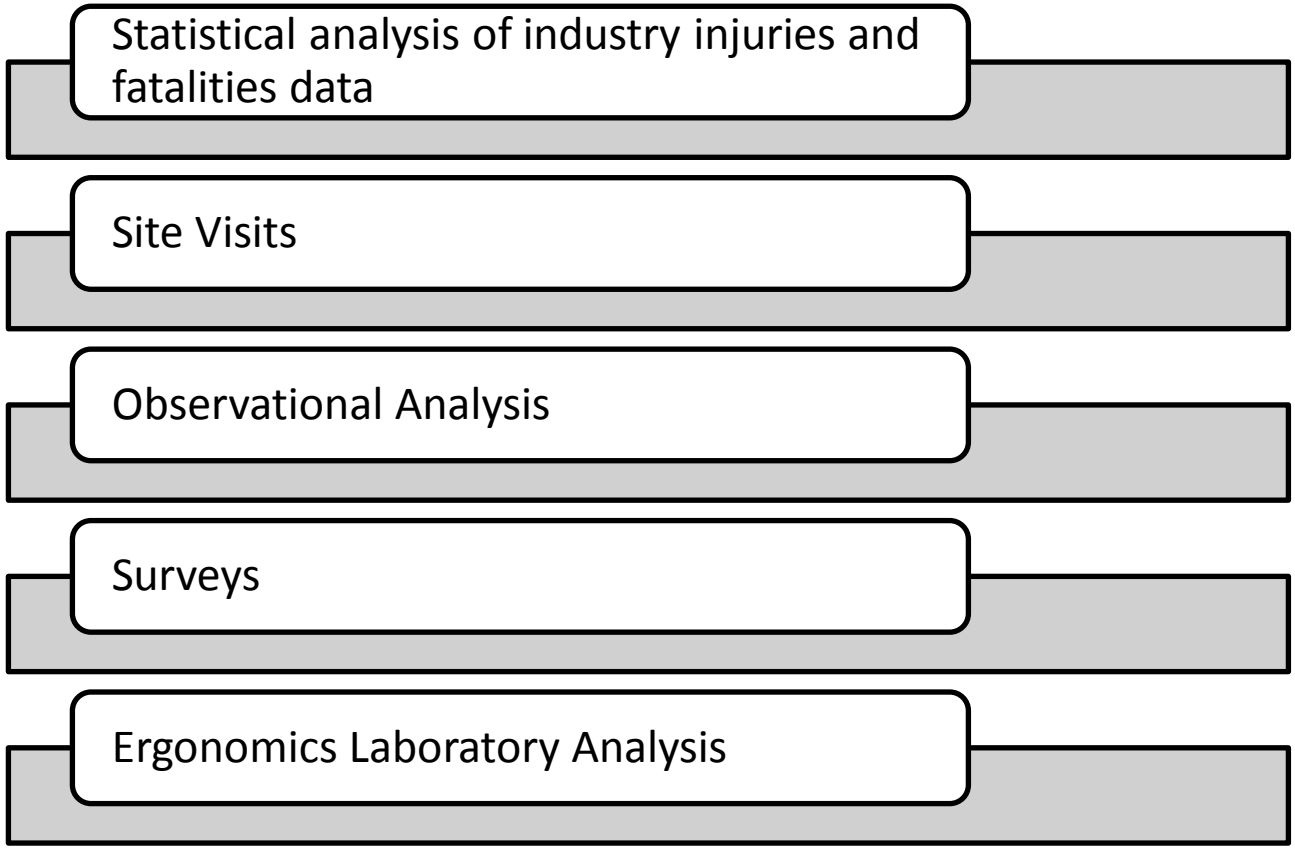
An Ergonomic Study of Solid Waste Collection

