

Digital Human Modeling of Non-Occupational Risk Factors for Manufacturing Work Task Design



1st International Symposium to Advance TOTAL WORKER HEALTH

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Comprehensive Evaluation of an Integrated Health Protection and Health Promotion Program

Four-year intervention trial (2012-2016)

Two facilities operated by same manufacturing company

Does an integrated approach:

1. Reduce occurrence and impact of musculoskeletal health outcomes?
2. Reduce modifiable risk factors for chronic health conditions?
3. Provide an economic benefit?

Project Team

Nathan Fethke, PhD	(PI)
Fred Gerr, MD	(Co-I)
Linda Merlino, MS	(Study Coordinator)
Cassidy Branch, MA	(Wellness Coach)
Mark Schall, MS	(Graduate Fellow)



Program Design



Background and Significance

Work-related musculoskeletal disorders (MSDs) are prevalent among manufacturing workers Gerr et al., (2014)

Risk factors associated with the development of MSDs

- Physical risk factors (e.g., repetition, forceful exertions)
- Psychosocial risk factors (e.g., high job demands / low job control)
- Workplace organizational factors (e.g., no job rotation)
- Non-occupational risk factors (e.g., age, gender, body mass index)

Background and Significance

Manufacturing safety committees are commonly tasked with

- Identifying potential occupational risk factors
- Modifying work tasks to reduce exposure

Methods used to assess the ergonomics of work tasks do not typically consider non-occupational risk factors

Example: Strain Index

- Rating system to estimate risk for upper extremity MSDs
- Observer assesses six work-related variables
 - Intensity of exertion
 - Hand and wrist posture
 - Speed of work
 - Duration of exertion (i.e., duty cycle)
 - Hand exertions per minute
 - Duration per day work is performed

Does not consider non-occupational risk factors!

Digital Human Modeling



<http://www.ccad.uiowa.edu/vsr/>



<http://blog.industrysoftware.automation.siemens.com/blog/2009/03/19/are-digital-humans-cool/>

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TECHNOLOGY



<http://biomechanicsforeverybody.wordpress.com/category/modeling/>

- Evaluate the ergonomics of existing work tasks
- Develop and evaluate alternative designs
- Consider non-occupational risk factors in work task design

Santos Digital Human

Biomechanical, computer-based model that predicts static posture, dynamic motion, joint strength and fatigue

Human performance capabilities based on research conducted by University of Iowa Virtual Soldier Research program

Initially developed for military applications



<http://www.ccad.uiowa.edu/vsr/>

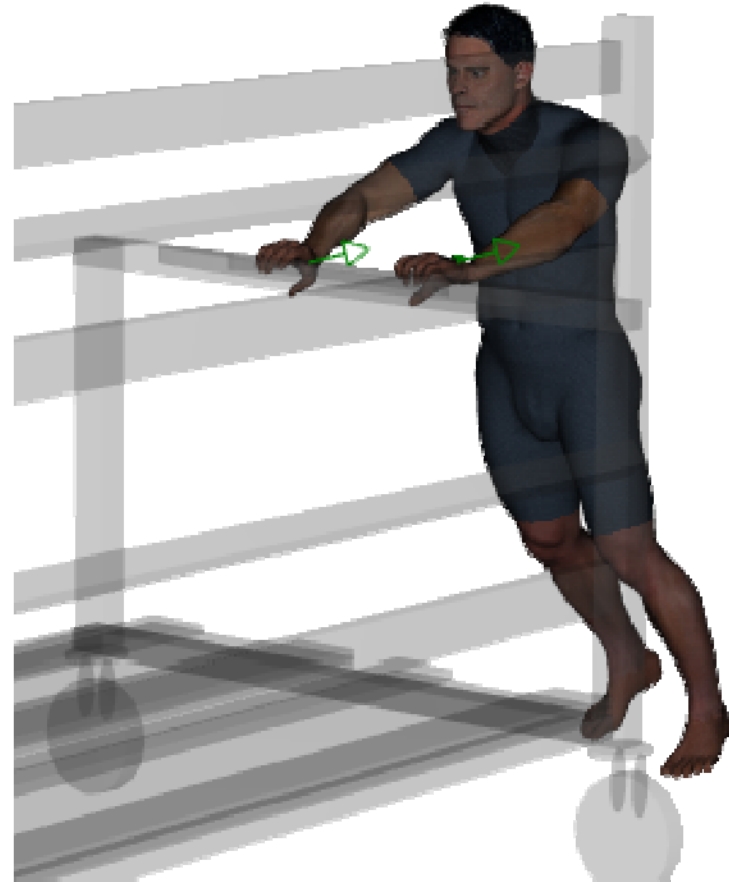


SANTOSHI JMANI



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Evaluate Existing Work Tasks

