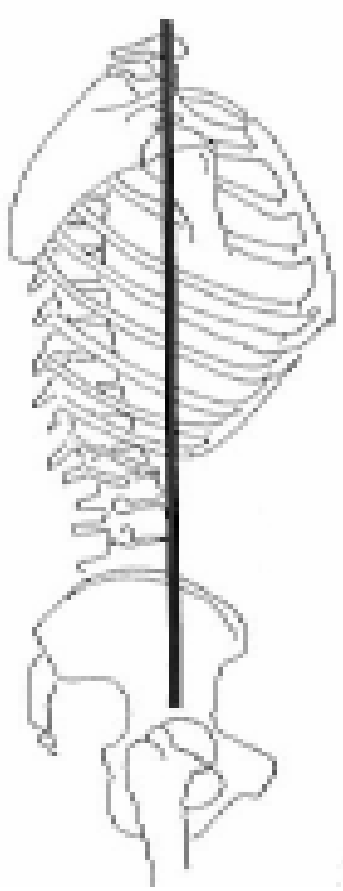
Section 36: Spine Biomechanics

Loads on the Spine

- Produced by:
  - Body weight
  - Muscle activity
  - Pre stress exerted by ligaments
  - Externally applied loads
- Constant forward bending moment produced by position of the line of gravity

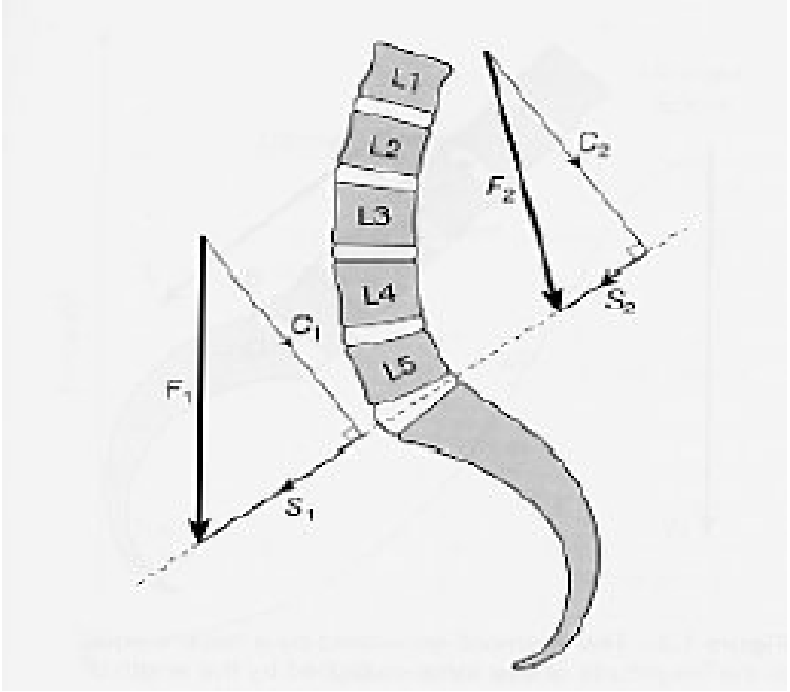


From: Peeler

Loading on the spine

- Abdominal (F1) and back (F2) muscle forces both have compression and shear components