Ergonomic Study-Objectives

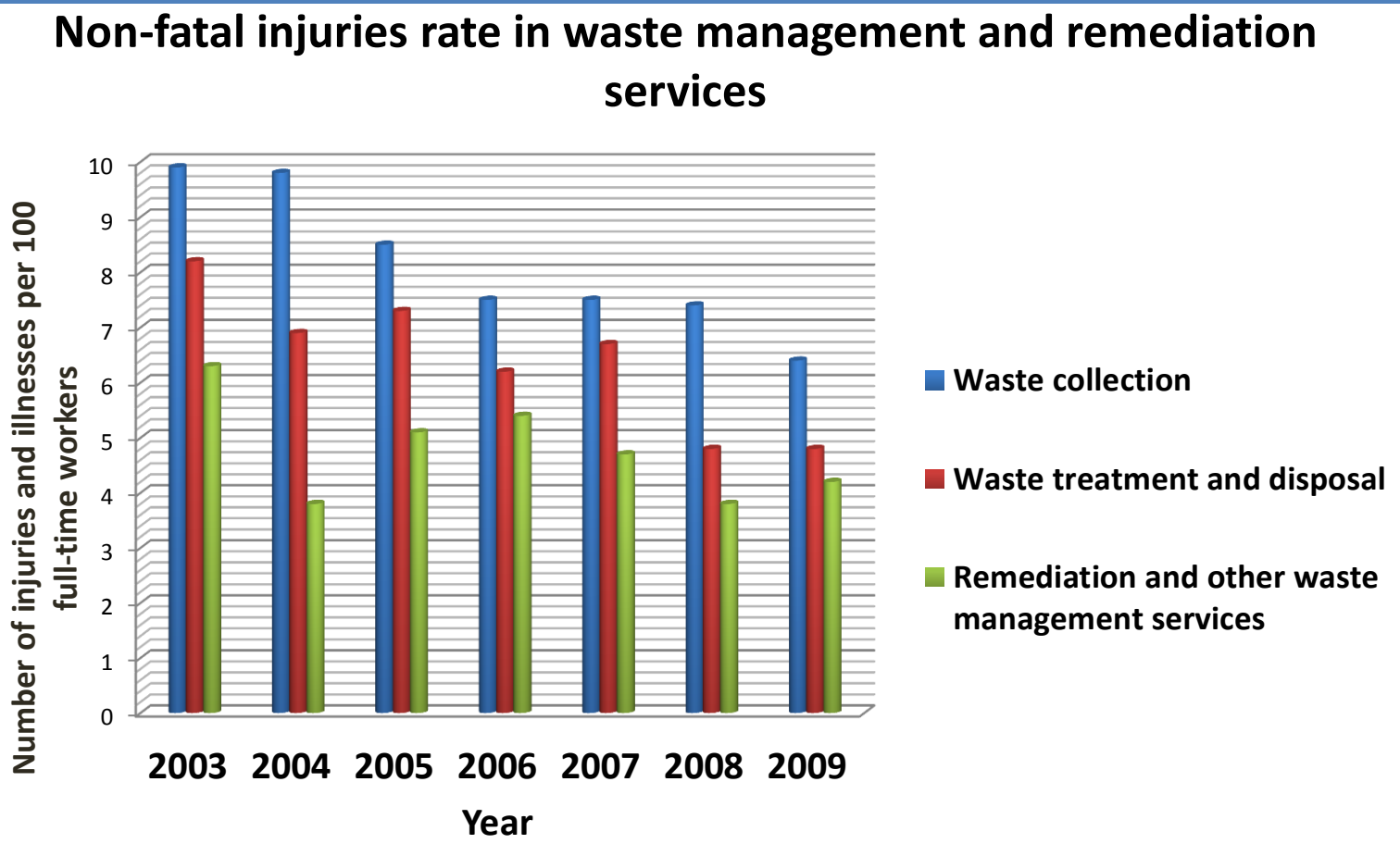
Identify the primary ergonomic-related risk factors that are producing injuries.

Perform an ergonomics assessment of the personnel collecting waste. The study will analyze three different types of waste collection (Manual, Semi-automated, Automated)and compare them from an ergonomics and risk factor perspective.

