

Exoskeletons and Ergonomic Risk

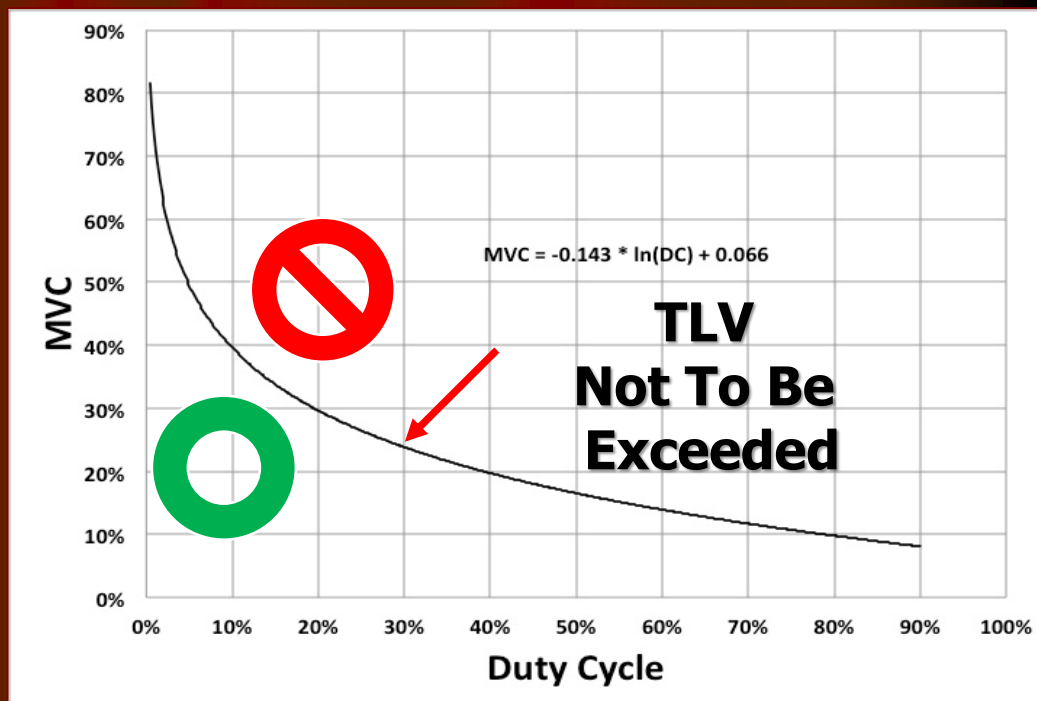


ACGIH - Upper Limb Localized Fatigue TLV

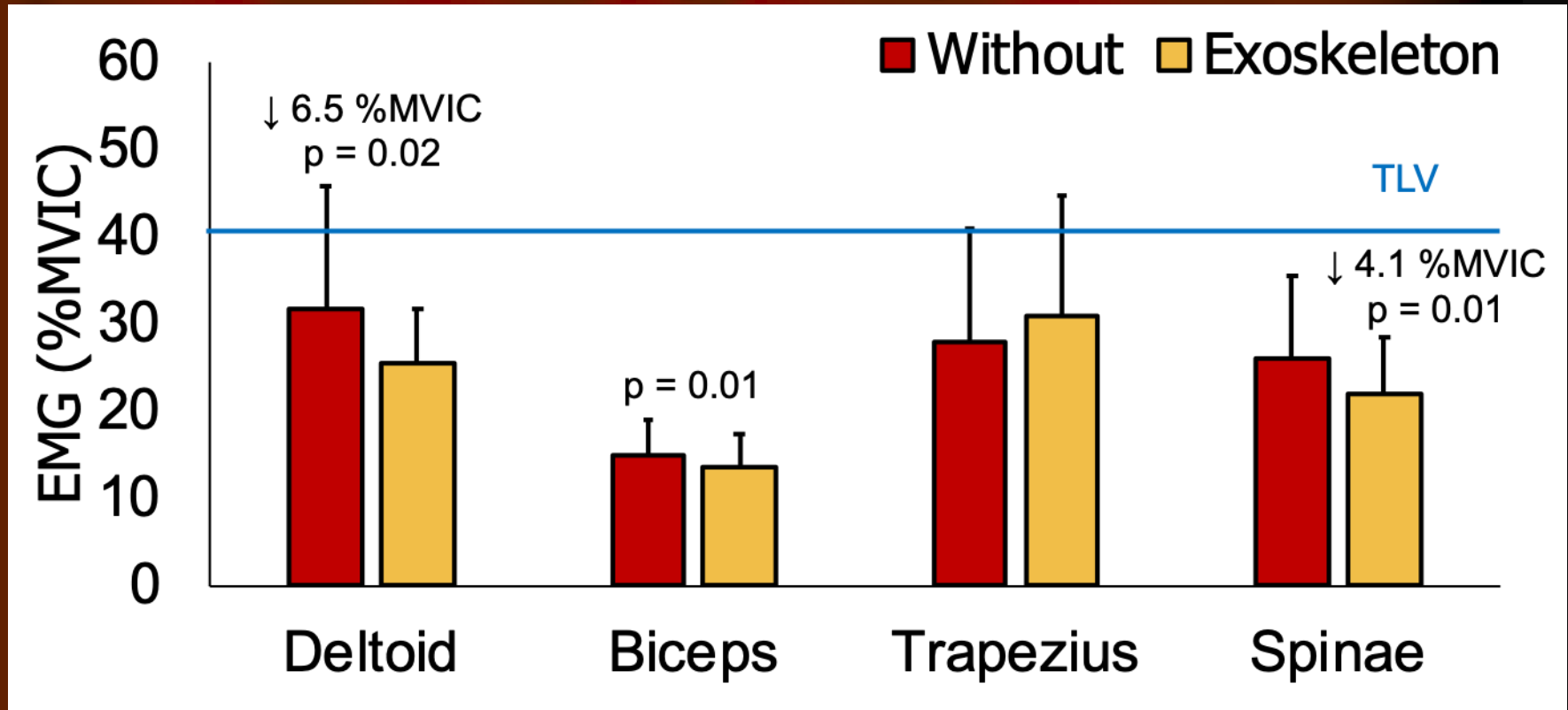
This Threshold Limit Value (TLV) sets the amount of time a person can work in a given posture before experiencing excessive upper limb musculoskeletal fatigue ACGIH® © 2016

Question to answer:

Does the duration an employee is in specific postures for their work cycle exceed the TLV?



Toyota Canada On-Site EMG Assessment



Maximum 10% EMG amplitudes determined for 11 workers performing 10 overhead assembly job tasks

