How to Leverage Wearable Technology

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Agenda

- Current State of Ergonomics – Aon Laser Analytics, Current Markets, and Operational Issues
- Advanced Technology - Definition of Wearable Technology
- A Brief History
- Common Issues with Technology
- Types of Advanced Technology for Ergonomics
  - 3D Motion Capturing
  - Body and Segmental Pressure Mapping
  - Dynamic Muscle Force Data
  - 3D Dynamic Biomechanical Modeling
- Case Study Examples of Wearable Technology:
  - Identifying risks
  - Support TCOR through WC cost reduction and productivity improvements
- Closing Comments

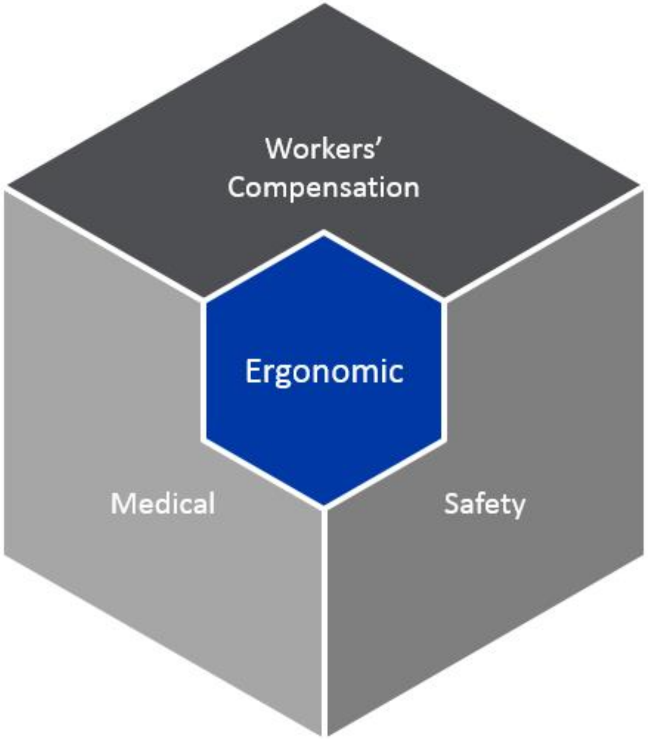
Current State of Ergonomics Analytics

- Musculoskeletal Injuries and Disorders leading types of injuries across nearly all industries (Aon Laser Analytics):
  - Food/Agribusiness 59%
  - Manufacturing 48%
  - Healthcare 45%
  - Retail 41%
  - Municipality 39%
  - Transportation 39%
  - Construction 35%
- A sample of 70 Laser Analytics Reports (Based on 3 year Loss Run):
  - 1.4 Billion in WC losses related to ergonomics issues only
  - Average program loss - $6.75 MM per year
  - These injuries lead to significant amount of Loss Time Days (TTD Days) associated with loss productivity which is not part of overall loss picture effecting staffing levels and production

Ergonomics – Micro Reactive Approach

Injury Perspective: Employee Driven Process

1. Reduce **likelihood of repeated injuries**
   – Employee pain and discomfort
   – Return-to-work
   – Regulatory responsibilities
   – Workers' compensation
   – Lost work days due to injury



Traditional View of Ergonomics

The Real Question is, how did we get here in the first place?

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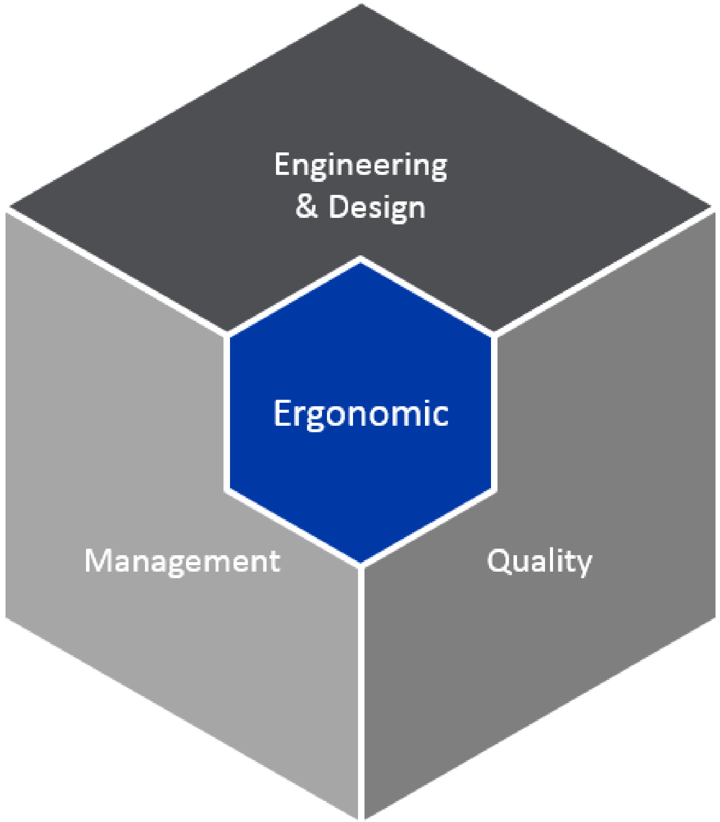
Ergonomics – Macro Data Driven Proactive Approach

Human Performance Perspective:
Risk Driven Process

2. Maximize **human performance**
   - Efficiency
   - Reduced defects from operator errors (Mura)
   - Focus on value added activities
   - Reducing non-value added movements (Muda)
   - Reduce overburden of human systems (Muri)
   - Results in “Employer of Choice”
     - Improved productivity
     - Higher retention rates
     - Reduced Costs (WC and Medical)



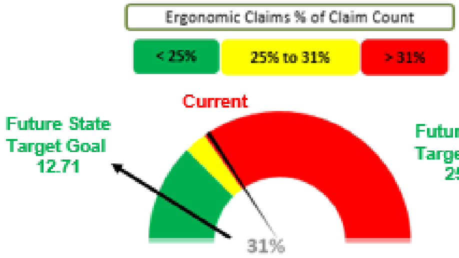
Human Performance View of Ergonomics

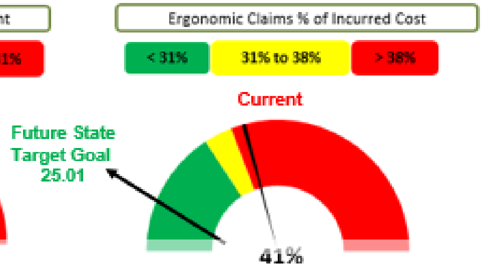
Points us in a direction where we need to move towards

Successful Ergonomics Process Impacts on TCoR

- A successful integrated ergonomics process can impact both traditional WC (red box) and operational metrics (green box)
- Using data to drive the process is the most effective for both lagging and leading indicators
- How much is being invested into prevention vs. what are we spending on losses?

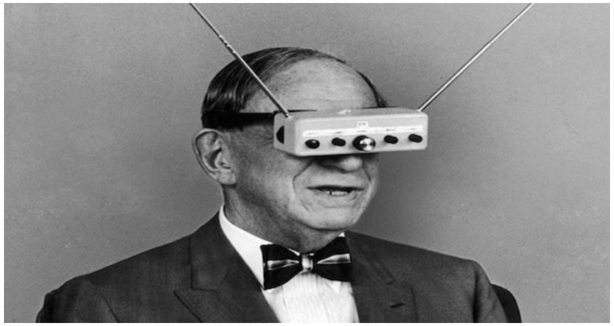
Effective Measure	Average
Number of WMSD Reduced	59%
Incident Rate Reduction	65%
Loss Workdays (Average days) Reduction	75%
Restricted Work Days	53%
Workers Comp Costs Reduced	68%
Average Cost per Claim Reduced	39%
Productivity Increase	25%
Labor Costs Reduced	43%
Scrap/Error Reduced	67%
Turnover Reduced	48%
Absenteeism Reduced (average days)	58%
Payback	0.7 years





What is Wearable Technology?

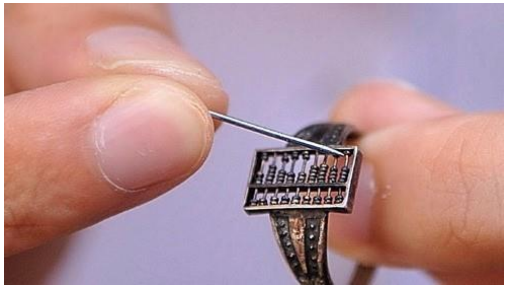
- Current Definition - Electronics that can be worn on the body, either as an accessory or as part of the material used in clothing and are connected to a data collection device that monitors personal metrics. Typically includes:
  - Smart Watches
  - Clothing
  - Fitness trackers
  - Jewelry
  - Glasses
  - Implants



- If we broaden the definition to include anything considered "new", they may not have to be electronic or actively be monitoring the person wearing it. Examples include:
  - Headphones
  - Braces (wrist and back)
  - GPS systems
  - Phones

A Brief History of Wearable Technology

Wearable Technology has been around a very long time.



17th Century - Abacus Ring

1571 - Wrist Watch

1907 - Spy Pigeon

1961 – Roulette Ball Timer

1980's – Pocket Ergo Meter

1990's Computer with Screen

A Brief History of Wearable Technology

Wearable Technology Today.

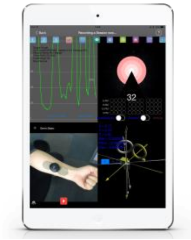
Generating Data

- Technology can provide valuable data that can provide feedback to those wearing devices. Data can be used to:
  - Monitor goals related to fitness activities
    - (steps taken, stairs climbed, calories burned, etc.)
  - Status of current health
    - (heart rate, blood pressure, sitting times, etc.)
  - Status of current physical work
    - (heat rate, distance covered, elevation gains, power output, etc.)
  - Provide biofeedback
  - Collect data related to posture and muscle activation levels

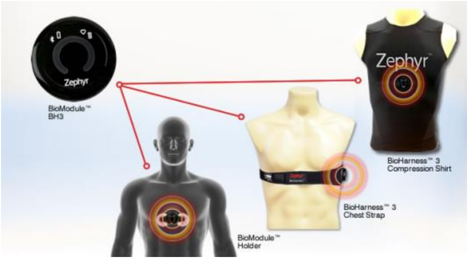
Ergonomics Applications - Spectrum of Wearable Technology

Exemples of Posture, Muscle Force, Pressure, etc.