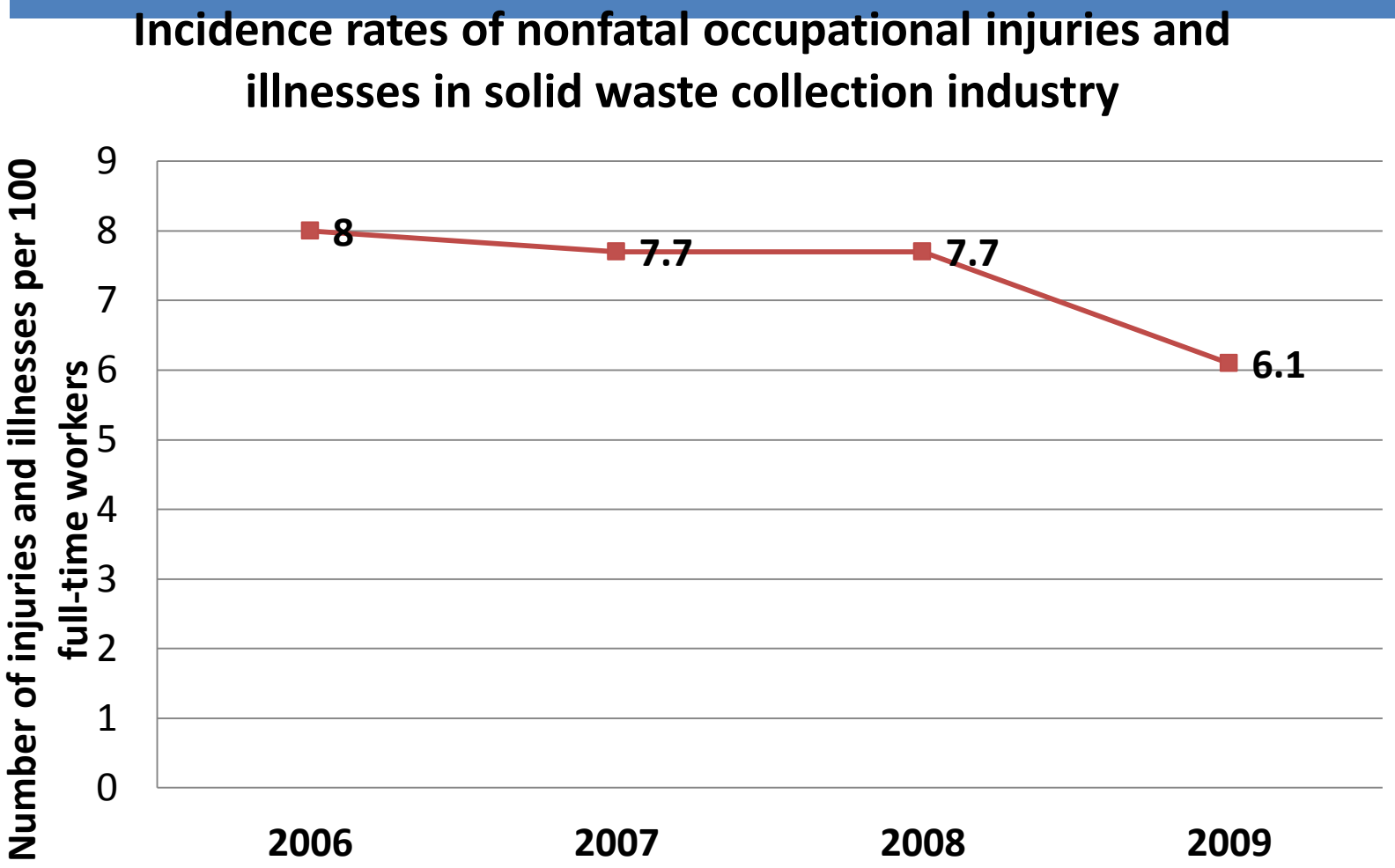
Methodology



Statistical Analysis of Bureau of Labor Statistics (BLS) Data

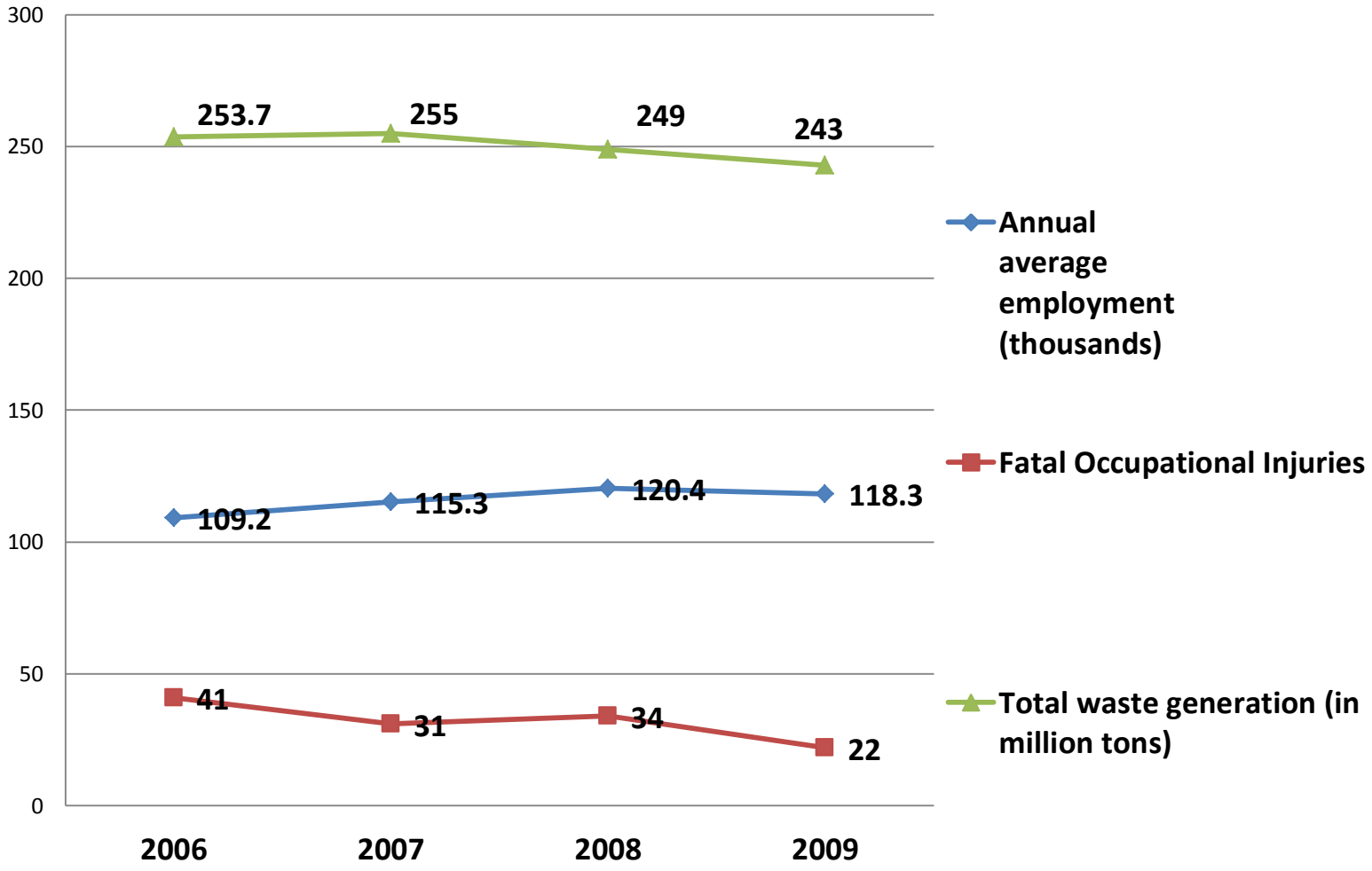


BLS Data Cont'd



BLS Data Cont'd

Trends of waste fatalities ,employment and waste amount



Observational Analysis

- Observe waste collectors during actual task performance
- Objective
  - Obtain detailed understanding of task characteristics
  - Determine appropriate tools to use for assessment
  - Visual determination of opportunities for ergonomic interventions
- Used the Washington Industrial Safety and Health Act (WISHA) to assess risks

Observational analysis

WISHA Check list Results : Manual Collection Tasks

Body Zone	Overall Evaluation		
	None	Caution	Hazard
Low Back			X
Hands and Wrists			X
