NIOSH Lifting Equation

19.525 Introduction to Industrial Hygiene/Ergonomics
Fall 2006

What is it?

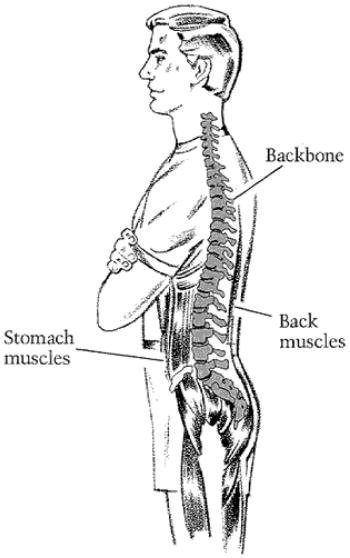
- ✓ The NIOSH lifting equation is a tool to evaluate lifting tasks
- ✓ It was developed by NIOSH to assist in the identification of solutions for reducing the physical stress associated with manual lifting

NIOSH Equation - Objectives

- ✓ Prevent or reduce occurrence of **lifting-related low back pain** among workers
- ✓ Potentially reduce other **lifting-related disorders or injuries** such as shoulder/arm pain

Back Pain

- ✓ Back troubles can be painful and reduce one's mobility and vitality
- ✓ Back troubles often lead to long absences from work and in modern times are among the main cause of early disability



Low Back Pain

- ✓ Low back pain occurs in **80%** of adults at some point in their lives
- ✓ Low back pain is second only to upper respiratory infections as a cause for absence from work

Low Back Pain

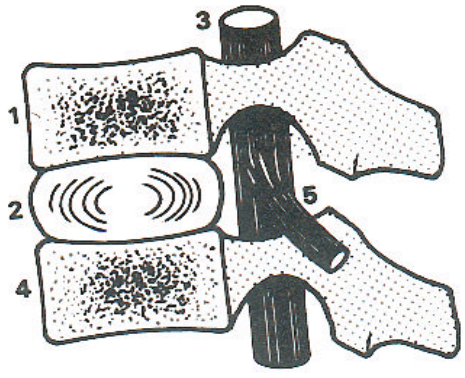
- ✓ Back symptoms are among the 10 leading reasons for patient visits to emergency rooms, hospital outpatient departments, and physician offices

Low Back Pain

- ✓ Low back pain costs approximately $24 billion per year in direct medical expenses and another $27 billion per year in lost productivity and compensation. Total annual costs for back pain increase from $35 to $56 billion when disability costs are included
- ✓ Almost 90% of all cases of low back pain are due to sprains and strains and by definition almost always improve

How is the back affected?

THE SPINE

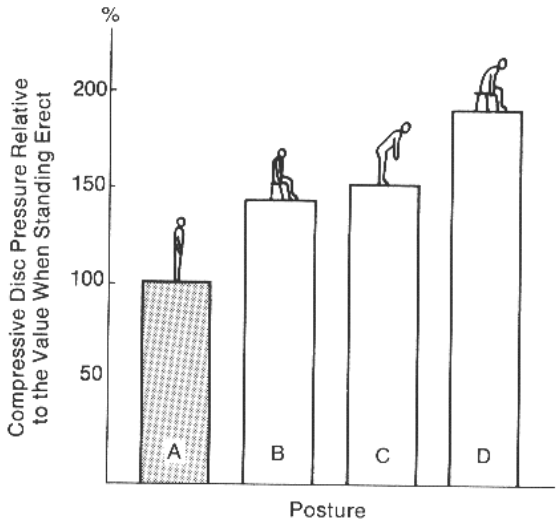


The disc (2) lies between two vertebrae, (1) and (4); behind, the spinal cord (3) and a nervous tract (5).

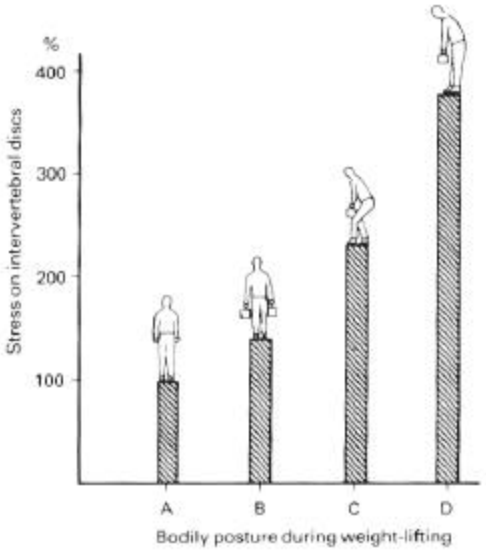
The disc is like a cushion which gives flexibility to the spine

Load compresses the vertebral discs and may cause damage/injury

How is the back affected?