Lumo Lift - $79

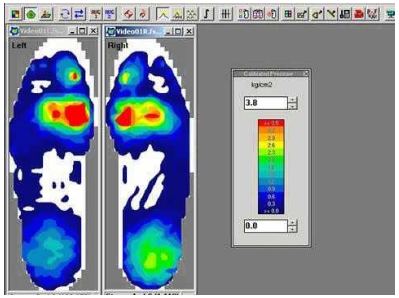


Somaxis Cricket - $250

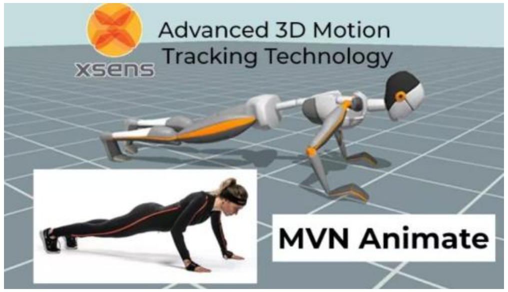


Zephyr Bioharness - $4,600

DataLink System - $9,000



Tekscan - $25,000



Xsens - $45,000

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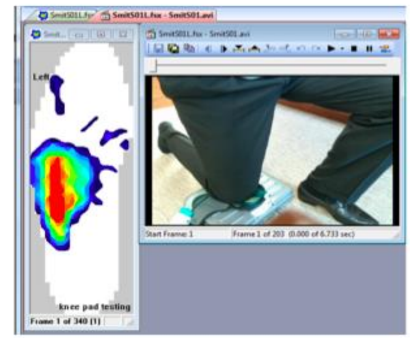
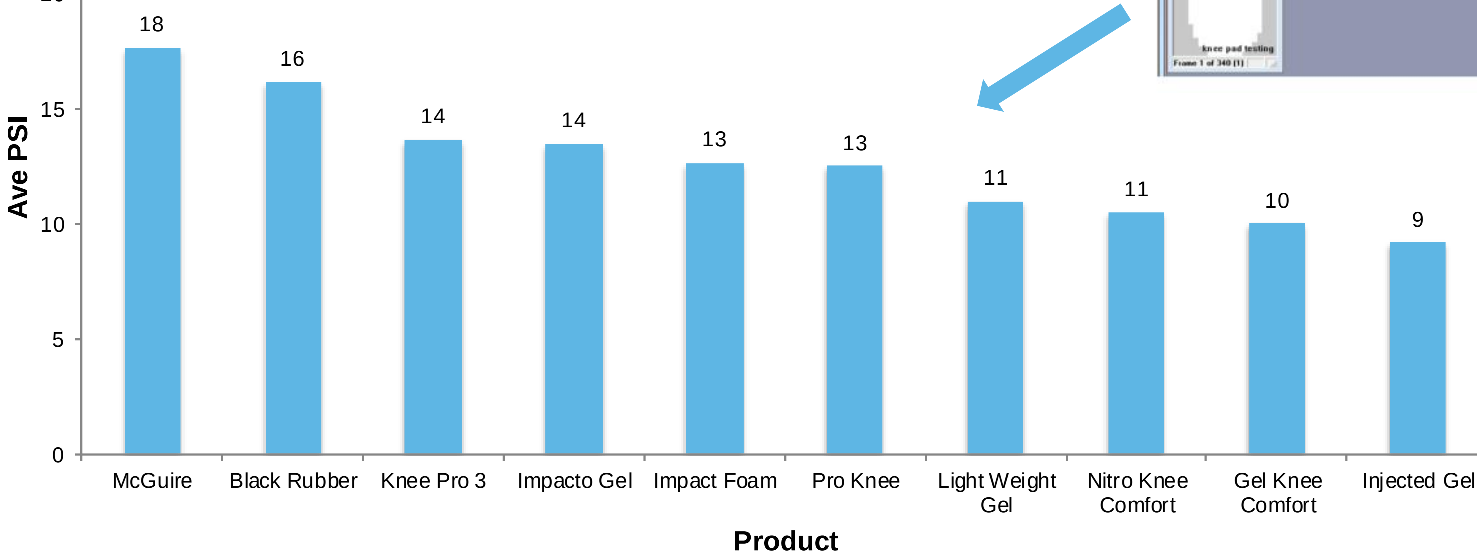
Case Study Example: Best-in-Class Assessment of Knee Pads

- Pressure mapping study:
  - Two shipyards experiencing high volume of knee type injuries and identified need to assess knee pad performance





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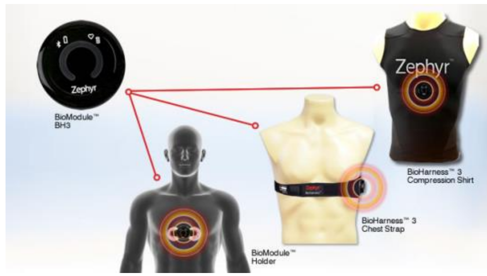
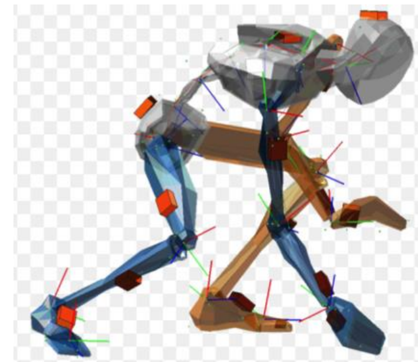
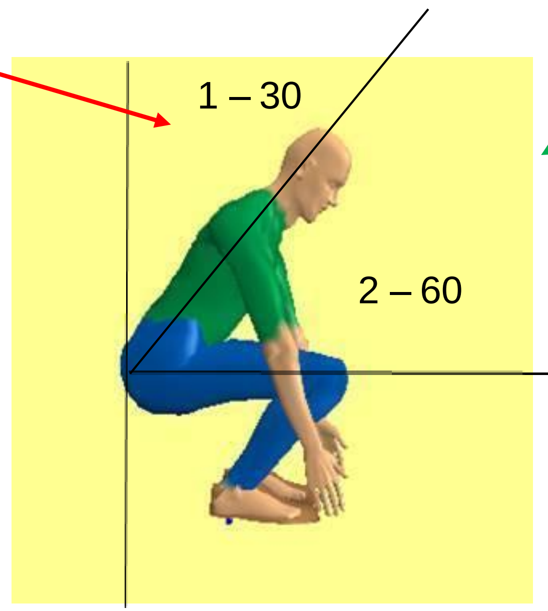
Buyer Beware Though – Inclinometer vs Goniometer Example





Inclinometer – Measures from Vertical

Goniometers – Measure Joint Axis



Ergonomics - Common Issues with Wearable Technology

Smart sensors will make sure you lift with your knees bent and back straight

News Article Claiming Back Safety Though Technology

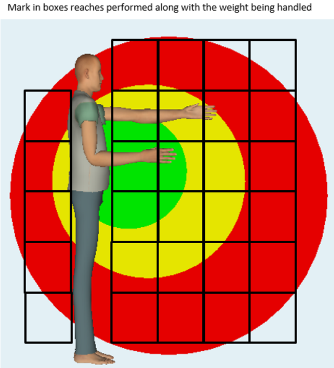
Sample Lifting Data Using a Simple Observation Tool

Ergonomics Job Observation Assessment

Operation Name: ______________________

Mark in boxes reaches performed along with the weight being handled

Assessors Name: ______________________



Time of Day of Observation AM – 1 2 3 4 5 6 7 8 9 10 11 12

Time of Day of Observation PM – 1 2 3 4 5 6 7 8 9 10 11 12

High Risk Observations

Medium Risk Observations

Low Risk Observations

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33%

41%

26%

Zone 1 Hi-Lo Observations					
# of over the shoulder strethches/lifts observed:	Reaches	Lifts	Stooping	**Percent of Total**	
# of over the stooping/bending strethches/lifts observed:					
0-10lbs	48	0	95	76%	
11-25lbs	15	0	23	20%	
26-35 lbs	2	0	0	1%	
>35lbs	5	0	0	3%	
Are step stools used (Goal 100%)?	Yes	No			
50%	3	3		**Total =**	**188**
Are safe lifting practices followed (Goal 100%)?	Yes	No			
100%	8	0		**% of Total Lifts**	**33%**
				Design Goal	**<20%**
Zone 2 Hi-Lo Observations					
# of reaches/lifts observed:	Reaches	Lifts		Percent of Total	
0-10lbs	74	102		76%	
11-25lbs	25	17		18%	
26-35 lbs	0	0		0%	
>35lbs	15	0		6%	
Are step stools used (Goal 100%)?	Yes	No			
33%	2	4		**Total =**	**233**
Are safe lifting practices followed (Goal 100%)?	Yes	No			
100%	8	0		**% of Total Lifts**	**41%**
				Design Goal	**<30%**
Zone 3 (lifting of 25 lbs or more)					
# of reaches/lifts observed:	120	28			
				Total =	**148**
Are step stools used (Goal 100%)?	Yes	No			
88%	7	1		**% of Total Lifts**	**26%**
				Design Goal	**>50%**