Lab-Based EMG Posture Assessment



**60° Down:
Shoulder 60°
Elbow 0°**

14 %MVC

**60° Up:
Shoulder 60°
Elbow 90°**

16 %MVC

**90° Out:
Shoulder 90°
Elbow 0°**

23 %MVC

**90° Up:
Shoulder 90°
Elbow 90°**

23 %MVC

**135°:
Shoulder 135°
Elbow 0°**

36 %MVC

**180°:
Shoulder 180°
Elbow 0°**

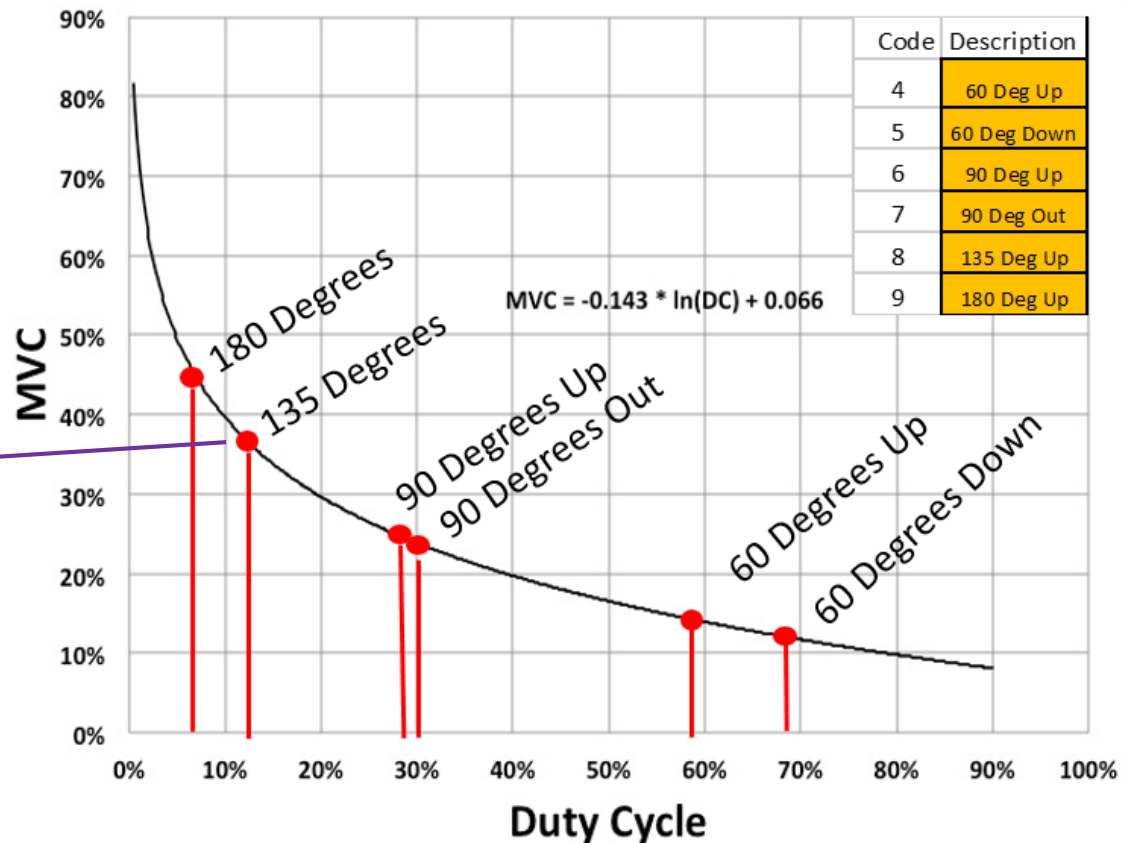
44 %MVC

**Maximum 10% EMG amplitudes for 10 participants
repetitively moving to 6 postures**

Matching TLVs to Postures



ISU Shoulder Posture TLV Results



Threshold Limit Value (TLV) Calculations and Ergonomic Posture Lab Testing Results Without Exoskeleton

Enter Duration
of Job Task
Analyzed In
Minutes:

1

Posture Risk	Posture	Results
	Shoulder 60° Elbow 0° %MVC	14
	Duty Cycle Percentage	58
	Shoulder 60° Elbow 90° %MVC	16
	Duty Cycle Percentage	50
	Shoulder 90° Elbow 0° %MVC	23
	Duty Cycle Percentage	33
	Shoulder 90° Elbow 90° %MVC	23
	Duty Cycle Percentage	33
	Shoulder 135° Elbow 0° %MVC	36
	Duty Cycle Percentage	12
	Shoulder 180° Elbow 0° %MVC	44
	Duty Cycle Percentage	7

TLV per Job
Task (seconds)

TLV for 2 Hour
Shift (minutes)

35 | seconds

70 | minutes

30 | seconds

60 | minutes

20 | seconds

39 | minutes

20 | seconds

39 | minutes

7 | seconds

15 | minutes

4 | seconds

9 | minutes

A Starting Point

Why might fatigue be overestimated?	
A	The TLV values were determined using the highest 10% (peak) EMG values while repetitively moving to the specified posture. It could be argued that more conservative highest 25% (in position) or highest 75% (duty time) EMG values should be used.
B	Fatigue would likely be overestimated if there is any down time in the two hour work shift. This would allow for additional recovery from fatigue. Down time can be factored into the TLV table by measuring or estimating posture durations over two hour shifts.
C	The EMG data were taken on a relatively small number of participants (ten) that weren't necessarily used to the postures we measured. Workers may be better adapted and use less muscle activation during the challenging overhead postures we tested.
Why might fatigue be underestimated?	
A	The TLV table only takes into account single postures rather than the combined effect of using multiple postures during a shift. A worker in the 180 degree up elbow posture at 80% TLV is not ranked differently than a worker in multiple postures at 80% TLV.
B	The TLV times do not include the weight of the tool or the amount of force applied. As the tool weight (and/or applied force) and moment arm increase, muscle activation and fatigue are also likely to increase.
C	For strenuous jobs, the TLV times may decrease as the work day progresses. During on-site data collections, the amount of deltoid muscle activation needed to complete a task tends to increase from the beginning compared to the end of the work shift.

Questions