How is the back affected?



Bending the back, while keeping the knees straight, puts a much greater stress on the discs in the lumbar region than keeping the back as straight as possible and bending the knees!

Loading of the disc during various postures and tasks (disc compression forces in N)

Posture/activity	**N**
Standing upright	860
Walking slowly	920
Bending trunk sideways 20°	1140
Rotating trunk about 45°	1140
Bending trunk forwards 30°	1470
Bending trunk forwards 30°, supporting weight of 20kg	2400
Standing upright holding 20 kg (10 kg in each hand)	1220
Lifting 20 kg with back straight and knees bent	2100
Lifting 20 kg with bent back and knees straight	3270

Finding the Neutral Spine

1981 NIOSH Guidelines

- ✓ Limits for load lifting were estimated
- ✓ Considerations: horizontal distance of the load from the body, frequency of lifting, vertical travel distance and height of the load at the beginning of lifting
- ✓ Admissible load: **40kg (392N)** under optimal conditions for 75% of all American women and 99% of men

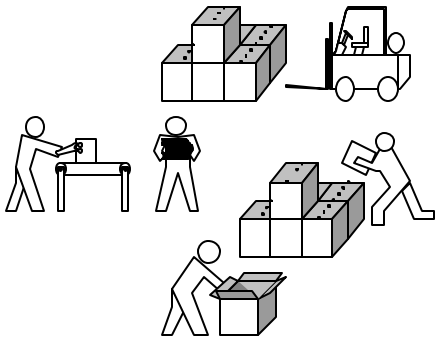
1981 NIOSH Guidelines

Major drawback:

The guidelines covered only symmetrical two-handed lifting performed directly in front of the body

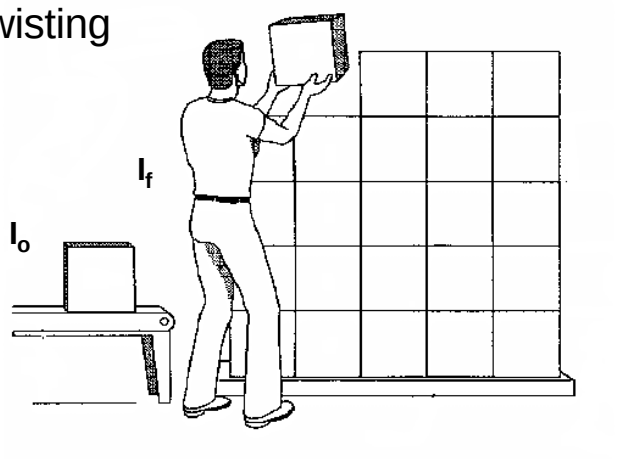
1981 NIOSH Guidelines

Most lifting activities on the shop floor involve sideward movements, rotation of the trunk or some other asymmetrical elements (body twisting)



Asymmetric Lifting

Body twisting



1991 NIOSH Revised Guidelines

- ✓ Better protection was sought, especially for female load handlers
- ✓ Take asymmetric lifting into account
- ✓ Specify the coupling between hands and object
- ✓ Guidelines apply to both lifting and lowering loads
- ✓ Maximum recommended weight is 23 kg (225N) even under the most favorable conditions

1991 NIOSH Revised Guidelines

Recommended Weight Limit

- ✓ The weight for which nearly all healthy workers could perform over 8 hours without increased risk of back pain/injury
- ✓ Uses following criteria: biomechanics, physiological, psychophysical, and epidemiological
- ✓ Produces recommendation based on most conservative of these criteria

NIOSH Criteria

- ✓ Biomechanical
  - Examines forces and torques on body, particularly lumbar region of back
  - Lumbar region of spine potentially most vulnerable
- ✓ Physiological
  - Energy requirements of task
- ✓ Psychophysical
  - Perceived ability to perform task
  - Maximum acceptable weight includes 99% males, 75% females
- ✓ Produces the most conservative estimate allowed by any one criteria