Neck and Shoulder			X
Knee			X

WISHA Check list Results : Semi-Automated Collection Tasks

Body Zone	Overall Evaluation		
	None	Caution	Hazard
Low Back	X		
Hands and Wrists		X	
Neck and Shoulder	X		
Knee	X		

Site Visits

- Research team traveled to two waste management companies to meet with waste collectors and management
- Objective
  - Determine ergonomic interventions currently in use
  - Discuss ergonomics risks and need for interventions
  - Collect survey data

Survey Questions

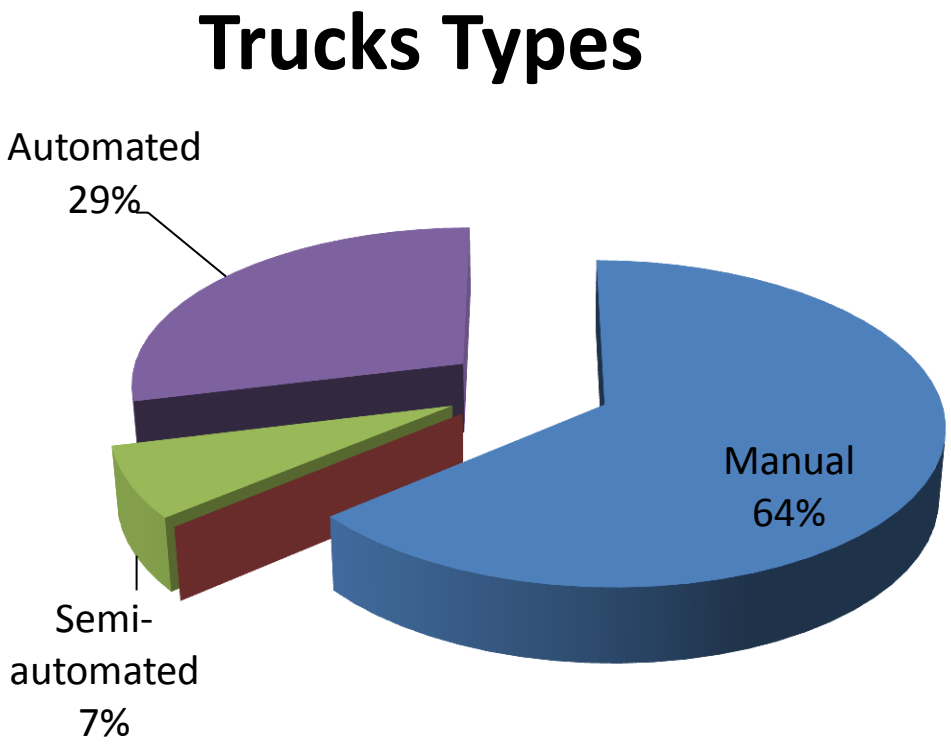
- Participants Demographics
- Type of waste trucks being used
- Route day duration and number of stops collected
- Estimated Container Weight
- Frequency of safety training programs
- Discomfort/Injuries frequency and location
- Days off due to pain or injuries

