



WORKPLACE LIFTING INJURY (SANTOS DEMONSTRATION)

“Was the lifting task within normal human capability?”

1. Case Summary

Scenario:

A warehouse worker (plaintiff) is injured while lifting a heavy box from the floor to a pallet.

Claims:

- The task required excessive forces
- The employer failed to ensure safe lifting conditions
- Result: lumbar disc injury

Defense:

- Task was within normal capability
- Injury resulted from improper technique or pre-existing condition

Why This Case is Ideal for SANTOS

This case depends on **objective biomechanical questions**:

- What forces were required to perform the lift?
- Do these forces exceed human capability?
- Was the task within safe ergonomic limits?

These are exactly the strengths of SANTOS.

2. Santos Simulation:

A. Santos Input Parameters (Worker anthropometry):

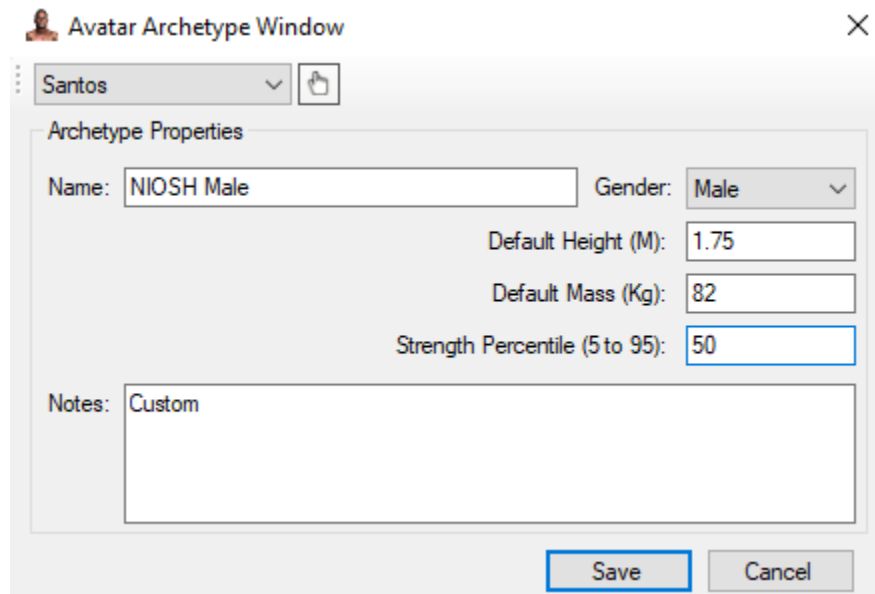
Male

Age: **42 years**

Height: **1.75m**

Strength: **50th percentile** strength profile (NIOSH Standard)

Weight: **82 Kg**



Avatar Archetype Window

Santos

Archetype Properties

Name: NIOSH Male Gender: Male

Default Height (M): 1.75

Default Mass (Kg): 82

Strength Percentile (5 to 95): 50

Notes: Custom

Save Cancel

Figure 1. Setting Worker Parameters in Santos

Unsafe Lift:

B. Object Characteristics

Worker lifts a handled 25 kg (245.25 N) box of dimensions 50 cm x 40 cm x 35 cm from near-floor to table. Lift includes:

- Symmetric two-handed lift
- No slippage or external support
- 70.66 cm of vertical travel distance
- 10.18 cm of horizontal distance traveled
- -4.4 degrees of asymmetry distance traveled

Initial Lift Posture:

Note: Parallelogram represents ZMP (green if in balance, red if out of balance), diamond represents extremity of spine shear and compression on a red-green scale (with red being more extreme and green being less extreme), and the yellow dot represents center of gravity.