The NIOSH lifting equation **does not apply** if:

Lifting/lowering:

- ✓ With one hand
- ✓ For more than 8 hours
- ✓ While seating or kneeling
- ✓ In a restricted work space
- ✓ Hot, cold, or contaminated objects
- ✓ With unpredicted conditions (unexpected heavy loads, slips, falls

The NIOSH lifting equation **does not apply** if:

Lifting/lowering:

- ✓ Unstable loads (center of gravity varies significantly during the lift. E.g. containers of liquid or incompletely filled bags, etc)
- ✓ While carrying, pushing, or pulling (the equation still applies if there is a small amount of holding and carrying, but carrying should be limited to one or two steps and holding should not exceed a few seconds
- ✓ With wheelbarrows or shovels

The NIOSH lifting equation **does not apply** if:

Lifting/lowering:

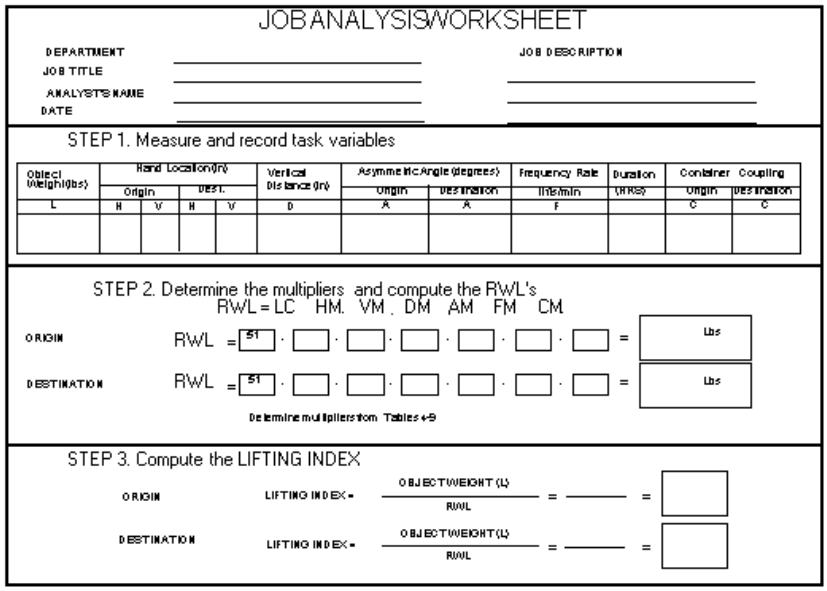
- ✓ With high speed motion (faster than about 30 inches/s, a lift from floor to table height in < 1s)
- ✓ Unreasonable foot/floor interface (<= .4 coefficient of friction between the sole and the floor)
- ✓ With low coefficient of friction between hand and object
- ✓ Unfavorable physical environment (temperature outside the 66-79°F (19-26°C) range, relative humidity outside 35-50% range

1991 NIOSH Lifting Equation

Recommended Weight Limit = RWL

RWL = LC x HM x VM x DM x AM x FM x CM

LC = load constant
HM = horizontal multiplier
VM = vertical multiplier
DM = distance multiplier
AM = asymmetric multiplier
CM = coupling multiplier
FM = frequency multiplier



JOB ANALYSIS WORKSHEET

DEPARTMENT _____ JOB DESCRIPTION _____
JOB TITLE _____ _____
ANALYST'S NAME _____ _____
DATE _____ _____

STEP 1. Measure and record task variables

Object Weight (lbs)	Hand Location (in)				Vertical Distance (in)	Asymmetric Angle (degrees)		Frequency Rate	Duration	Container Coupling	
	Origin		Dest.			Origin	Destination	(lifts/min)	(HRS)	Origin	Destination
L	H	V	H	V	D	A	A	F		C	C