Survey Results

- Two survey forms were distributed to solid waste collectors and safety personnel at three waste companies.
- 63 waste collectors were surveyed, 27% of them reported that they didn't experience pain or injuries.

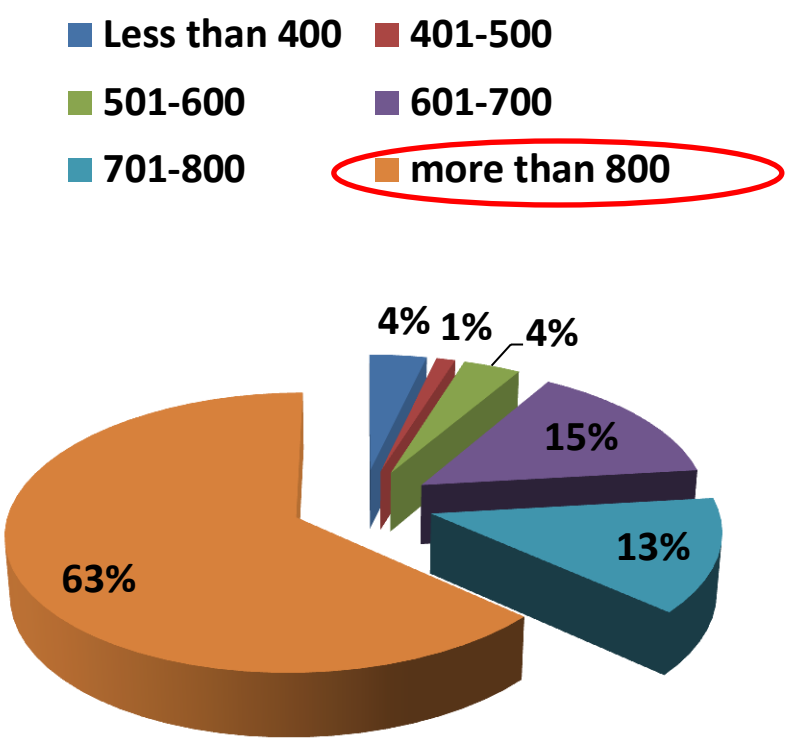
Vehicle Types

- Manual: 64%
- Automated: 29%
- Semi-automated:7%

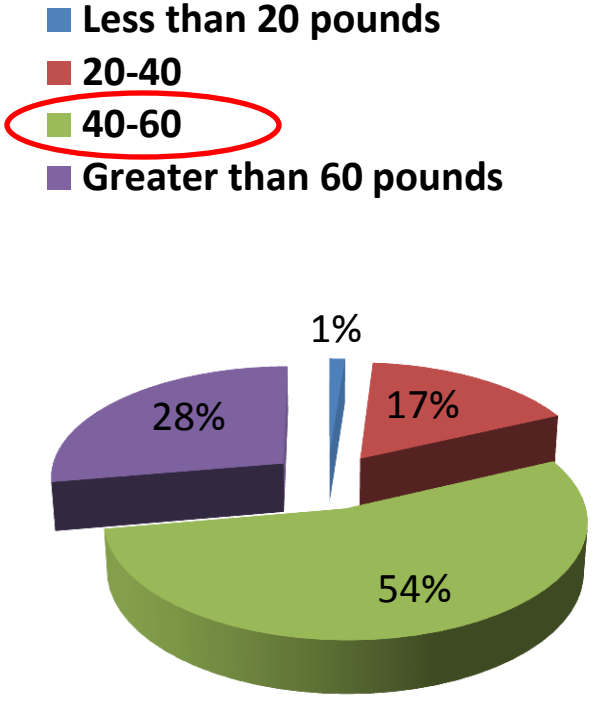


Surveys-Cont'd