Total Lifts Observed	**569**

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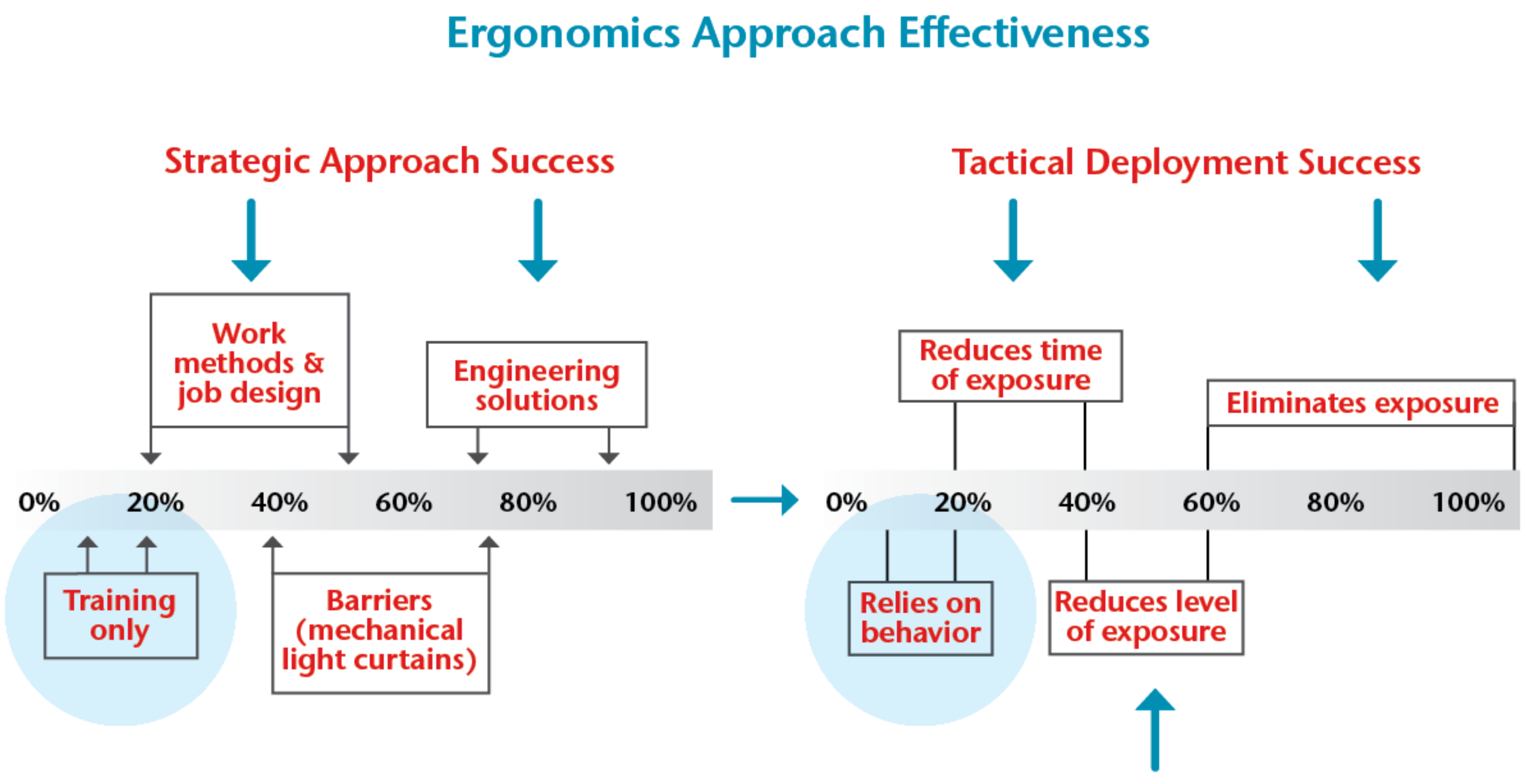
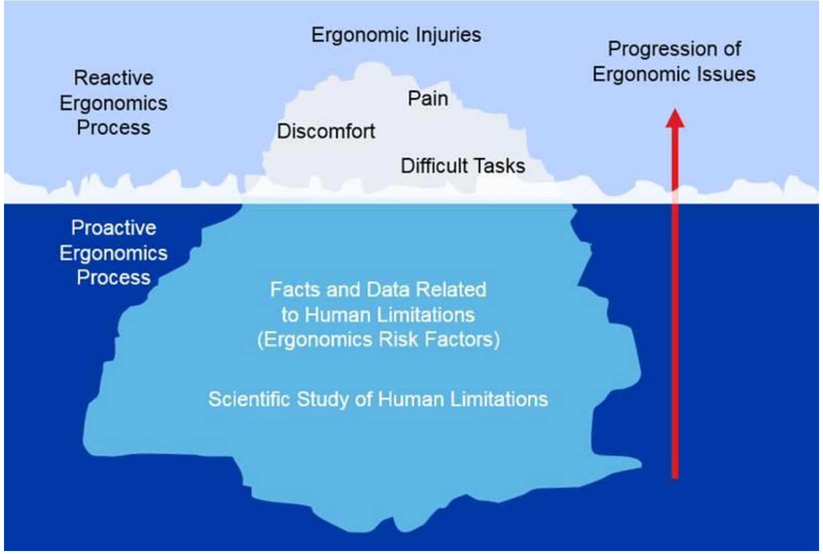
Ergonomics - Common Issues with Wearable Technology



The Science of Ergonomics

- Ergonomics is the “scientific study of the interaction of people within their work environment”
- Much of what is know about human performance has been studied in labs and in the field and published to create the evidence of “work-relatedness”
- Facts and data must drive the process otherwise “opinion” can slow the process down and wrong decision can be made even if for the right reasons
- Traditional ergonomics approach typically review a job task as applies checklist or risk assessment method but does not measure the actual employee response to the work



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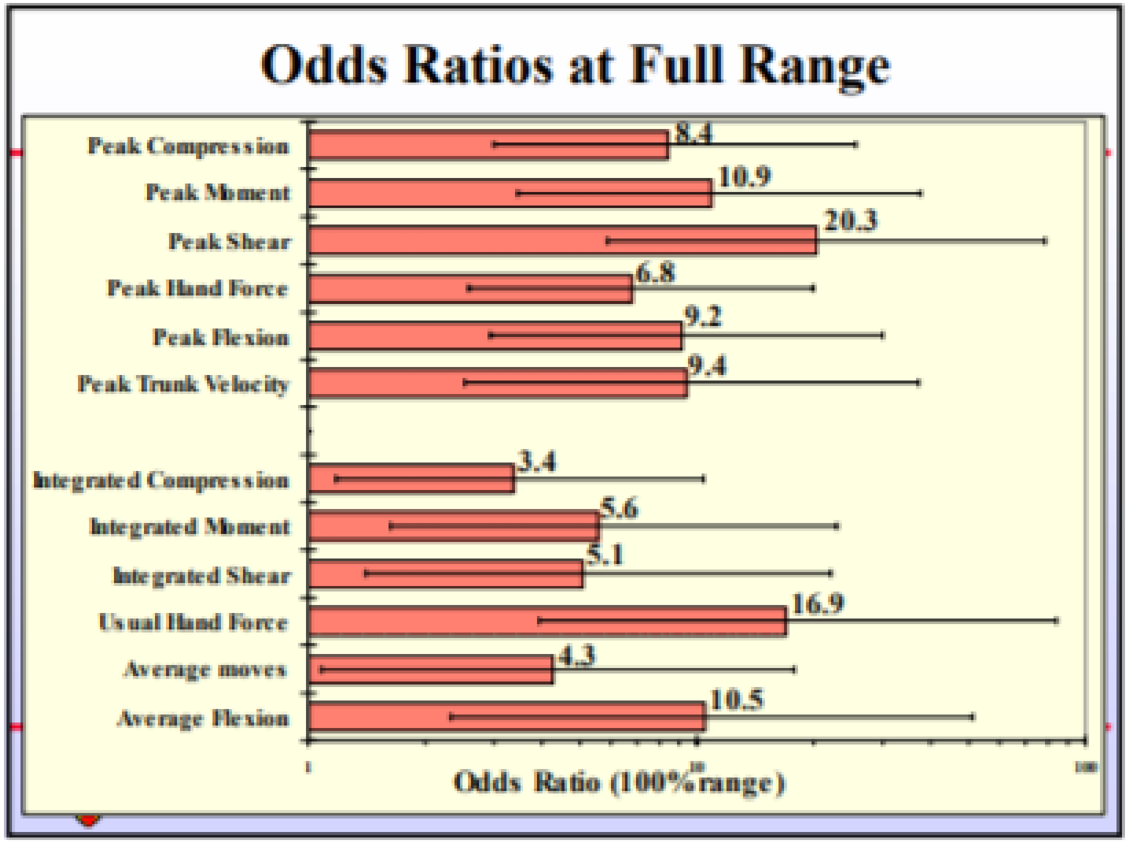
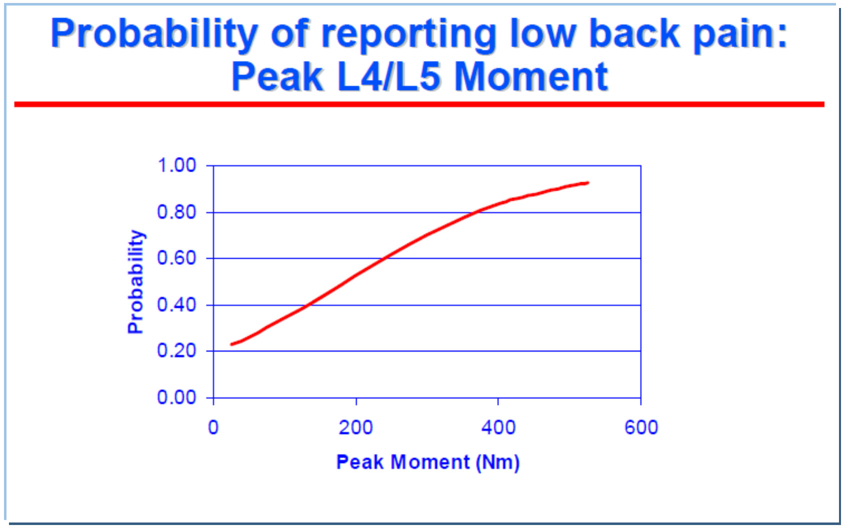
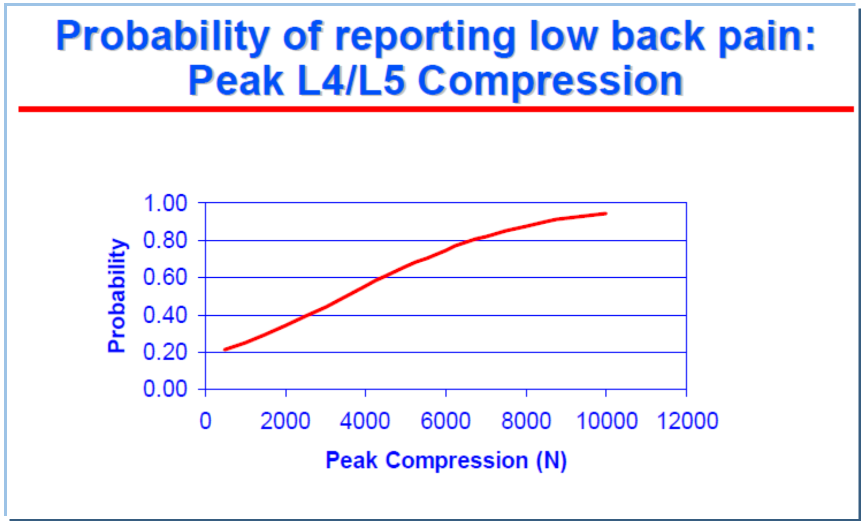
Ergonomics - Common Issues with Wearable Technology