- Adams et al., 2002



From: Iatridis

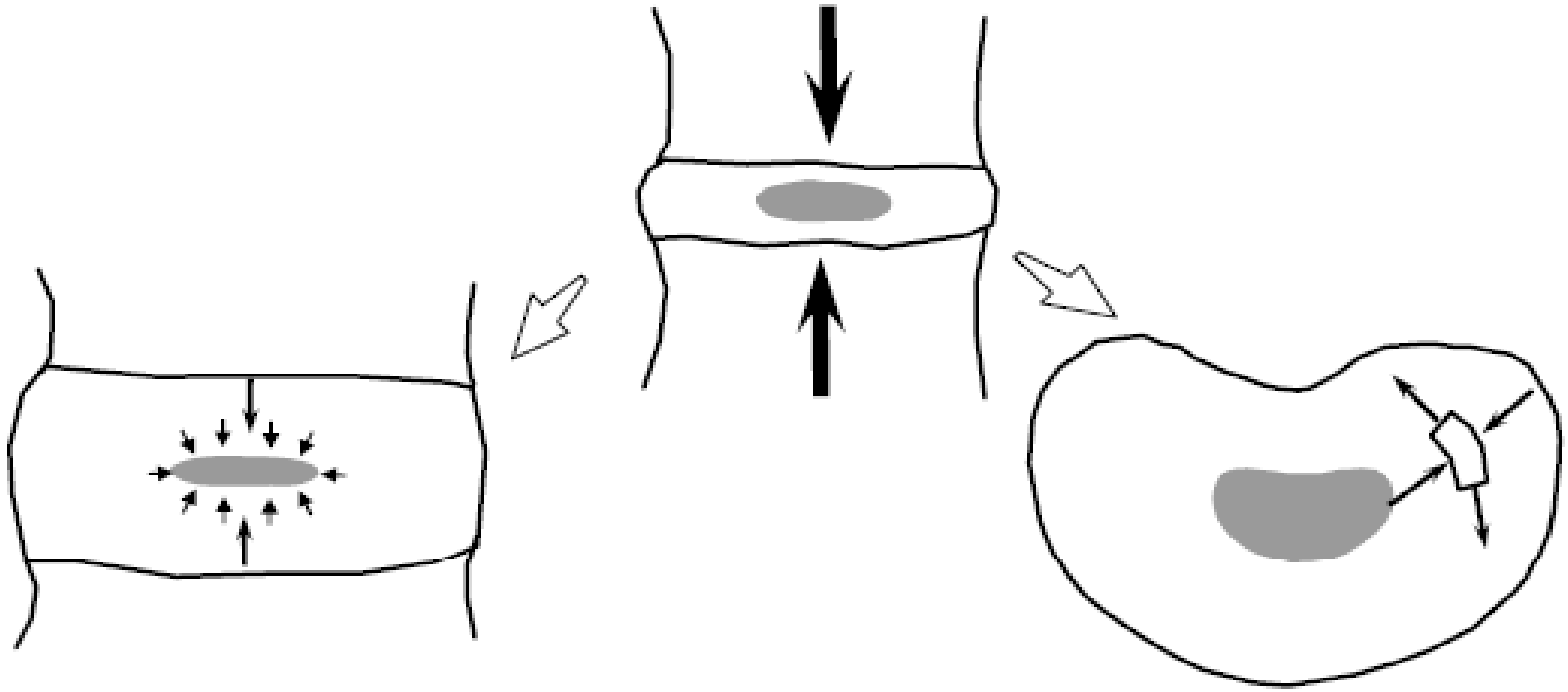
Theory of weight bearing

- Nucleus pulpous ***imbibes water***
- Develops internal pressure
- Pressure exerted in all directions
  - Lateral forces
    - Against annulus
  - Superiorly and inferiorly directed forces
    - Against end plates
  - Increases stiffness
    - Of end plate and annulus fibrosus

- Nucleus Pulposus
  - Eccentrically positioned posteriorly
  - Young & healthy
    - 50% cross-sectional
    - 90% water, bound to proteoglycans
  - Aging> dessication> increase viscosity> fissuring
  - Pascal's law
    - Fluid mass within closed container> local increase in pressure> transmit around entire side wall (annulus)
    - Young nucleus> even distribution of load
    - Old nucleus> undue concentration on vertebral body edges
  - Small displacement w/ ROM, ball-bearing like
  - Compressive stress predominates