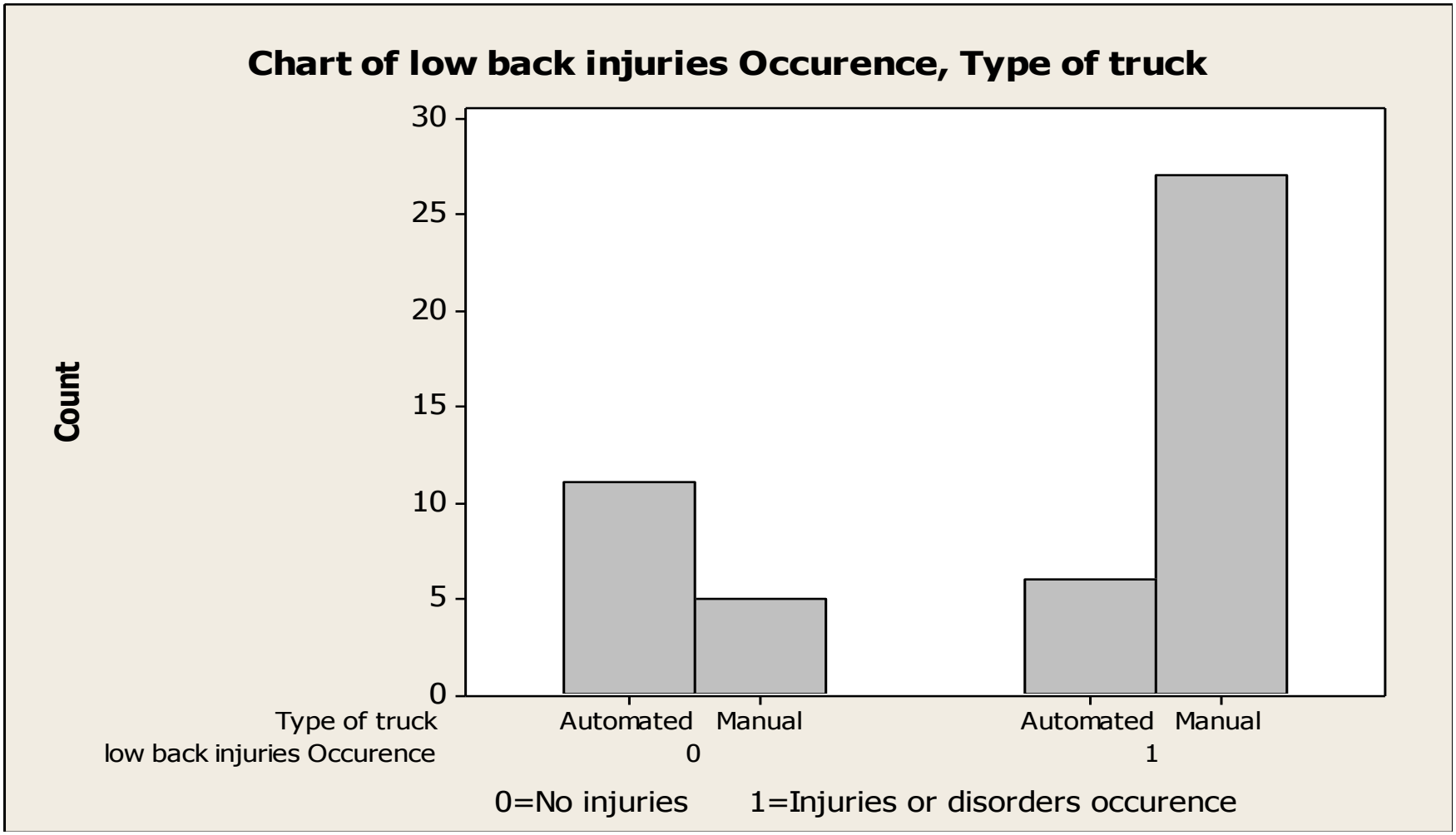
Number of stops collected on average route day



Estimated Average Container Weight



Disorders and Injuries



Laboratory Analysis

Equipment

- 3DSSPP Analysis Tool
  - L4/L5 load
  - Balance
- JACK Analysis Tool
  - L4/L5 load
  - Rapid Upper Limb Assessment Tool
  - Rapid Entire Body Assessment Tool
- Goniometer
- Timex Ironman Heart Rate Monitor
- Loaded Trashcan