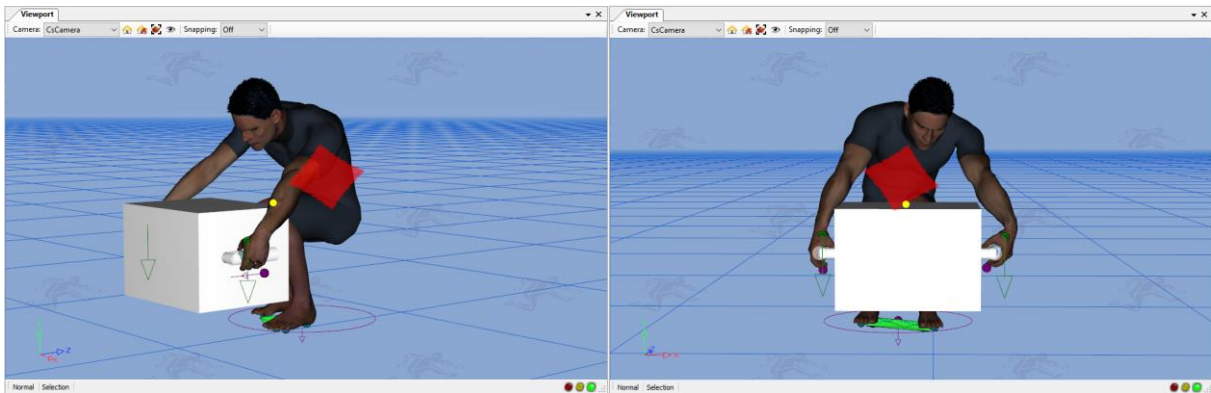


Figure 2 & 3: Unsafe Lift

End Lift Posture:

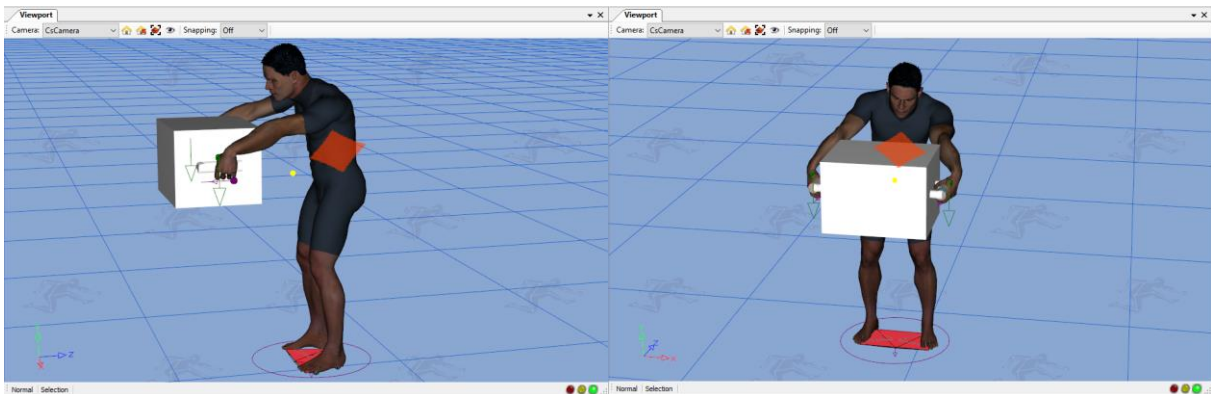


Figure 4 & 5: Unsafe Lift

C. Detailed Analysis:

Note: Colored dots represent extremity of static joint torque on a red-green scale (with red being higher levels of torque and green being lower levels).