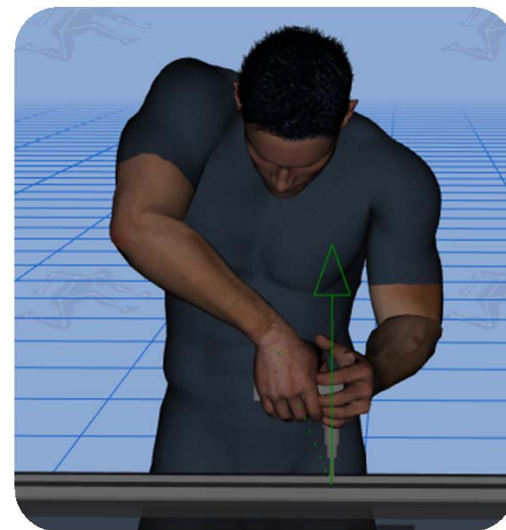
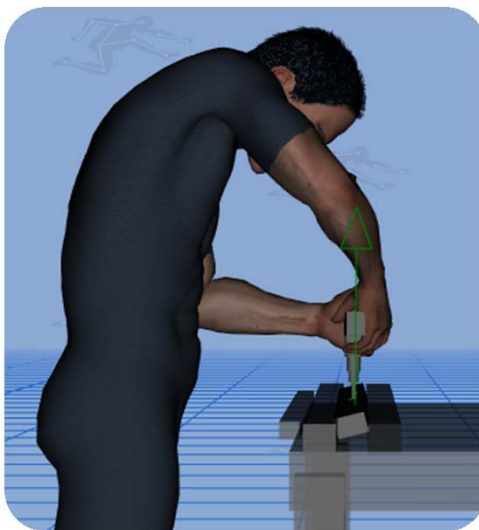


Develop and Evaluate Alternative Work Stations



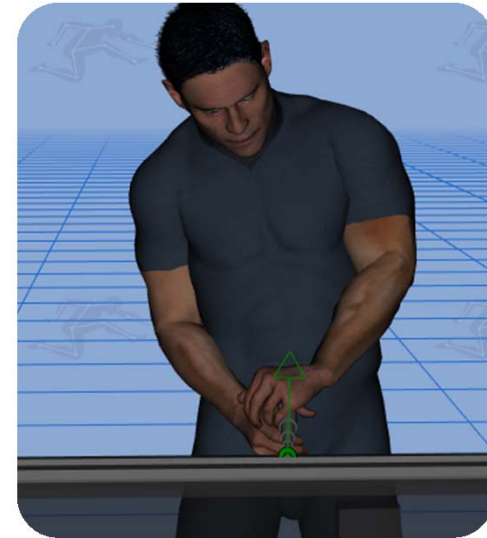
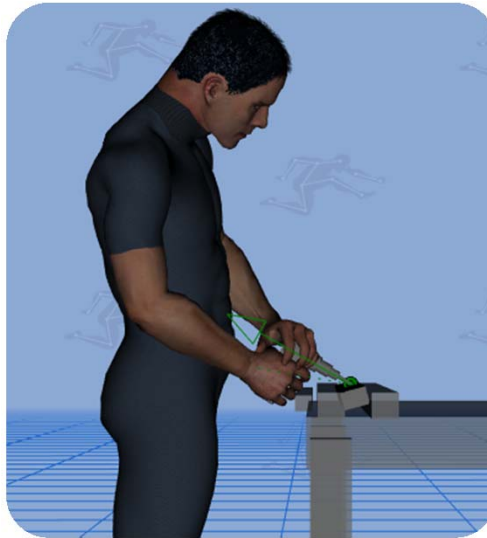
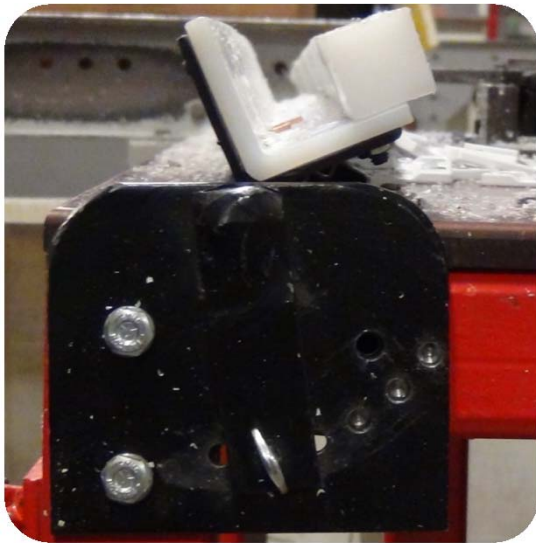
Develop and Evaluate Alternative Work Stations