Laboratory Study Methodology

- Survey and Consent Form
- Measure Joint Angles
- Simulated Waste Collection Task
  - Walk from the table to trash can
  - Pull trash can to table
  - Lift can
  - Dump contents onto table
  - Place can back on floor
  - Pull trash can back to starting location
  - Return to starting location next to table

Laboratory Experiment

Results

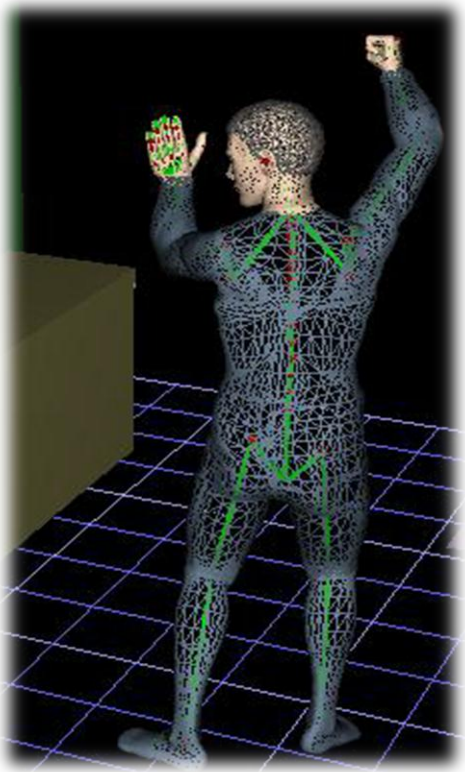
- Participants
  - Two groups
    - Students (25 subjects)
    - Mature subjects (6 subjects)
- Overhead lifting increases moments and forces in three regions: neck, arm/shoulder and L4/L5
- Risks at L4/L5 frequently exceeded NIOSH guidelines
- Locations of hands increased moment and thereby increased the load when lifting
- Pushing and pulling reduces the loading vs. lifting
- Walking and movement to and from the curb provided a “recovery period” for the musculoskeletal system

Ergonomics Laboratory Analysis

Low Back Analysis of Manual Collection : Dumping the waste container Task

The force on the worker's L4/L5 vertebral disc exceeds NIOSH force limits (>3400 Newton)

JACK



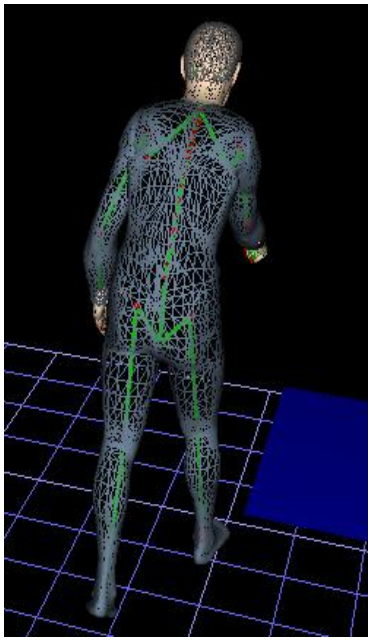
3DSSPP

Ergonomics Laboratory Analysis

Low Back Analysis of Semi-Automated Collection : Pushing the waste container Task