From: Yang

Load Support in the Disc

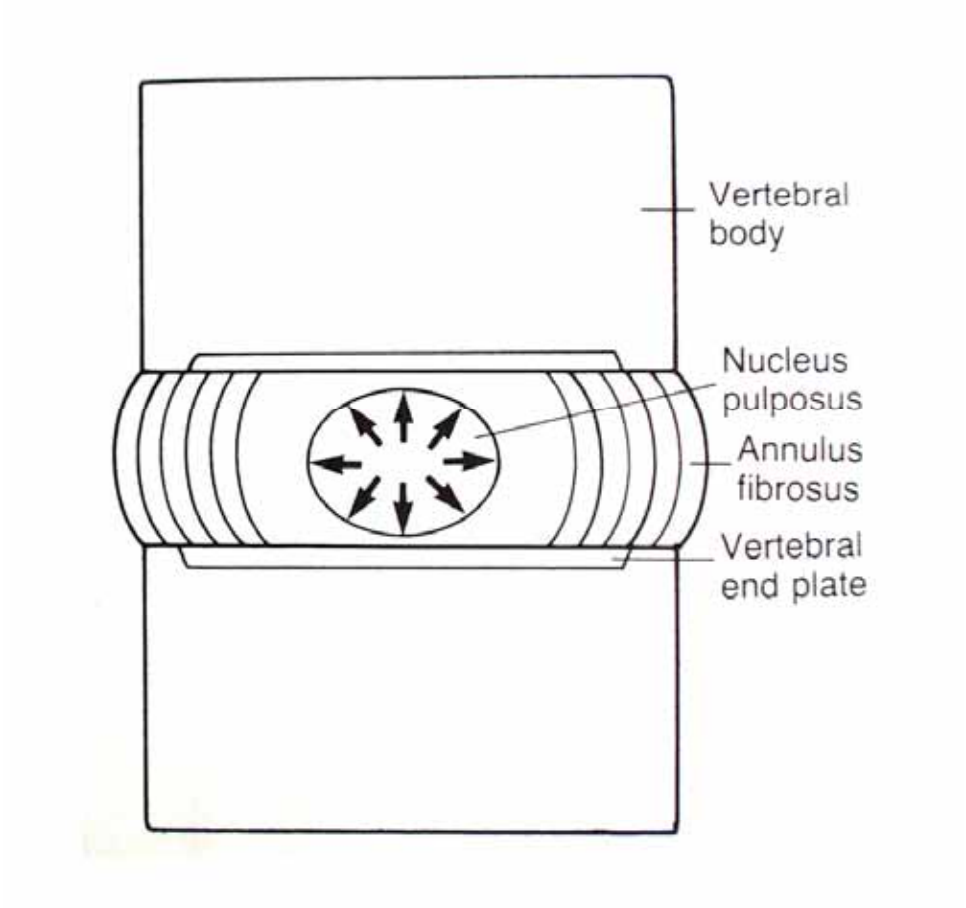


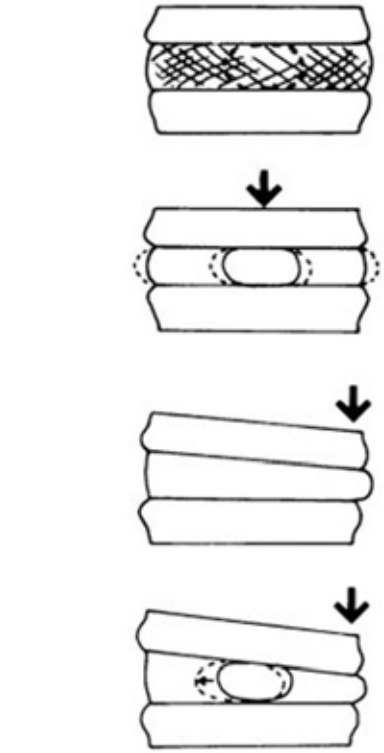
Pressurization & compressive stress of nucleus pulposus and annulus fibrosus

circumferential **tensile** stress
radial **compressive** stress
of annulus fibrosus

From: Iatridis

Theory of weight bearing (cont'd)