Original - 90° from horizontal drilling



Develop and Evaluate Alternative Work Stations

Alternative – Adjustable drilling position



Consider Non-Occupational Risk Factors

Example: Evaluate effect of BMI on work task design criteria

Healthy BMI

Model:

BMI = 19.1 kg/m²

Strength and mobility
profile based on
empirical data of 100
healthy BMI
individuals



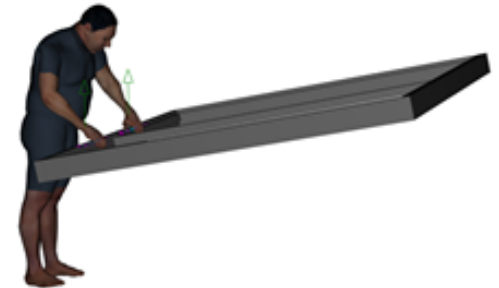
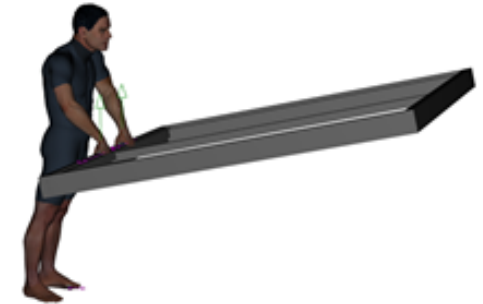
Overweight BMI

Model:

BMI = 31.1 kg/m²

Strength and mobility
profile based on
empirical data of 100
overweight BMI
individuals