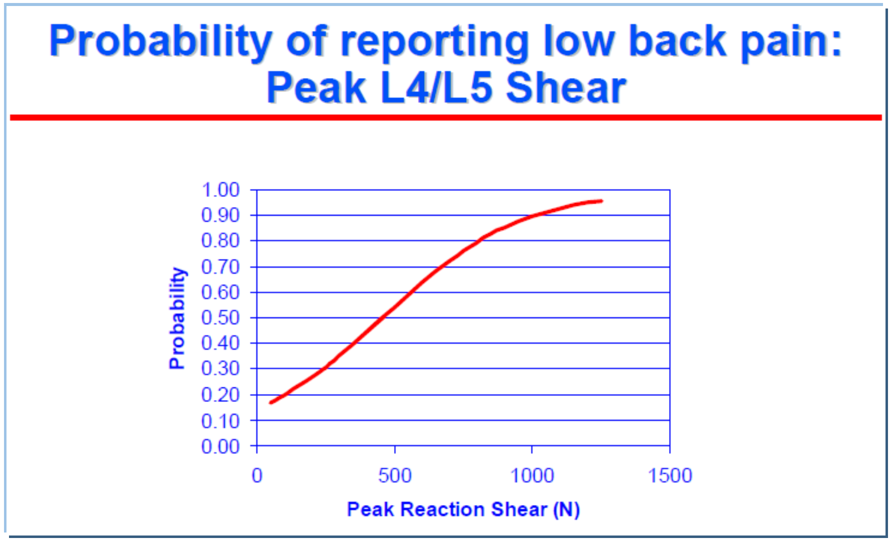


Ontario Universities Back Pain Study (OUBPS), 1998

Scientific Studies Risk Factors Related to Low Back Pain







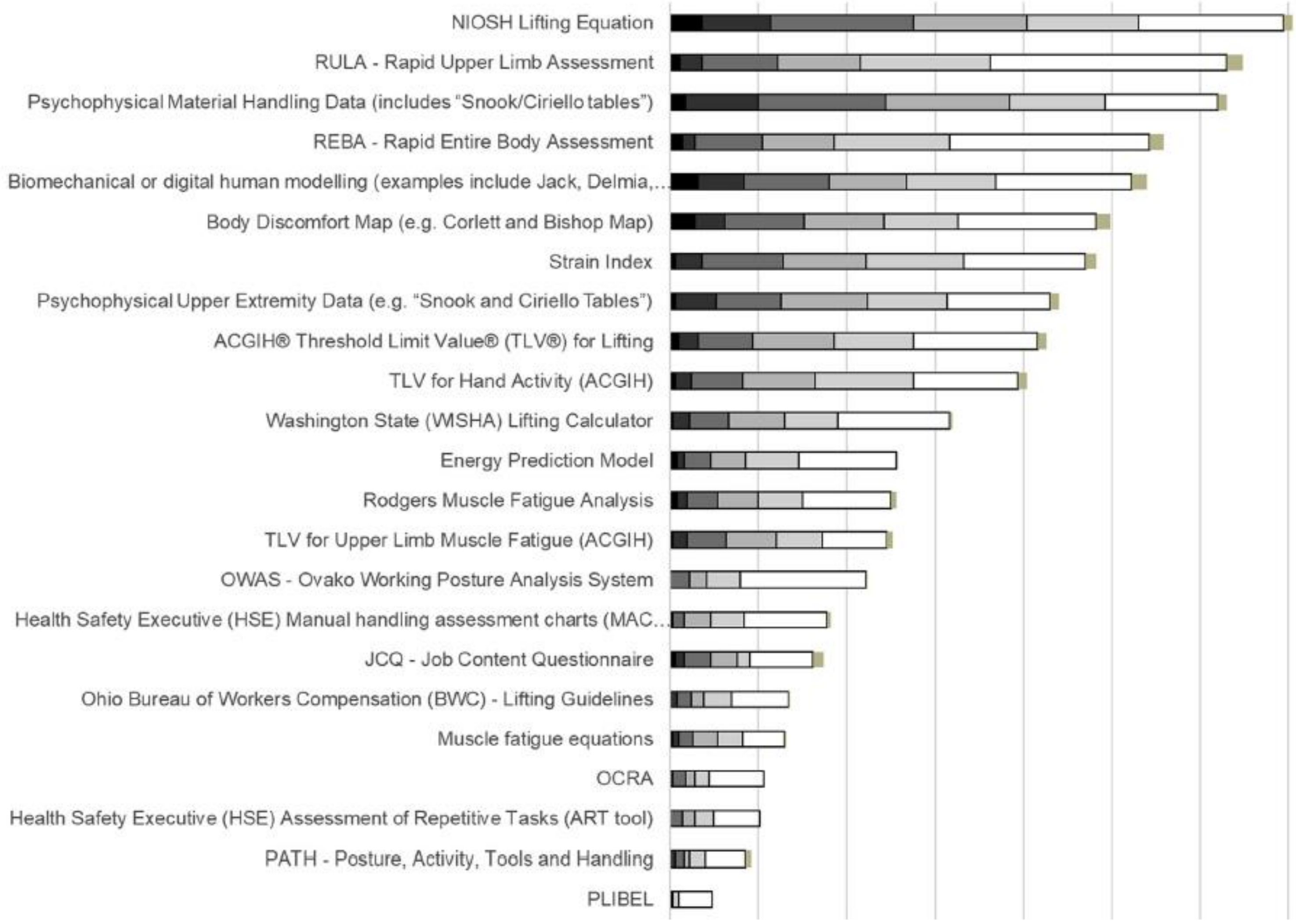
Ontario Universities Back Pain Study (OUBPS), 1998

Increased Quality of Analysis Related to Work/Task Requirements

- Monitor environmental conditions
  - (temperature, chemicals/toxins, etc.)
- Movement
  - (posture: low back, neck, shoulder, elbow and wrist angles)
- Physiological workloads
  - (energy output to monitor overall body fatigue)
- Muscle effort
  - (localized muscle fatigue and strain type injuries)
- Rates of repetition
- Static vs. dynamic type work conditions
- Vibration (whole body (e.g., lift truck) to hand-arm (e.g., hand tools)
- Breathing rates
- Acceleration and velocity of movement patterns
- Mechanical pressure acting on the body

Creates "Leading Indicators" on how a person is reacting to work practices that lead to a proactive assessment of likelihood of injuries in the workplace.

Ergonomics Tools of the Trade - Study 2005 to 2019



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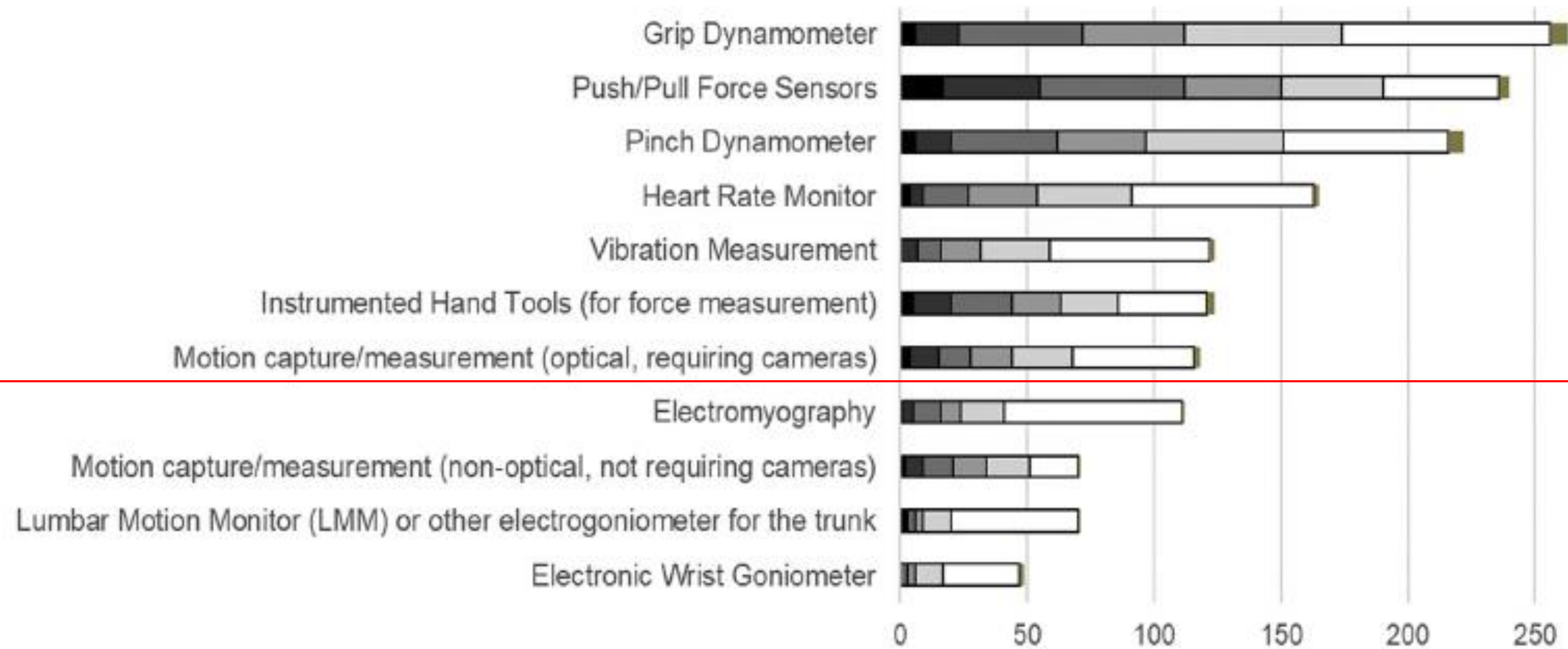
Assessment Equipment use in Ergonomics – Study 2005 to 2019



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Assessment Methods use in Ergonomics – Are They Really Working?

Musculoskeletal disorders rank second worldwide in curbing 'productive life': study

- WHO's Data from 2000 to 2015 from 183 Counties – "Years of Productive Life Lost Due to Disability":
  - In 2000 – 77.4 Million and now increased to 103.8 Million in 2015
  - Only heart disease and strokes ranked higher
- Tools are 15 to 30 years old but population is 15 to 30 years older
- Population BMI is also higher than 15 to 30 years ago
- Tools are still highly variable in results related to user experiences and at best "screening tools"
- More accurate systems are needed to actually measure the impact of work on employees' vs. a checklist or risk assessment screening tools

Why Use Wearable Technology?

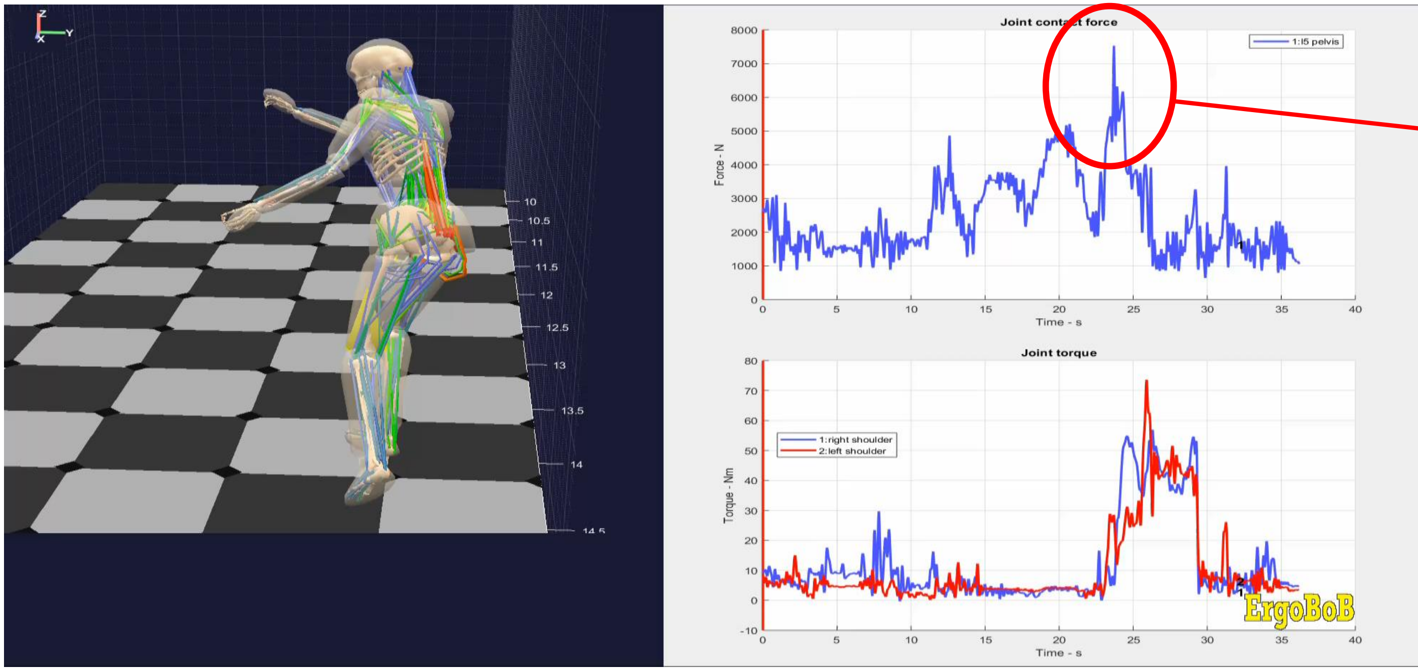
- The old saying goes, "what you don't know won't hurt you." In reality, what you don't will hurt you and your people!