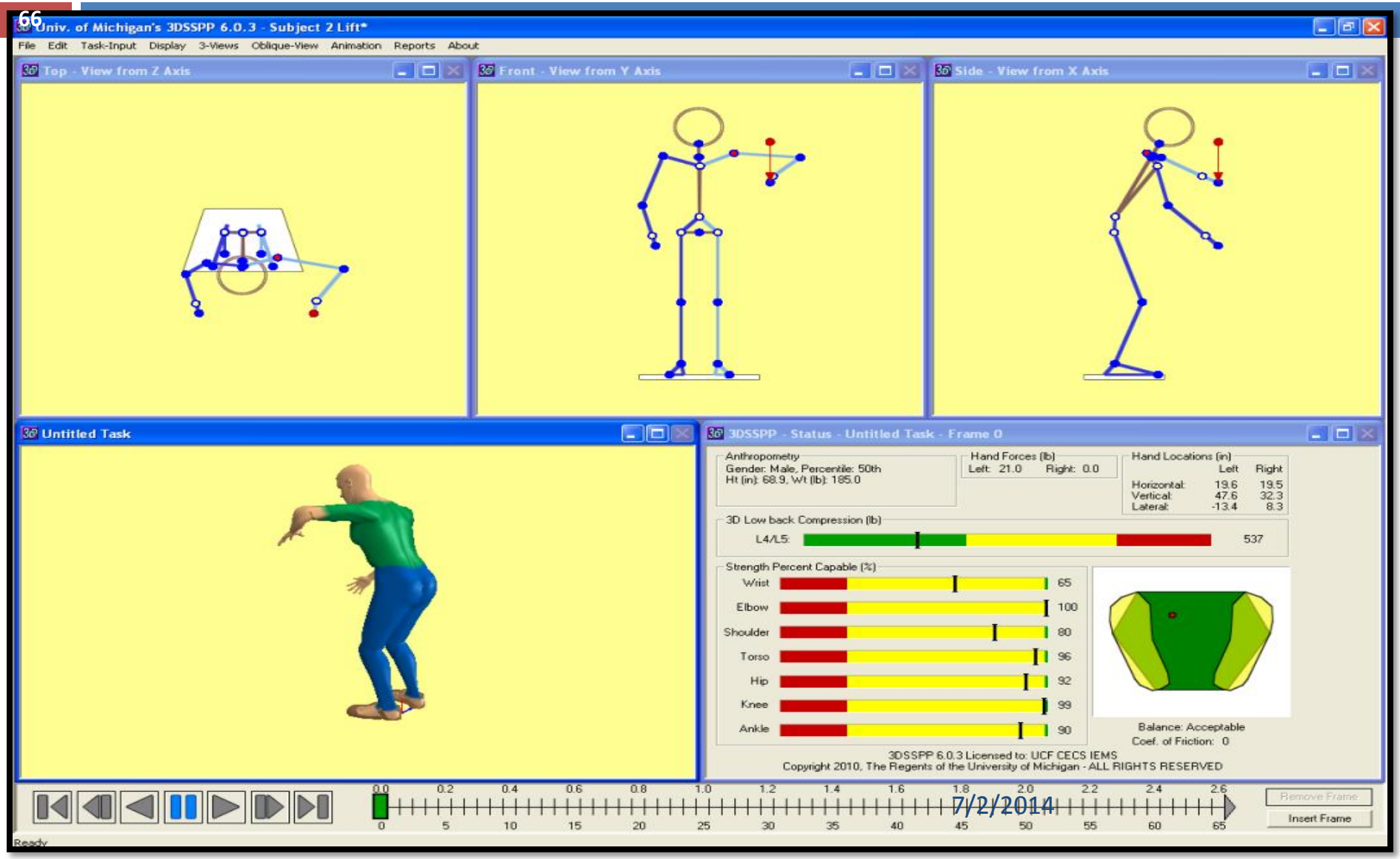
The forces on the worker's L4/L5 vertebral disc is within NIOSH Lifting Guideline limits (< 3400Newton)

JACK



3DSSPP

Results


Univ. of Michigan's 3DSSPP 6.0.3 - Subject 2 Lift*
File Edit Task-Input Display 3-Views Oblique-View Animation Reports About
Top - View from Z Axis
Front - View from Y Axis
Side - View from X Axis
Untitled Task
3DSSPP - Status - Untitled Task - Frame 0
Anthropometry
Gender: Male, Percentile: 50th
Ht (in): 68.9, Wt (lb): 185.0
Hand Forces (lb)
Left: 21.0 Right: 0.0
Hand Locations (in)
Left Right
Horizontal: 19.6 19.5
Vertical: 47.6 32.3
Lateral: -13.4 8.3
3D Low back Compression (lb)
L4/L5: 537
Strength Percent Capable (%)
Wrist 65
Elbow 100
Shoulder 80
Torso 96
Hip 92
Knee 99
Ankle 90
Balance: Acceptable
Coef. of Friction: 0
3DSSPP 6.0.3 Licensed to: UCF CECS IEMS
Copyright 2010, The Regents of the University of Michigan - ALL RIGHTS RESERVED
Remove Frame
Insert Frame
Ready

Outcomes

- Risk of musculoskeletal injury due to
  - L4/L5 load
  - Loading at the hands and wrist
  - Awkward joint posture
- Improvements may be achieved by:
  - Decreasing amount of bending in trunk
  - Reducing repetition
  - Modifying handle locations
  - Reducing the load
  - Increasing “recovery” opportunities for the musculoskeletal system

Conclusions

- Waste collectors of manual waste vehicles are at risk for musculoskeletal disorders .
- Pulling and pushing waste containers cause less compression forces on the lower back which don't exceed the acceptable NIOSH limits.
- Lifting of waste containers may exceed NIOSH limits
- Periodic surveillance for waste collectors to detect early signs of occupational disorders.
- Ergonomic training programs should implemented

Acknowledgment

•Environmental Research and Education Foundation

The research team would like to thank EREF for supporting this project

EREF | Environmental Research & Education Foundation

Lighting a path to sustainable waste management practices

Thank You

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