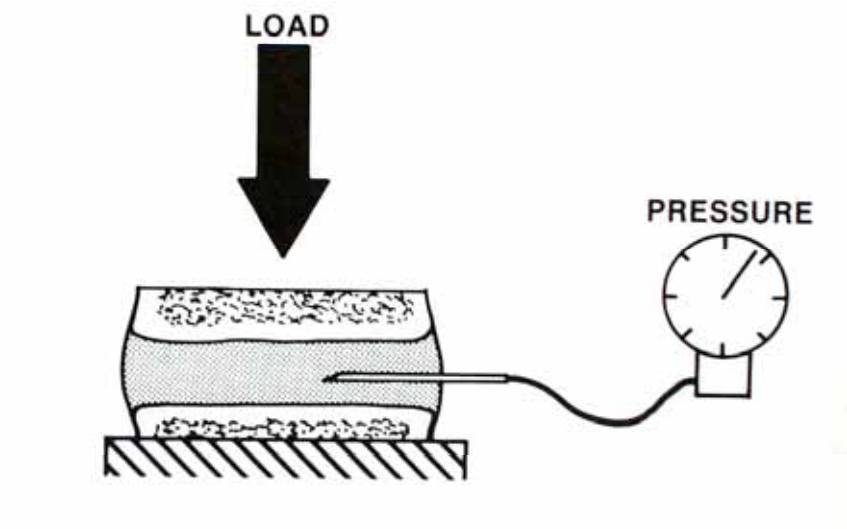
when uneven loading takes place

From: Ziv

- Intradiscal Pressure
  - Compressive loads in vivo: 500N standing, 700N sitting
  - Increased to 3000 to 6000N during lifting of moderate weights, decreases with load closer to body
  - Estimate of P = 1.5X compressive load divided by the cross sectional area
  - Disk pressure is usually uniform
  - Pressure lowest in supine position
  - Disk usually does not fail, but end plates fracture

Measurements of In vivo Loads

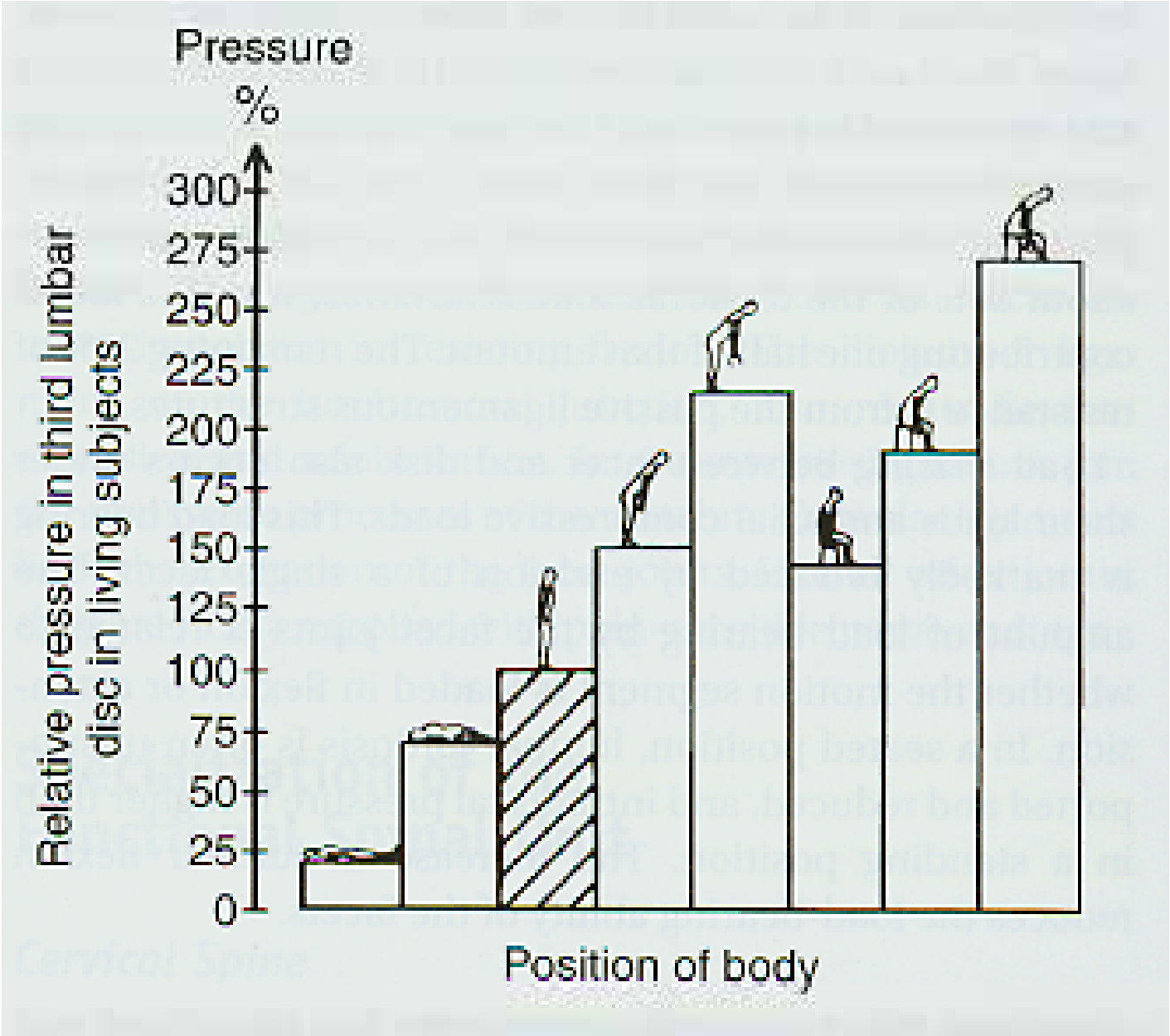
- Needle pressure transducer
- Calibrated
  - Introduced into nucleus pulpous of cadaveric functional unit
- Inserted in vivo in L3-4 disc