- Leverage wearable technology to be a predictor of potential injury vs. waiting for an injury claim to happen.

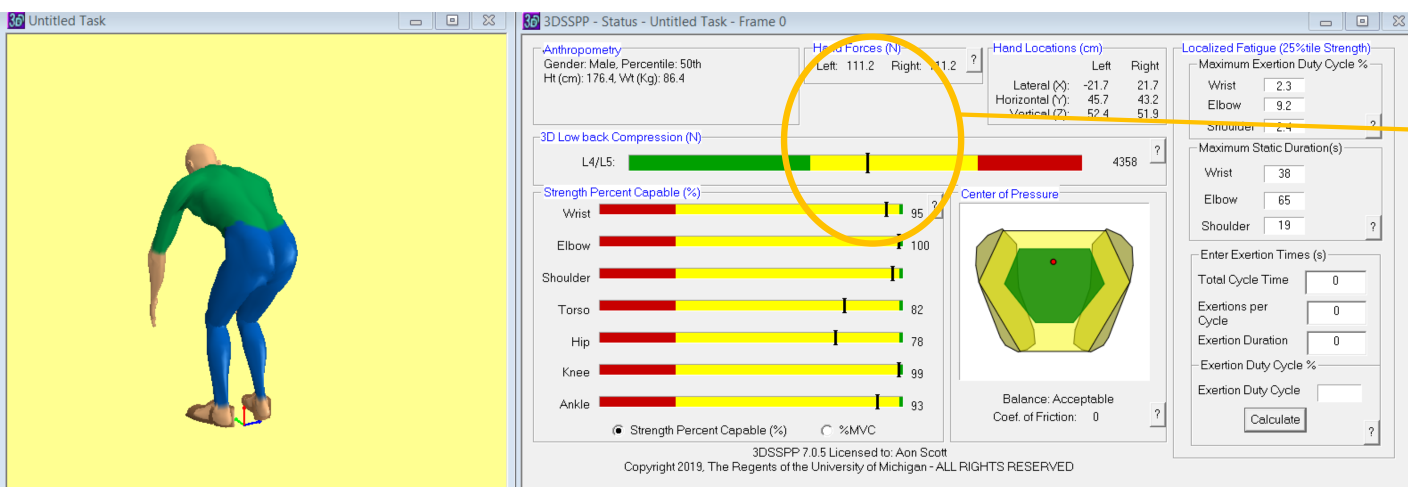
Why Use Wearable Technology? Some Research Findings

- Article published in 2008 but Merryweather, Bloswick and Sesek – University of Utah Department of Mechanical Engineering Ergonomics and Occupational Biomechanics Department
  - Initial review of literature review indicated that peak low back forces may be under reported in static biomechanical models by 19 to 200%
  - Static models don't account for acceleration and velocity of movement
  - Findings found that fast movement were 42% higher forces than static forces
- Additionally, Koblauch (2015 - Low Back Disorders in Airport Baggage Handlers), found lighter bags posed more of a risk related to "throwing" than heavier bags using a dynamic biomechanical model

Dynamic vs. Static Biomechanical Modeling Sample



7,480 N of Force
High Risk with 50 lbs.



4,358 N of Force
Moderate Risk with 50 lbs.

Authors Note:
High Risk Occurs at 114 lbs.

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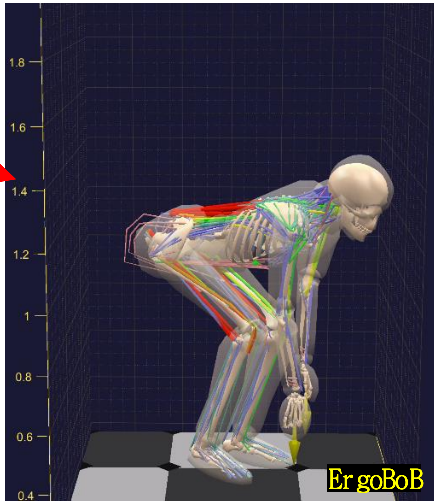
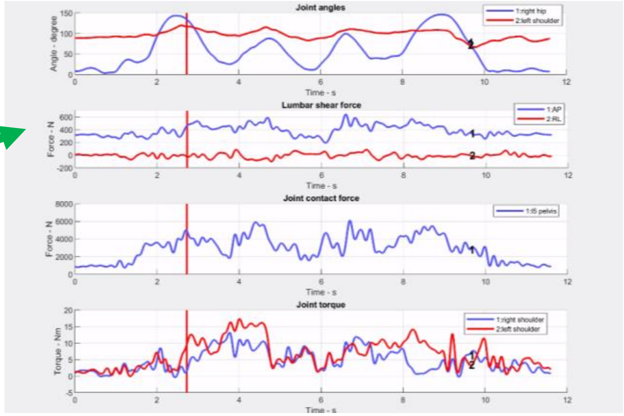
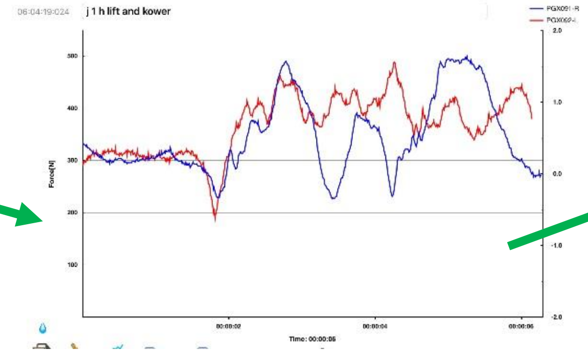
Wearable Data Collection Process

Motion Sensors Capture Full Body Dynamic Movement and Feed Data into 3D Software

3D Model Calculates all Dynamic Joint Postures, Forces, Torques, Muscle Forces, Activity and Energy Levels. On over 600 muscles







Force Measuring Insoles Capture Dynamic Force Changes Acting on Body

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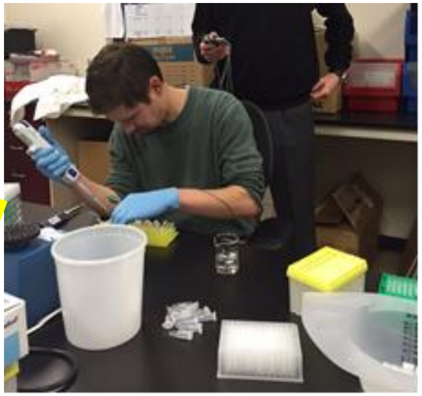
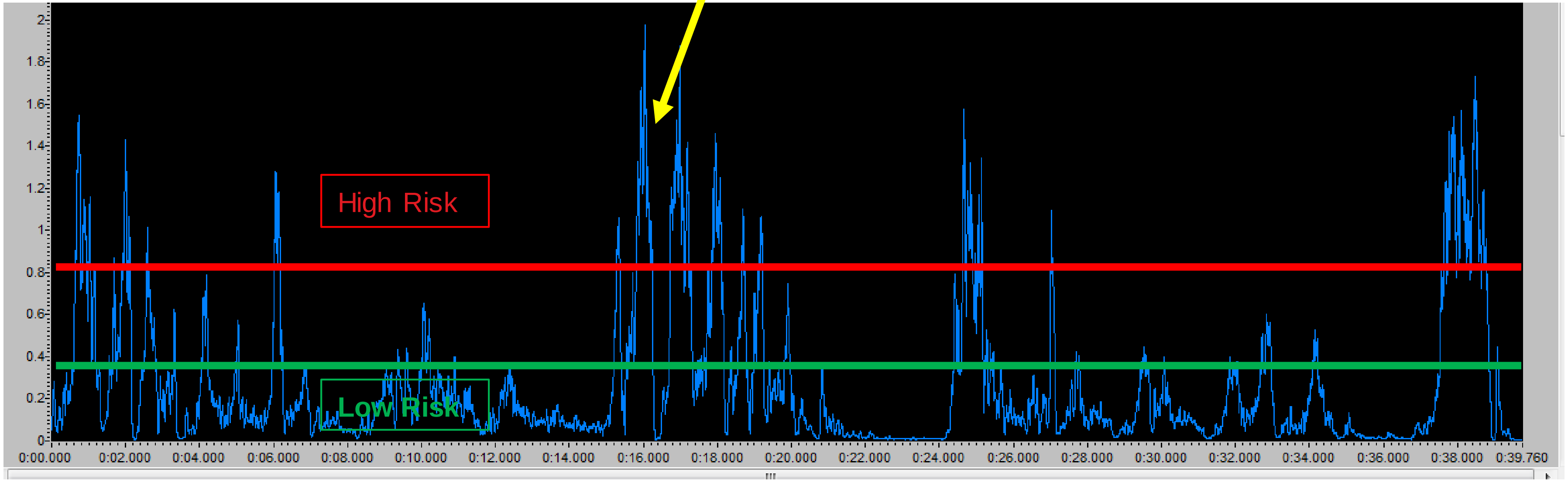
Example – Analysis of Forearm and Thumb Activity Levels

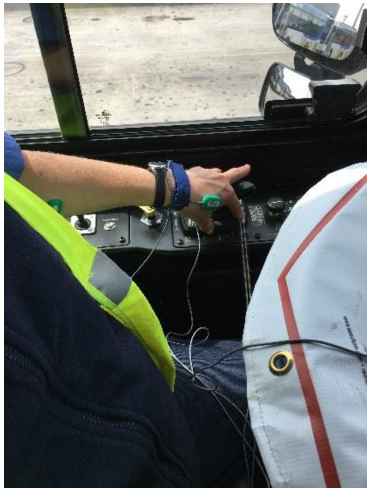
Identifying High Hand Forces During Pipetting Tasks:

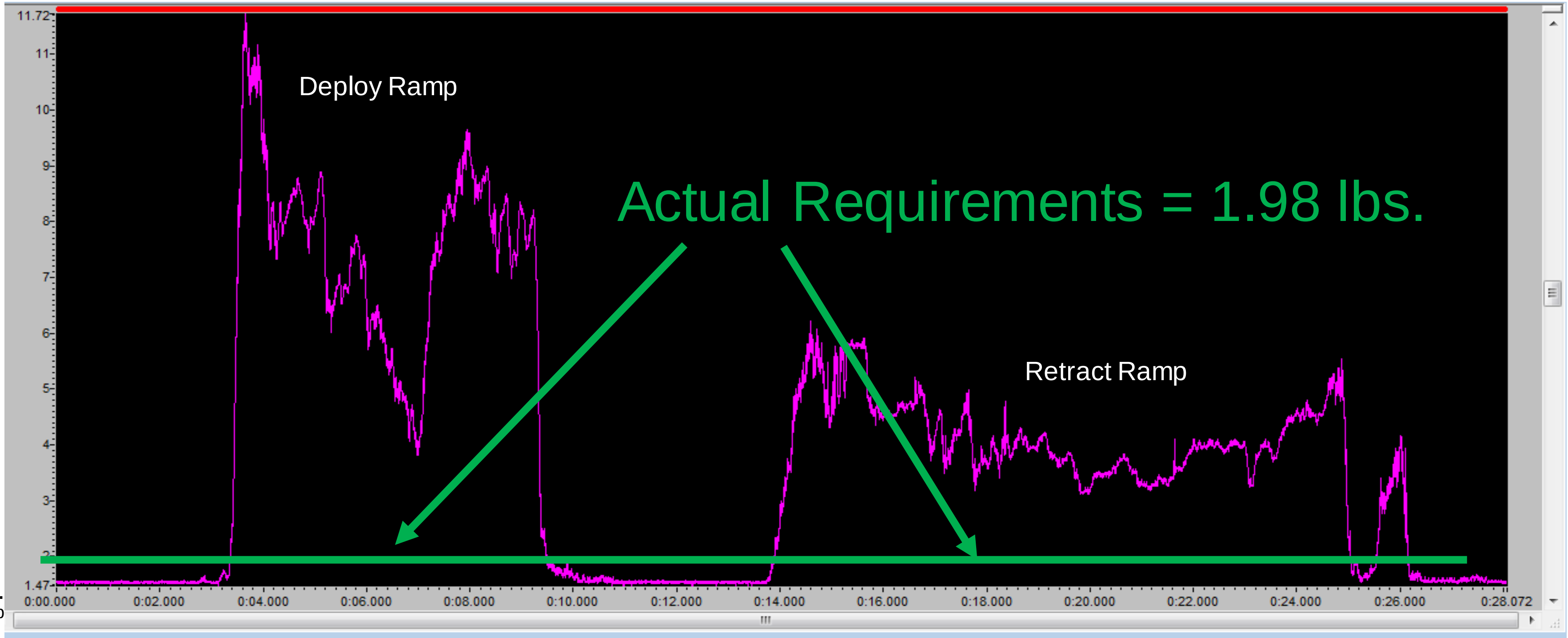
- Used sEMG to evaluate 3 different pipettes to determine average and peak hand forces as well as repetition of tasks
- Site management bought into the fact that they needed to investigate at semi-automated systems to reduce muscle stress to the employees





Example – Finger Push Force Analysis vs. Actual Requirements





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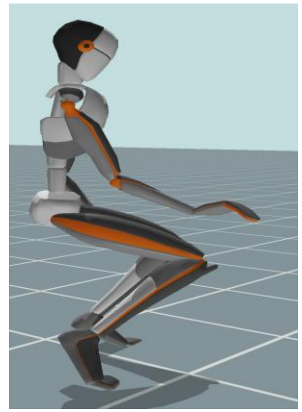
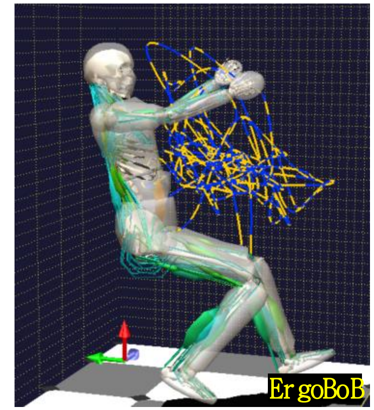
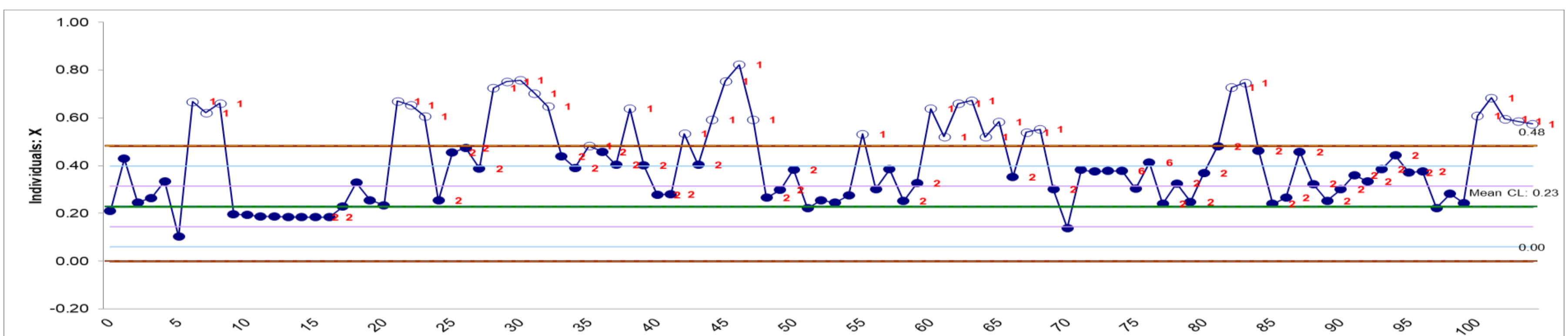
Example - Measuring Productivity and TCoR Impact

Real People/Real Work



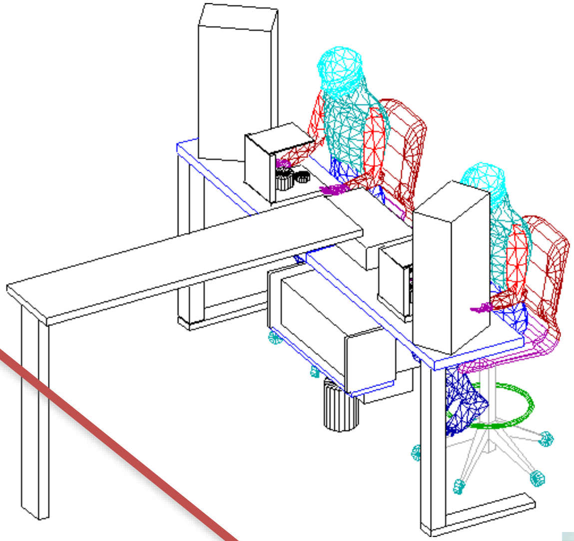


- Analysis of time and motion savings to reduce MFG cycle times
- 32.38% time spent in >19”
- 12.38% spent <9”
- 44.76% spent between 9 and 19 “



Example - Measuring Productivity and TCoR Impact

Current State



Future State

Virtual Testing State

Example - Measuring Productivity and TCoR Impact

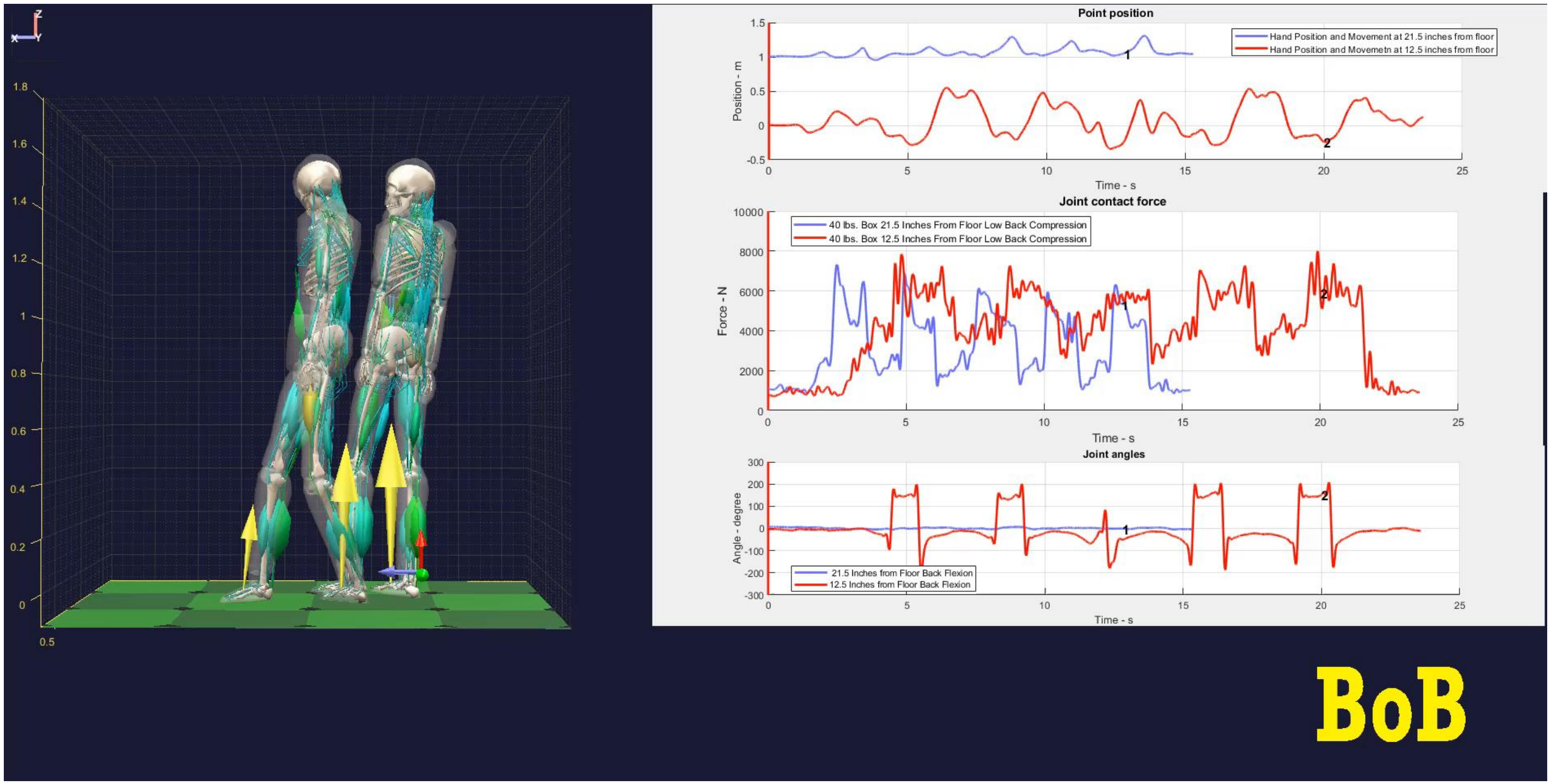
- Moving from a cycle time of 50 seconds to 42.5 means the operator can will go from 72 pieces per hour to 84.7 per hour without any extra internal effort.
- Profit per unit is $100
- Potential throughput increase on the bottle neck operation:
  - 12.7 units per hour * $100 profit per unit = $1,270/hour
  - 95 units per day * $100 profit per unit = $9,500 per shift
  - This is a two shift operation: 2 shifts * $9,500 per shift = $19,000/day
  - $95,000 per week (5 day a week operation)
  - $4,750,000 per year (50 weeks a year)
    - ROI on $6,000 Investment = 79,067%

Newly Design Workstation

- Movements of walking, reaching to the floor, high finger forces, long reaches and high posture deviations from hands were eliminated completely.