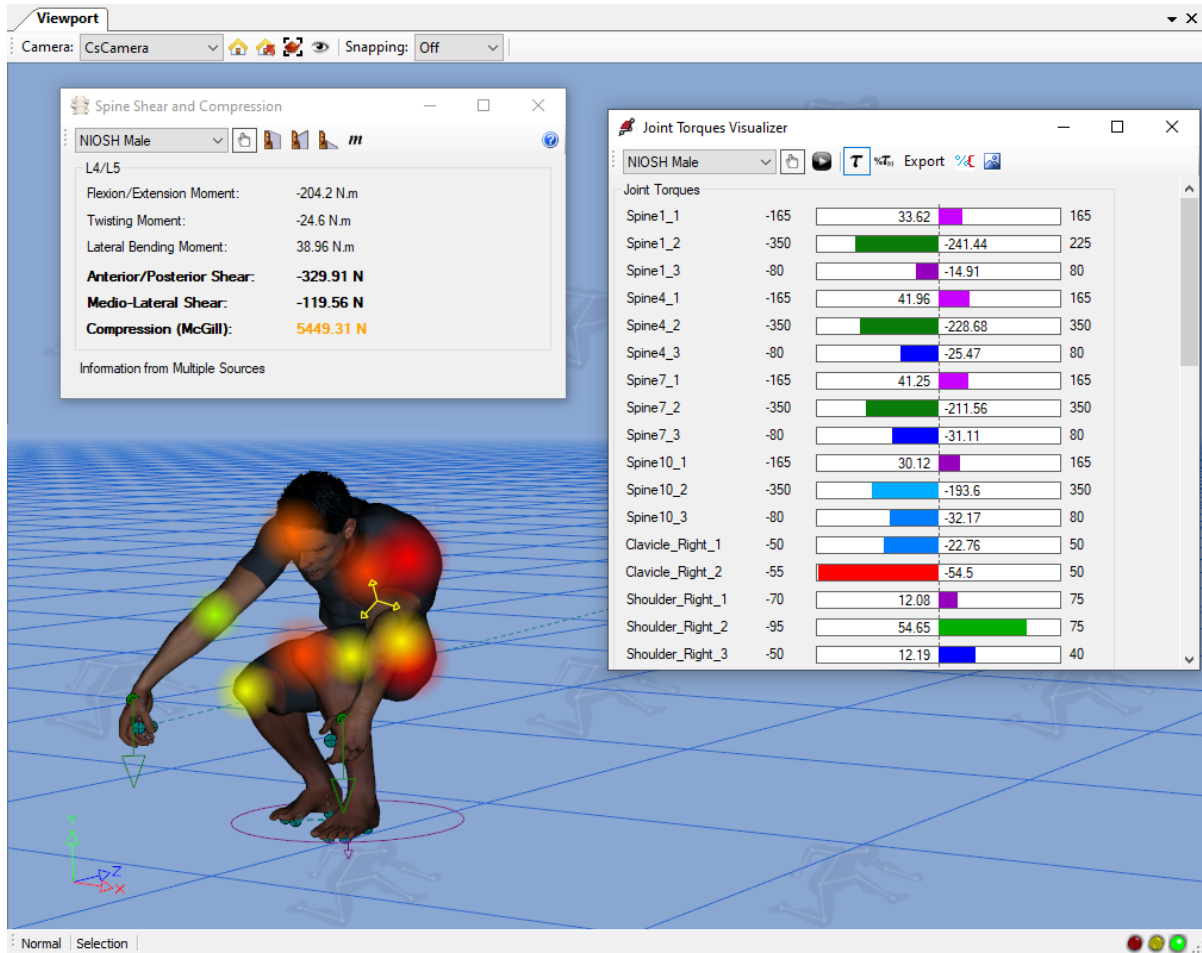


Figure 6: Initial Lift Posture with Metrics – Unsafe Lift

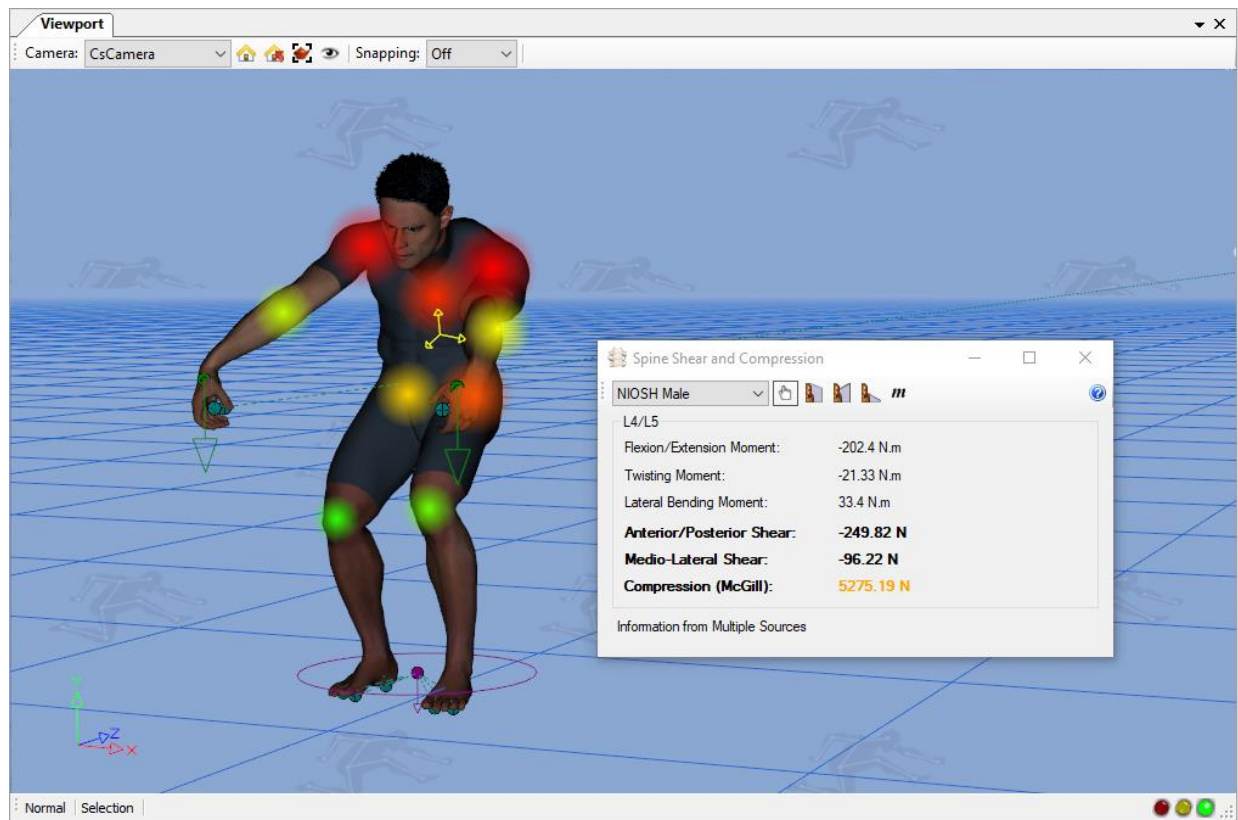


Figure 7: Midway-Through Lift Posture with Metrics – Unsafe Lift

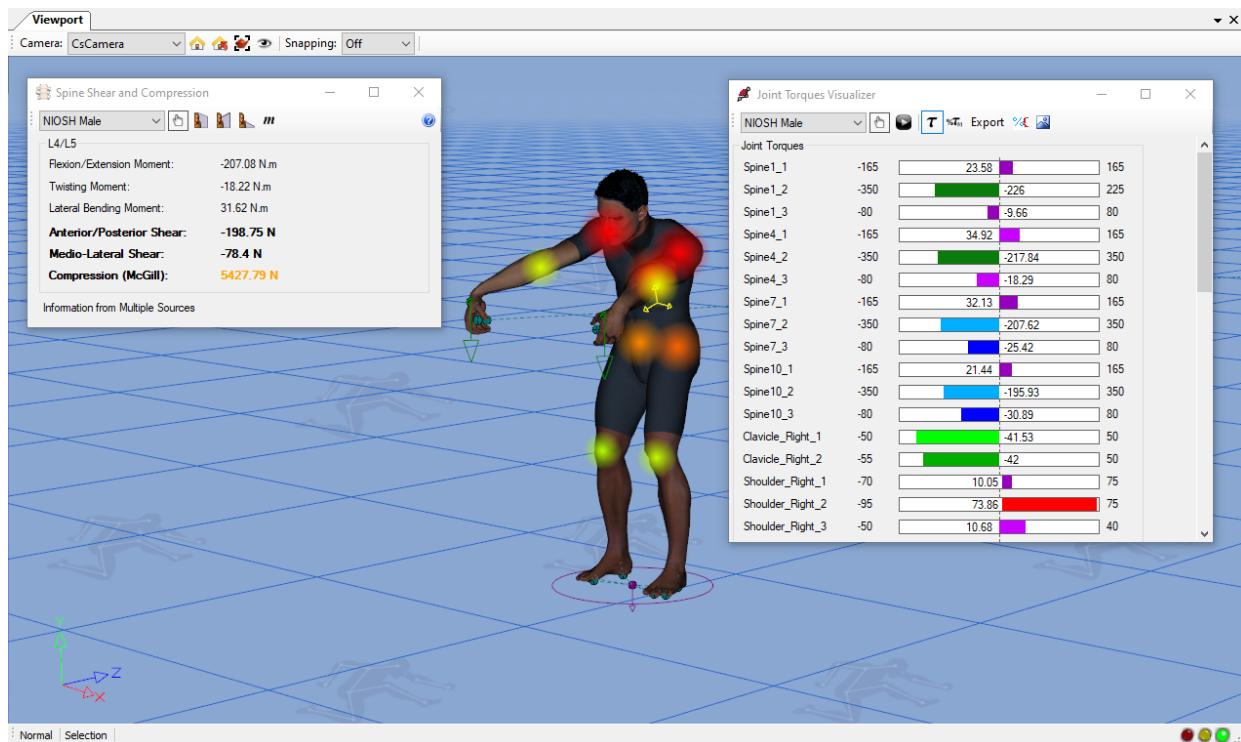


Figure 8: Ending Lift Posture with Metrics – Unsafe Lift

D. Santos NIOSH Analysis Results:

Using initial and ending postures, a lift simulation can be set up, with the initial and ending postures “marked” via timestamp. Then, the NIOSH Lift Analysis Visualizer gleans posture specific values from these timestamps to calculate lift metrics:

The screenshot displays the NIOSH Lift Analysis Visualizer window. At the top, the subject is identified as 'NIOSH Male'. Under 'Automatic Data Generation', the 'Start Marker' is 'User - 0.63s' and the 'End Marker' is 'User - 1.25s'. The 'Auto Calculate' button is highlighted. The 'Lifting Variables' section contains the following inputs and calculated values:

Variable	Value	Unit	Auto Calculation
Horizontal Distance Origin:	46.38	cm	☒
Horizontal Distance Destination:	56.56	cm	☒
Vertical Height Origin:	32.18	cm	☒
Vertical Height Destination:	102.84	cm	☒
Vertical Travel Distance:	70.66	cm	
Assymetry Angle Origin:	8.69	deg	☒
Assymetry Angle Destination:	4.29	deg	☒
Frequency:	0.0	lifts/min	
Work Duration:	0.00	hours	
Gripping Type:	Good		
Weight of Object:	245.25	N	

The 'Equation Results' section shows the following calculated values:

Maximum Weight Origin:	91.03	N
Maximum Weight Destination:	79.64	N
Lifting Index Origin:	2.694	
Lifting Index Destination:	3.080	

Figure 9: NIOSH Lift Analysis Visualizer – Unsafe Lift

As indicated by the **Santos** results, the maximum weight a worker can safely lift in this scenario is 91.03 N (9.48 kg) at the start of the lift and 79.64 N (8.11 kg) at the end of the lift.

The Lift Index (LI) indicates by how many times the lift exceeds the maximum weight recommendation. Given the scenario's 25 kg box, the lift index at the start of the lift is 2.694, and 3.080 by the end of the lift, indicating the lift far exceeds recommended safety limits (by 2.6 - 3 times) and is hazardous to the worker.

Note: maximum weight recommendation decreases and lift index increases as lift frequency (lifts/min) and work duration (hours of lifting and rest in 8-hour workday) increase.

Safe Lift:

E. Object Characteristics

Worker lifts a handled 10 kg (98.1 N) box of dimensions 50 cm x 40 cm x 35 cm from near-floor to table. Lift includes:

- Symmetric two-handed lift
- No slippage or external support
- 50.68 cm of vertical travel distance
- 7.11 cm of horizontal distance traveled
- 0.84 degrees of asymmetry distance traveled

Initial Lift Posture:

Note: Parallelogram represents ZMP (green if in balance, red if out of balance), diamond represents extremity of spine shear and compression on a red-green scale (with red being more extreme and green being less extreme), and the yellow dot represents center of gravity.

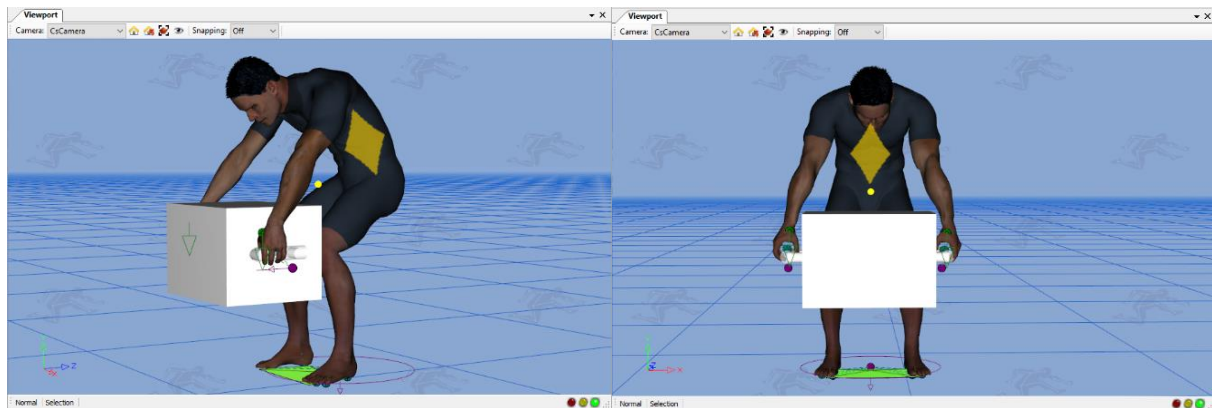


Figure 10 & 11: Safe Lift

End Lift Posture:

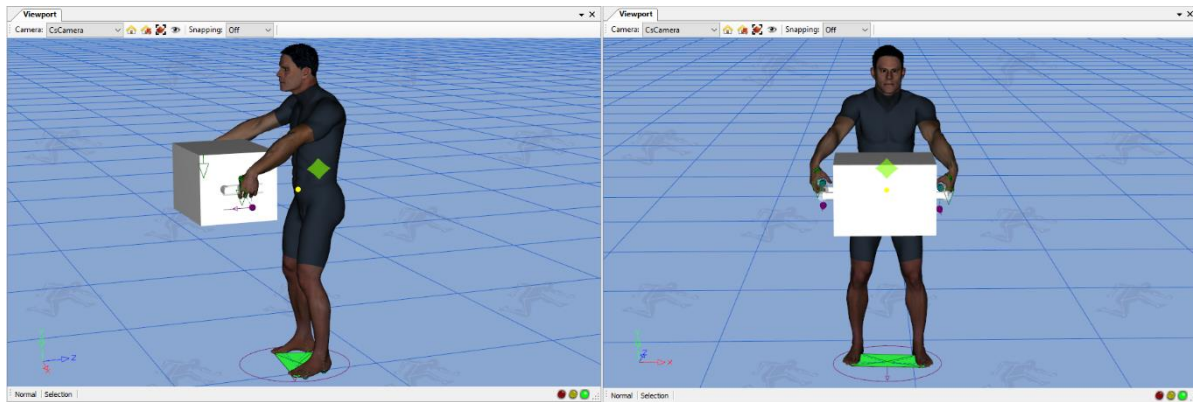


Figure 12 & 13: Safe Lift

F. Detailed Analysis:

Note: Colored dots represent extremity of static joint torque on a red-green scale (with red being higher levels of torque and green being lower levels).