From: Ziv

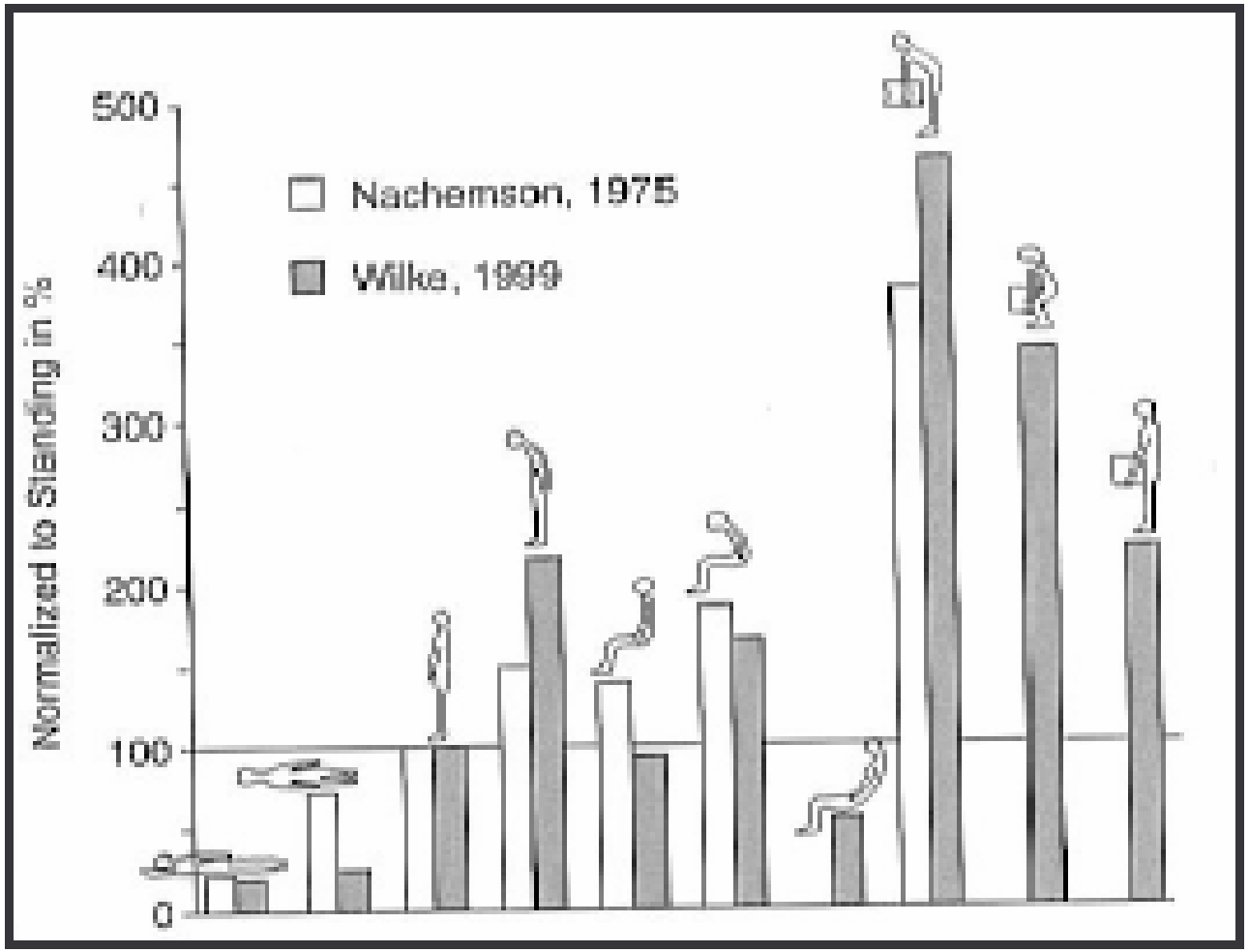
Shear & Tensile Characteristics

- In direct shear tests
  - Shear stiffness in horizontal direction
    - 260 N/mm^2
- Spine rarely fails in pure shear
- Similarly under normal physiologic activities
  - Pure tensile loading doesn't occur