Example – Measuring Impact of Future Change

Lifting from 12” vs 21” off the ground Peaks



Example – Predicted Probability of Future Injury

Current Probability of Low Back Disorder - (LBD) Near Bottom of Pallet

Liftrate (lifts/hour)	Moment (Nm)	Sagittal Position Max (degrees)	Average Twisting Velocity (deg/sec)	Maxiumum Lateral Velocity (deg/sec)	LBD Probability
55	213	88.2	0.08	2.5	96.26%

Future Probability of Low Back Disorder (LBD) - Top of Pallet

Liftrate (lifts/hour)	Moment (Nm)	Sagittal Position Max (degrees)	Average Twisting Velocity (deg/sec)	Maxiumum Lateral Velocity (deg/sec)	LBD Probability
55	110	10	0.08	2.5	31.26%

Improvement Percentage
68%

- Risk benchmarks
  - "High Risk" - LBD Risk values greater than 60%
  - "Moderate Risk" – LBD Risk between 30% and 60%
  - "Low Risk" - LBD Risk values below 30%

Heat Map of Lagging and Leading Indicators

	Lag	Leading	Lag	Leading	Leading
Job	Incurred Losses	EQuIP Risk Score	Loss Work Days	Low Back Disc Compression (lbs.force)	Low Back Disc Probability of Injury
Loader/Unloader	$136,696.62	115	900	1400	94%
Split	$63,499.18	100	434	1245	83%
Marking	$112,417.09	80	553	660	34%
Unpack	$62,030.22	75	510	770	45%
Stockroom Assoc	$5,000.00	65	0	550	33%
Stager	$1,569.70	60	0	500	29%
Receiving	$3,924.38	45	0	504	34%
Maintenance	$1,721.35	45	0	360	23%
Other	49,869.47	0	422	NA	NA

TCoR - Predicting the Future Using Analytics Data

- Regression Modeling to Predict Future Incurrent Costs based on Leading Risk Indicators
  - **Multiple Regression Model: Incurred Losses = (-8628.8) + (879.29) * Disc Compression**

Current Future State

Job	Incurred Losses	Current EQuIP Risk Score	Loss Work Days	Low Back Disc Compression (lbs. Force)	Low Back Disc Probability of Injury
Loader/Unloader	$136,696.62	115	900	1400	94%

Predicted Future State

Predicted Response Calculator:

Predictors	Enter Settings:	Predicted Response	Lower 95% CI	Upper 95% CI	Lower 95% PI	Upper 95% PI
Future Low Back Disc Compression (lbs.)	550	$ 26,531.23	$ (11,019.83)	$ 64,082.29	-73299.32015	126361.7869

TCoR and Risk Impact:

- **Low Back Compression Reduction: Current 1,400 lbs. to Future 550 lbs. = 61% Reduction**
- **Probability of Future Low back Pain: Current of 94% to Future of 33% = 65% Reduction**
- **Predicted TCoR: Current $136,696.62 to Future $26,531.23 = 80.5% Reduction in Future Cost**

Back Disorder Probability Model – Predicting Future TCoR

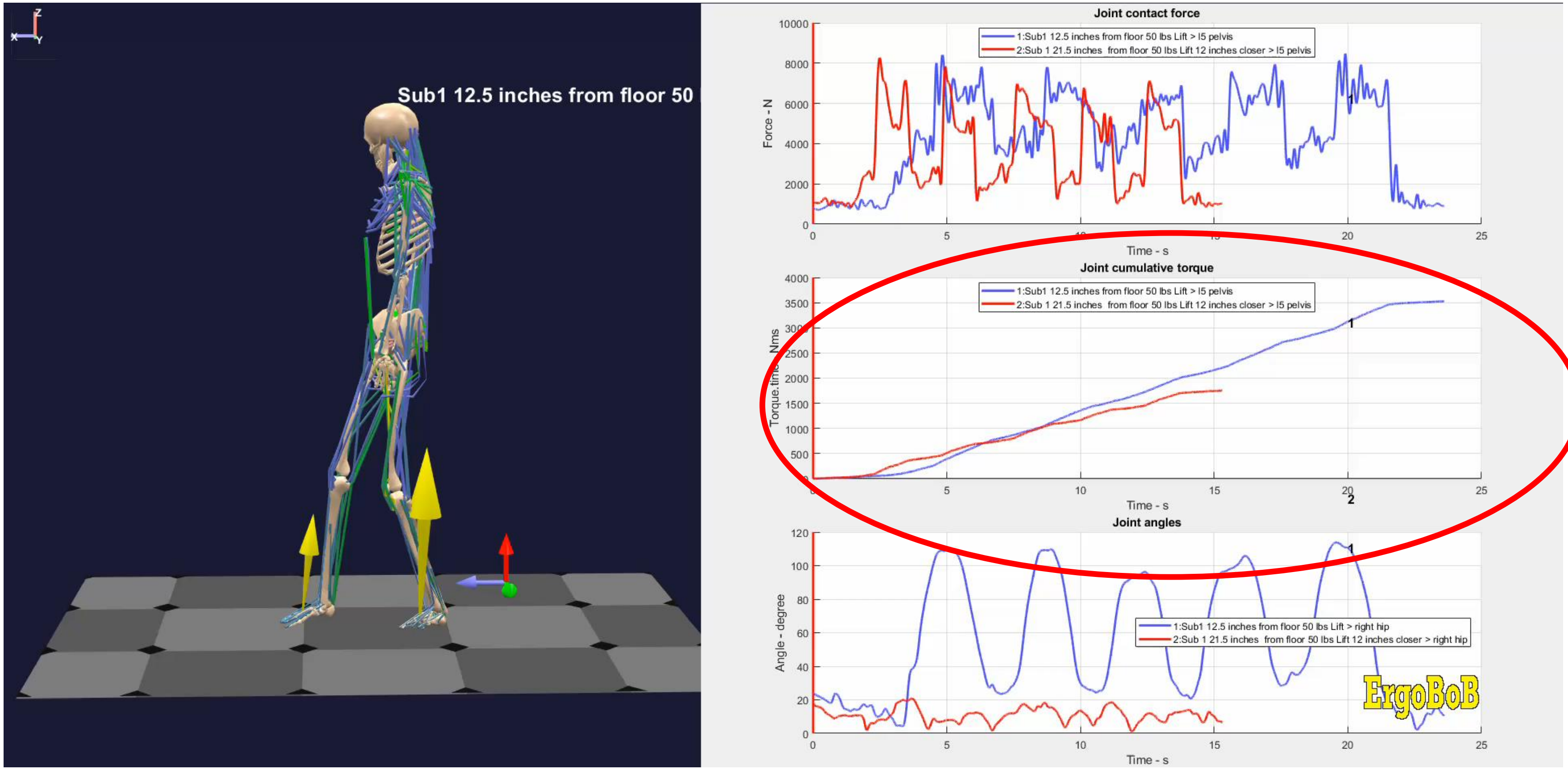
Lift Rate	Moment (Nm)	Sagittal Position Max	Average Twisting Velocity	Max Lateral Velocity	**LBD Probability**
1200	14.6	13.5	36.88	22.53	**82.65%**

When correlating %probability with Claim costs a client can predict savings for different solution sets:

Solution Options	Probability rating	Ave Claim Cost
Current state	82.65%	$14,000
Solution 1	60%	$4,000
Solution 2	40%	$2,000
Solution 3	10%	$0

Future - Analysis Related to Changes Over Time

Lifting from 12” vs 21” off the ground Cumulative Impacts



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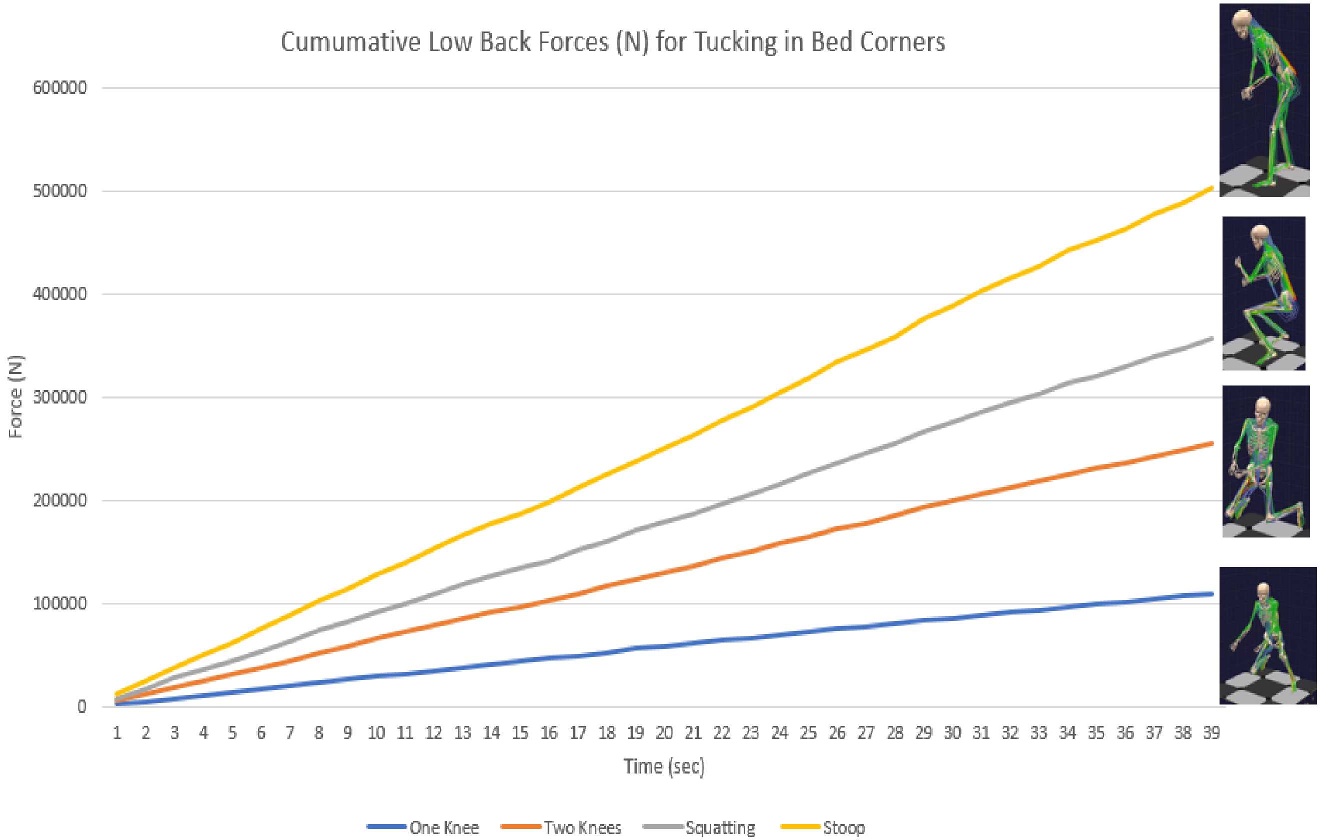
Not knowing will hurt your People!
Better Data, Better Decisions, Happier and More Productive Employees