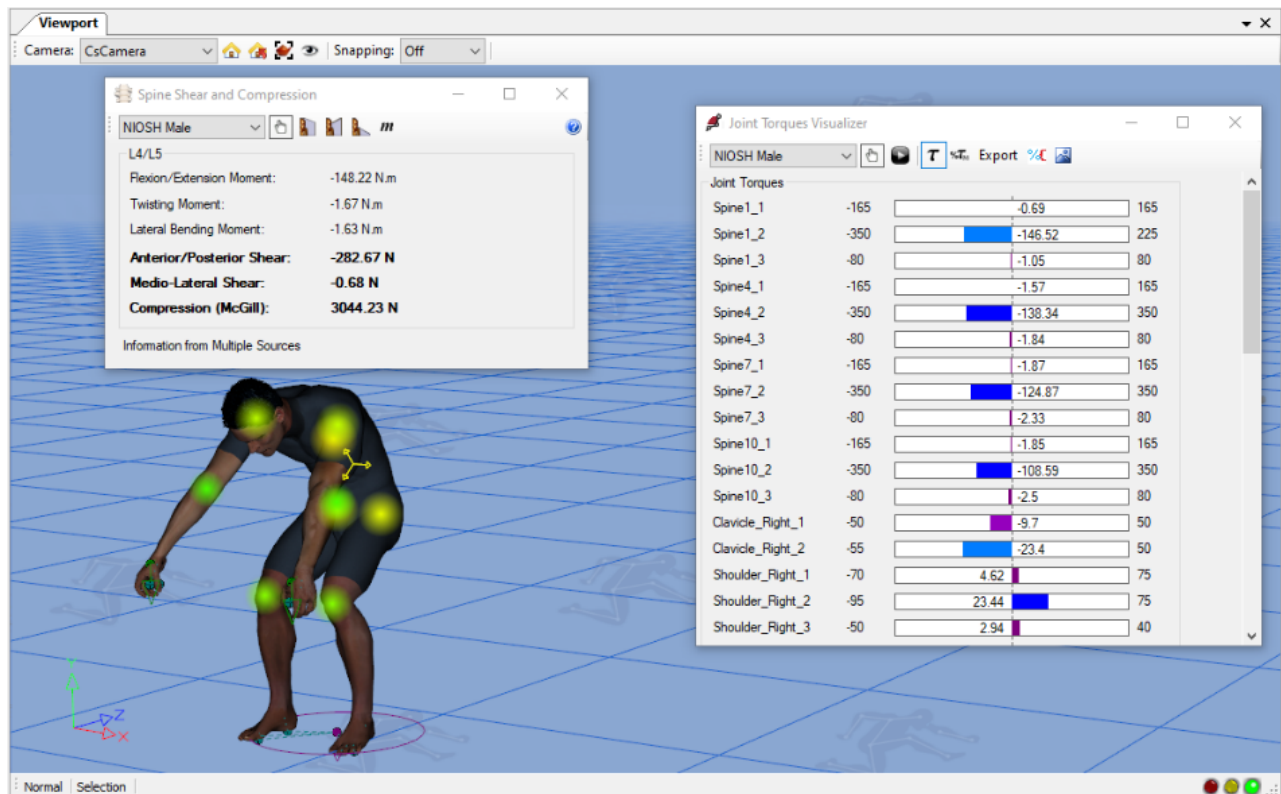


Figure 14: Initial Lift Posture with Metrics – Safe Lift

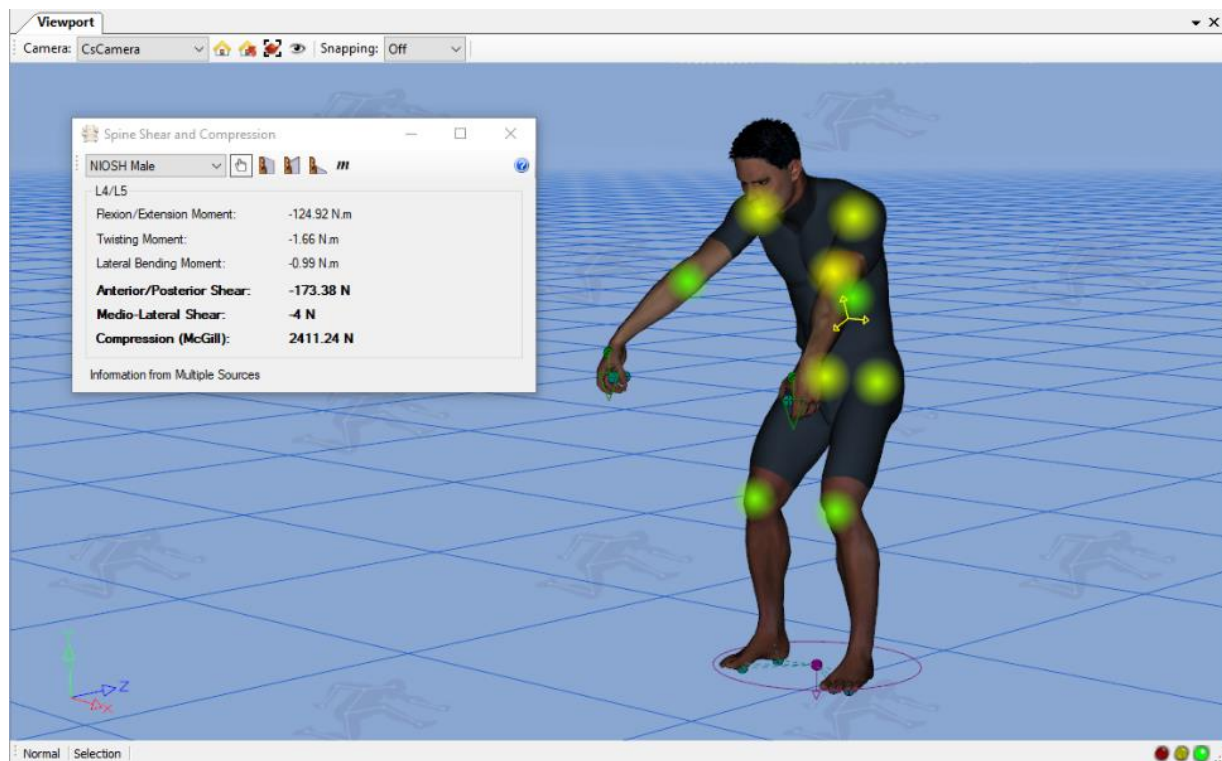


Figure 15: Midway-Through Lift Posture with Metrics – Safe Lift

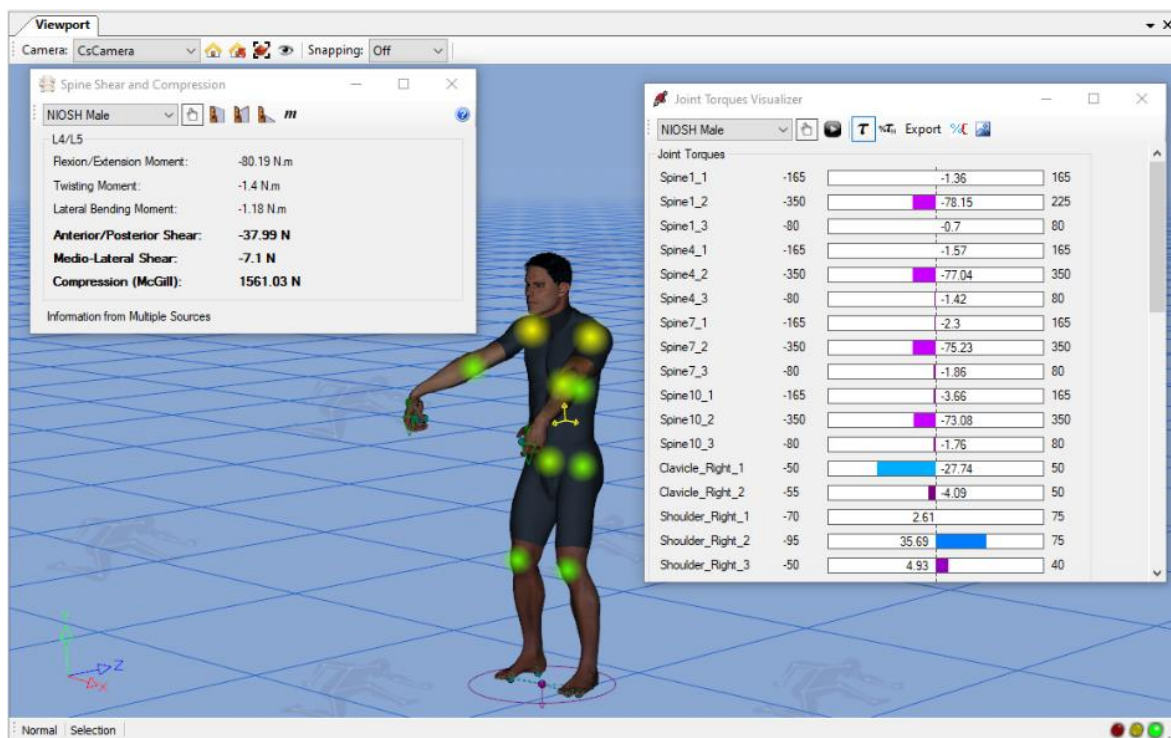


Figure 16: Ending Lift Posture with Metrics – Safe Lift

G. Santos NIOSH Analysis Results:

Using initial and ending postures, a lift simulation can be set up, with the initial and ending postures “marked” via timestamp. Then, the NIOSH Lift Analysis Visualizer gleans posture specific values from these timestamps to calculate lift metrics:

Automatic Data Generation	
Start Marker	End Marker
User - 0.63s	User - 1.25s
Auto Calculate	
Select All	

Lifting Variables	
Horizontal Distance Origin:	36.21 cm
Horizontal Distance Destination:	43.32 cm
Vertical Height Origin:	54.39 cm
Vertical Height Destination:	105.07 cm
Vertical Travel Distance:	50.68 cm
Assymetry Angle Origin:	1.27 deg
Assymetry Angle Destination:	2.11 deg
Frequency:	0.0 lifts/min
Work Duration:	0.00 hours
Gripping Type:	Good
Weight of Object:	88.10 N

Equation Results	
Maximum Weight Origin:	132.22 N
Maximum Weight Destination:	106.90 N
Lifting Index Origin:	0.742
Lifting Index Destination:	0.918

Figure 17: NIOSH Lift Analysis Visualizer – Safe Lift

As indicated by the **Santos** results, the maximum weight a worker can safely lift in this scenario is 132.22 N (13.48 kg) at the start of the lift and 106.90 N (10.90 kg) at the end of the lift.