Compare Model Capabilities While Completing Common Work Tasks



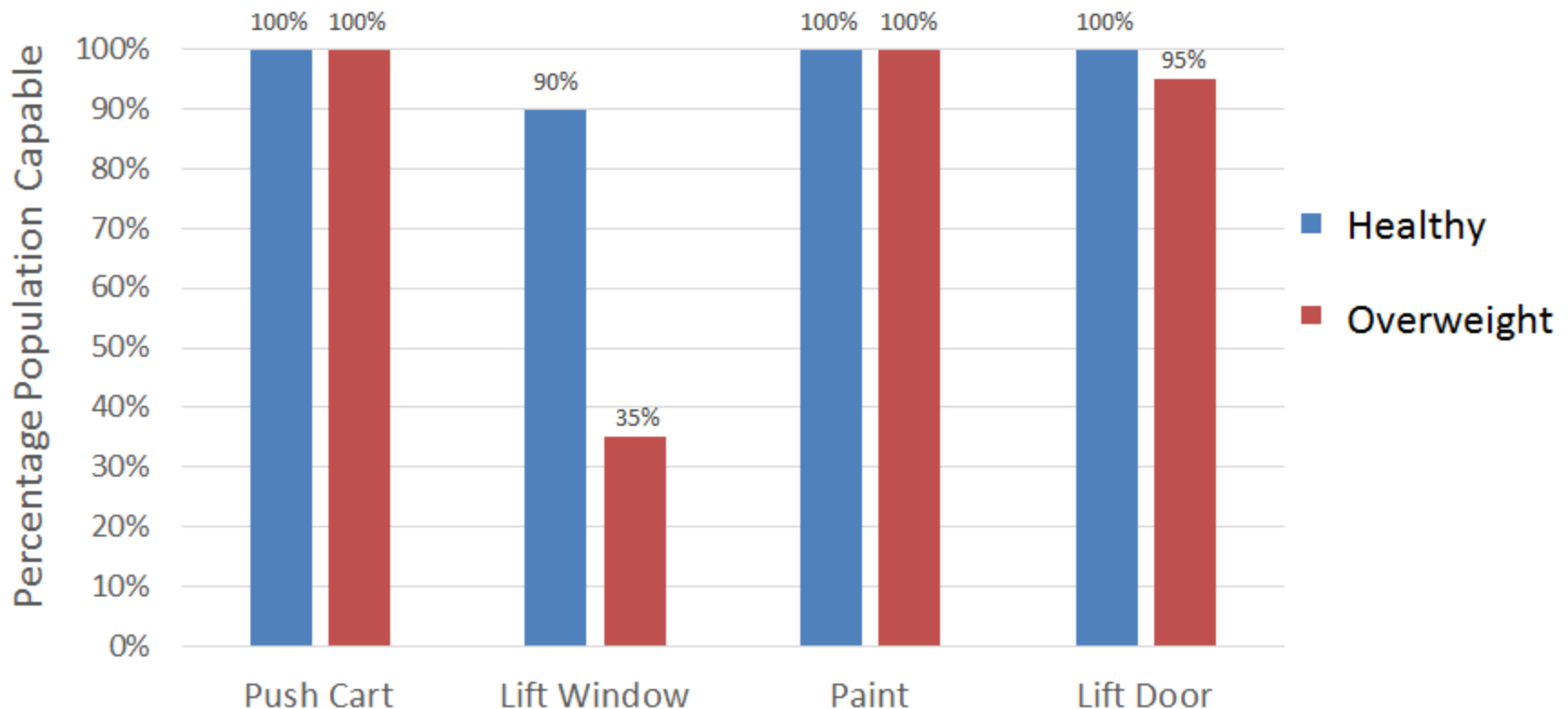
Push Cart

Lift Window

Paint

Lift Door

Results: Maximum Right Shoulder Torque



- Current work task design demands exceed right shoulder torque capability of 65% of overweight BMI population and 10% of healthy BMI population

Moving Window From Pallet to Conveyor



Walking with window

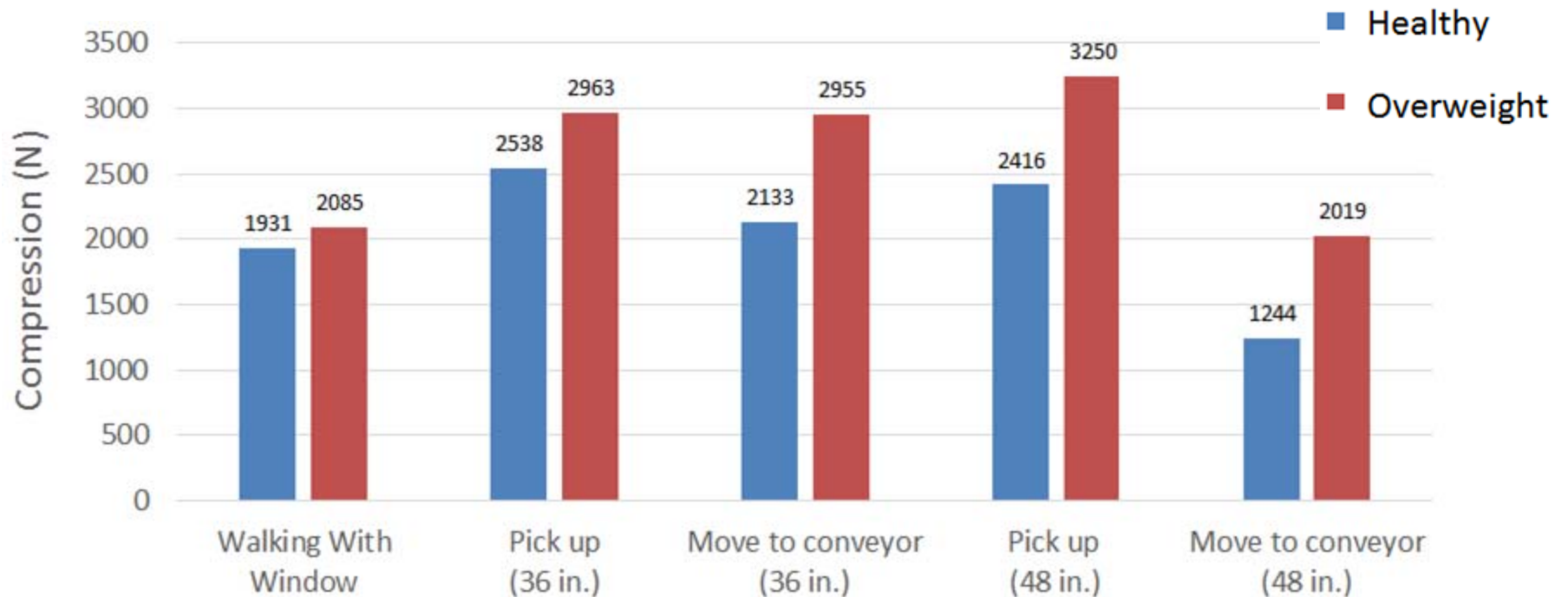


Lift and place (36 in)



Lift and place (48 in)

Results: Spine Compression



- NIOSH recommended action limit for spinal compression is 3400 N (Waters, 1993)
- Work task requiring placing window on 48 in. conveyor is very close to action limit