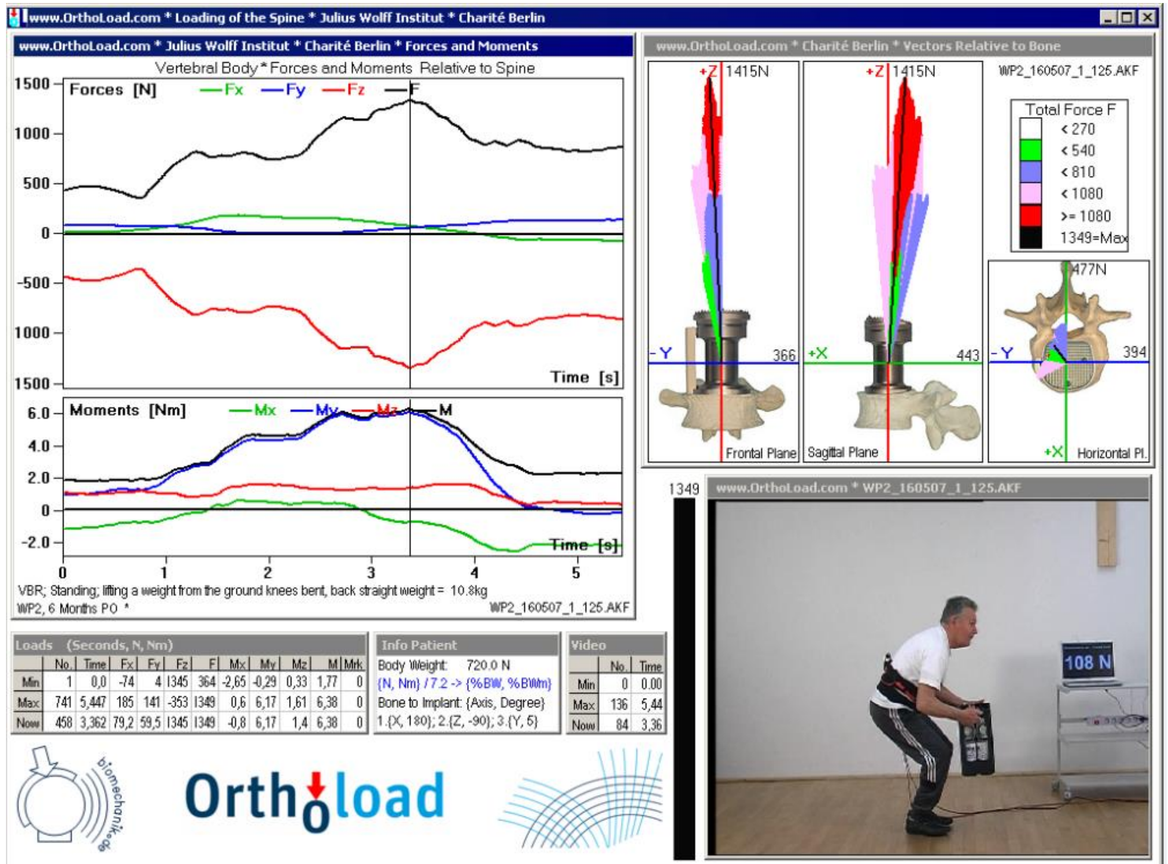
Low Back Cumulative Force Analysis – All Conditions



Analysis of Compression Over Time

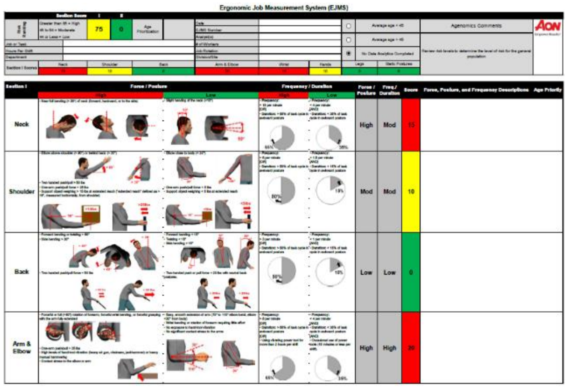
Lowest Forces – One Knee Posture
Highest Forces – Stooping

Future - Direct Measurement to Validate Models



[Julius Wolff Institute for Biomechanics and Musculoskeletal Regeneration](#)

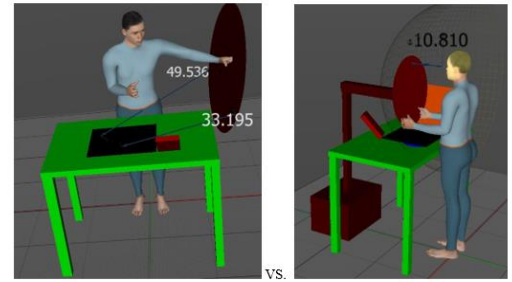
Wearable Data can also Supports Additional Types of Assessments

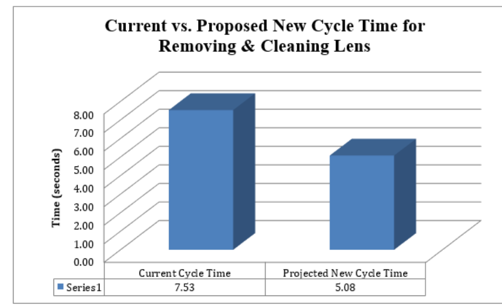


Risk Scores	Neck	Shoulder	Back	Arm/ Elbow	Wrists	Hands/ Fingers	Legs	Static Postures	Overall Score
Remove & Clean Lens	15▲	15▲	5▼	15▲	20▲	10▲	0▼	0▼	90▲

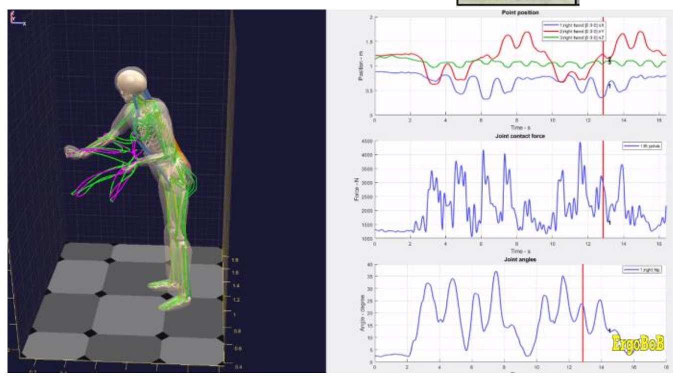
▼ Nominal ▸ Moderate ▲ High

Increased speed and accuracy of completing risk assessment methods





Accurate prediction of cycle time impacts



1) Lift and Carry

1-A) Lift / Carry bags of dirty linens
- Lift and carry bags of linens weighing up to 30 lbs. from the room to the hallway, usually less than 30 ft.
- Bags vary in weight based on the amount of linens placed in each bag and wetness of the linens (wet towels), usually bags are 10 to 20 lbs., but may range up to 30lbs
- Typically 1 to 2 bags of linens are handled per room, 10 to 40 per shift

1-B) Lift / Carry trash cans
- Lift and carry trash cans to remove trash from the room
- Trash cans usually weigh less than 5 lbs and carried up to 30 ft
- About 4 trash cans are in each room (not lifted if empty), usually less than 50 are lifted per shift

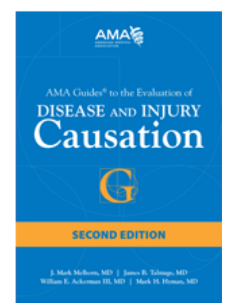
1-C) Lift / Carry clean linens
- Clean linens are lifted from supply closets to carts and directly to the room
- The weight of linens lifted is usually less than 15 lbs. depending on the number of linens lifted
- Linens are lifted 2 to 3 times per room and are carried up to 500 ft. from supply closets or about 30 ft. from carts

1-D) Lift vacuum from cart
- If a full cart (pictured) is used, the vacuum is stored on the cart and must be lifted onto and off of the cart
- The vacuum weighs about 20 lbs. and is lifted 2 time per room and is not carried
- If a mobile pack is used, the vacuum is not lifted as it is not stored on the mobile pack

1-E) Lift mattress edges to make bed
- The edges of the mattress are lifted to tuck sheets under the mattress while making the bed
- 10 to 30 lbs. of mattress is lifted depending on the type of mattress and how high the mattress is lifted while tucking sheets
- Mattress edges are lifted about 10 times while making the bed and there are 1 to 2 mattresses per room, about 80 lifts per shift

Increased accuracy of Actual Physical Demands

Work-relatedness assessment and Litigation Support



Closing Comments

1) A strategic implementation of a holistic ergonomic program:

- Directly and indirectly contributes to lowering TCoR across an entire organization,
- Can be a fundamental tool to take the edge off increasing insurance costs as part of an insurance/risk program,
- Offers the benefit of driving productivity, supporting well-being, job satisfaction and employee retention all using objective data.

2) Data is used to objectively assess the likelihood of injuries and predicting impacts to risk and productivity through improving the workplace or work methods.

3) Proactively measuring the how employees' are responding to work vs. waiting for injuries to occur which can reduce costs associated with time off work (productivity and efficiency) as well as employee retention.

Time for Questions

Thank You for Participating

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