STEP 2. Determine the multipliers and compute the RWL's

RWL = LC HM VM DM AM FM CM

ORIGIN RWL = 51 · ☐ · ☐ · ☐ · ☐ · ☐ · ☐ = Lbs

DESTINATION RWL = 51 · ☐ · ☐ · ☐ · ☐ · ☐ · ☐ = Lbs

Determine multipliers from Tables 4-9

STEP 3. Compute the LIFTING INDEX

ORIGIN LIFTING INDEX = OBJECT WEIGHT (L) / RWL = _____ = ☐

DESTINATION LIFTING INDEX = OBJECT WEIGHT (L) / RWL = _____ = ☐

Figure 3: Single Task Job Analysis Worksheet

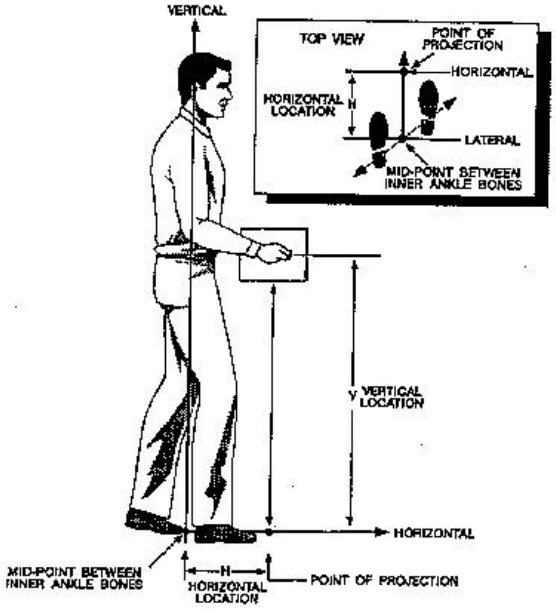
Definitions

- ✓ **Load constant** (LC): maximum weight that could be lifted under ideal circumstances (symmetric lifting, occasional lifts, < 25 cm vertical distance)
- ✓ **Horizontal multiplier** (HM): disc compression increases as horizontal spine-load distance increases
- ✓ **Vertical multiplier** (VM): lifting from floor is more stressful than lifting from greater heights
- ✓ **Distance multiplier** (DM) physical stress increases as vertical distance of lifting increases

Definitions

- ✓ **Asymmetric multiplier** (AM): torso twisting is more harmful than a straight back
- ✓ **Coupling multiplier** (CM): lifting is easier when coupling is good (e.g. handles)
- ✓ **Frequency multiplier** (FM): more frequently lifted loads are more stressful than low frequency lifting

1991 NIOSH Lifting Equation



Calculating the Multipliers

Component	Metric System	U.S. System
LC	23 kg	51 lb
HM	(25/H)	(10/H)
VM	(1-0.003/[V-75])	(1-0.003/[V-30])
DM	(0.82 + 4.5/D)	(0.82 + 1.8/D)
AM	(1-0.0032A)	(1-0.0032A)
FM	From Table	From Table
CM	From Table	From Table

Frequency Multiplier Table

Table 5

Frequency Multiplier Table (FM)

Frequency lifts/min (F) ‡	Work Duration					
	≤ 1 Hour		> 1 but ≤ 2 Hours		> 2 but ≤ 8 Hours	
	V < 30†	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

†Values of V are in inches. ‡For lifting less frequently than once per 5 minutes, set F = .2 lifts/minute.

Coupling Multiplier Table

Coupling	V < 75 cm (30 in)	V >= 75 cm (30 in)
	Coupling Multipliers	
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

Lifting Index

- ✓ Provides risk estimate of the lifting task
- ✓ Risk associated with various index values is not fully understood
  - Lifting Index (LI) = $\frac{\text{weight lifted}}{\text{RWL}}$
  - If
    - LI > 1, lifting task poses an increased risk for some workers
    - LI > 3, many or most workers are at high risk of developing low-back pain and injury

Practical Hints

- ✓ Seize the load and lift it with a straight back and with bent knees

- ✓ Get the load as close to the body as possible by grasping the load whenever possible between the knees and by good foot placement

Practical Hints

- ✓ Make sure that your hold on the load is not lower than knee height (it is recommended to work at knuckle height)
- ✓ If the load does not have handles, tie a rope sling around the load and use a harness or hooks
- ✓ Avoid rotating or twisting movement of the trunk when lifting or lowering a load

Practical Hints

- ✓ Try, wherever possible, to use a mechanical aid such as a trolley, a lifting ramp, etc.
- ✓ Try to replace lifting and lowering by pushing or pulling. Often a conveyor can be used to make push and pull easy
- ✓ Reduce size of product boxes to lighten load
- ✓ Move small weights often

Practical Hints

- ✓ Get a good grip, use gloves that aid in holding slippery objects
- ✓ Use adjustable palletizers that allow loading at waist height

- ✓ Select strong people based on tests