Summary

Digital human modeling software is becoming more sophisticated

Non-occupational risk factors may be modeled

- Age
- Gender
- Joint range of motion limitations

Adds value in context of TOTAL WORKER HEALTH

Questions



References

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Program Data Sources

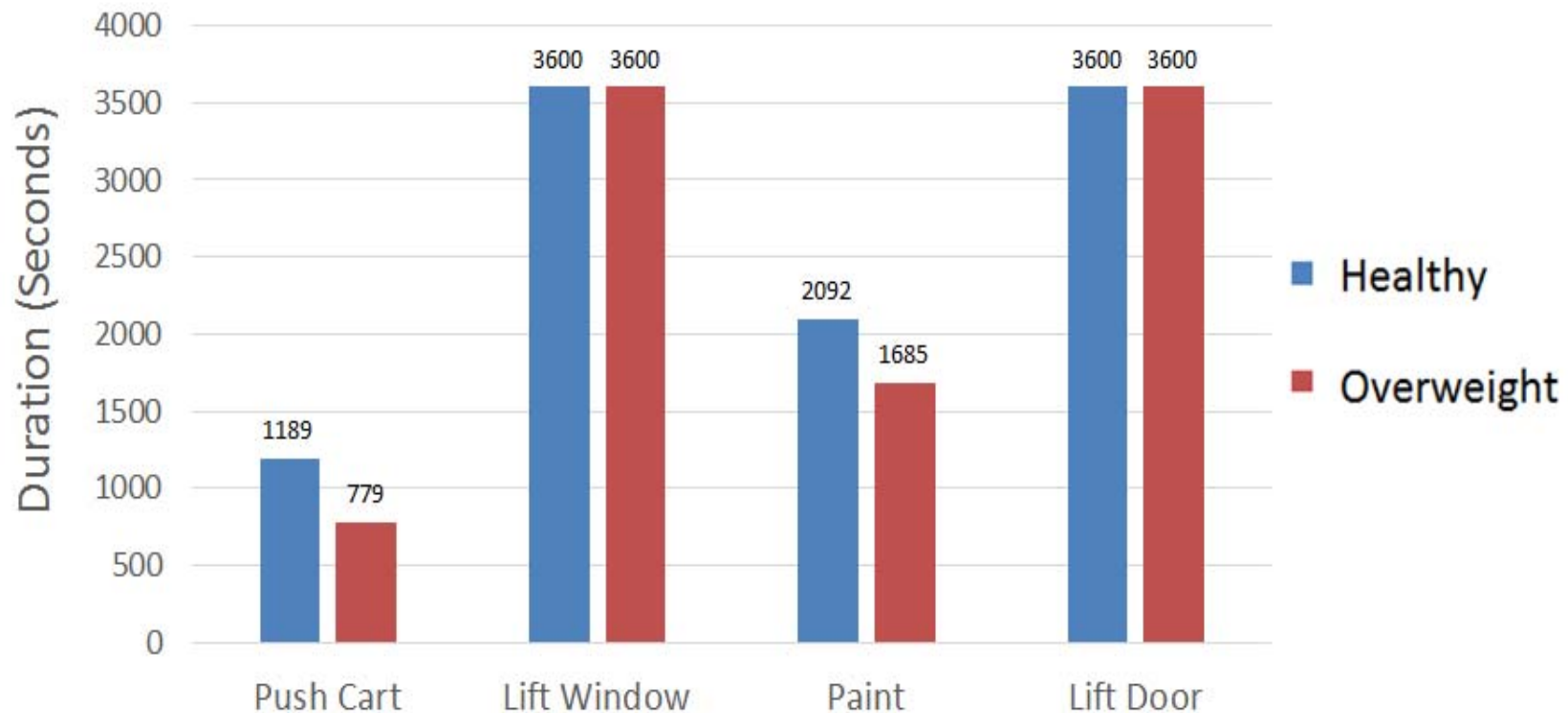
- Company/Facility Level
 - Health insurance claims/cost & EAP usage
 - Worker's compensation claims/cost
 - Video-based exposure assessment
- Participant Level
 - HRA/Biometrics
 - Demographics
 - Personal health
 - Job Content Questionnaire
 - SF-36
 - Musculoskeletal health

Participants Enrolled (2012-present)

Intervention facility: 191

Referent facility: 230

Results: Left Shoulder Fatigue



- No worker should push cart for more than \approx 13 minutes (779 sec)
- No worker should paint continuously for more than \approx 28 minutes (1685 sec)