The Lift Index (LI) indicates by how many times the lift exceeds the maximum weight recommendation. Given the scenario’s 10 kg box, the lift index at the start of the lift is 0.742 and 0.918 by the end of the lift, indicating the lift does not exceed recommended safety limits (0.742 – 0.918 times the recommended limit) and is not hazardous to the worker on its own.

Note: maximum weight recommendation decreases and lift index increases as lift frequency (lifts/min) and work duration (hours of lifting and rest in 8-hour workday) increase.

H. SCENARIO COMPARISON (VERY POWERFUL IN COURT)

Scenario A (Actual Case)

- Load: **25 kg**
- Reach: **56.56 cm**
- Result:
 - ✗ Unsafe
 - ✗ Exceeds limits
 - ✗ High joint torque
 - ✗ High spine shear and compression forces
 - ✗ High injury risk

Scenario B (Safe Alternative)

- Load: **10 kg**
- Reach: **43.32 cm**
- Result:
 - ✓ Within limits
 - ✓ Lower joint torques
 - ✓ Lower spine shear and compression forces
 - ✓ Acceptable risk

This comparison shows:

Injury was driven by **task design**, not just worker behavior

COURTROOM INTERPRETATION

Plaintiff Argument (Supported by Santos)

"The forces required to perform this lift exceed established biomechanical safety thresholds and approach or exceed human capability, making injury likely."