  - But annulus undergoes tensile loading during
    - Bending
    - Axial rotation
    - Extension


Pressure
%
300
275
250
225
200
175
150
125
100
75
50
25
0
Relative pressure in third lumbar disc in living subjects
Position of body

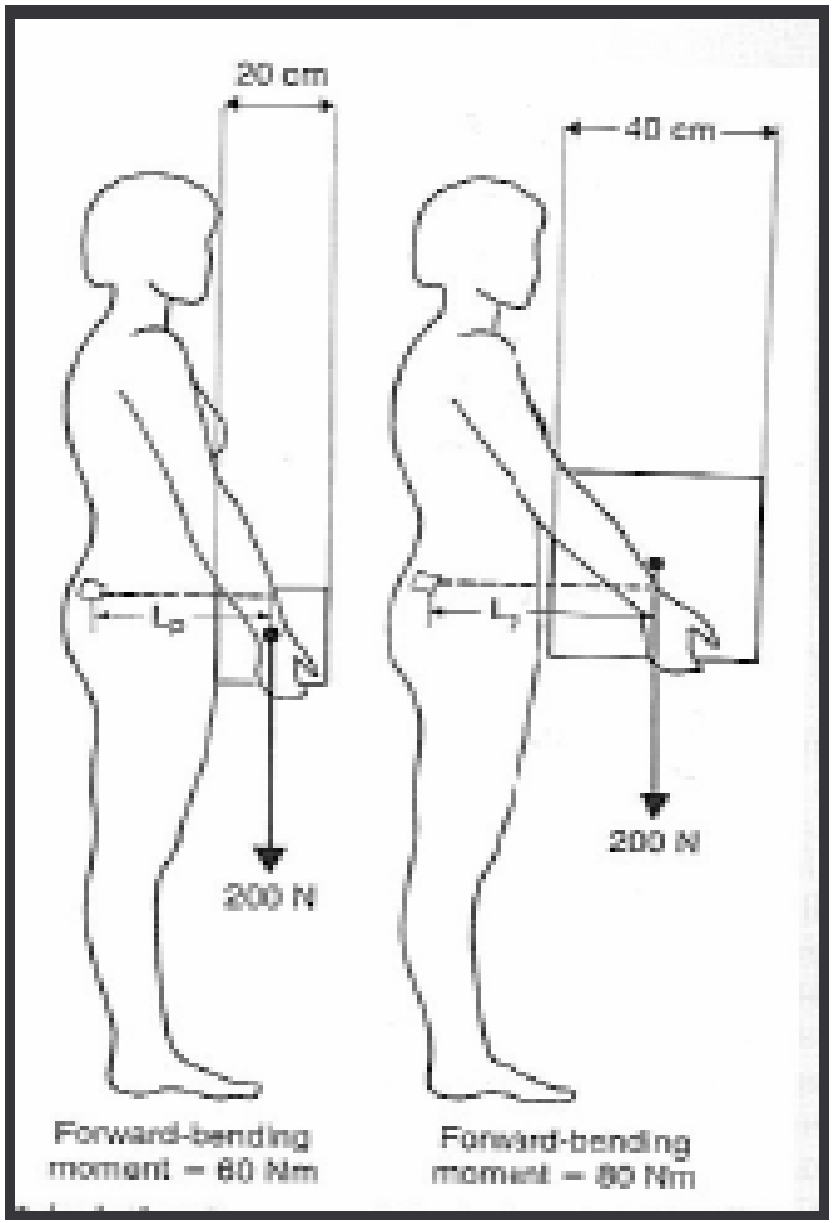
From: Yang

Influence of Body Position - Static



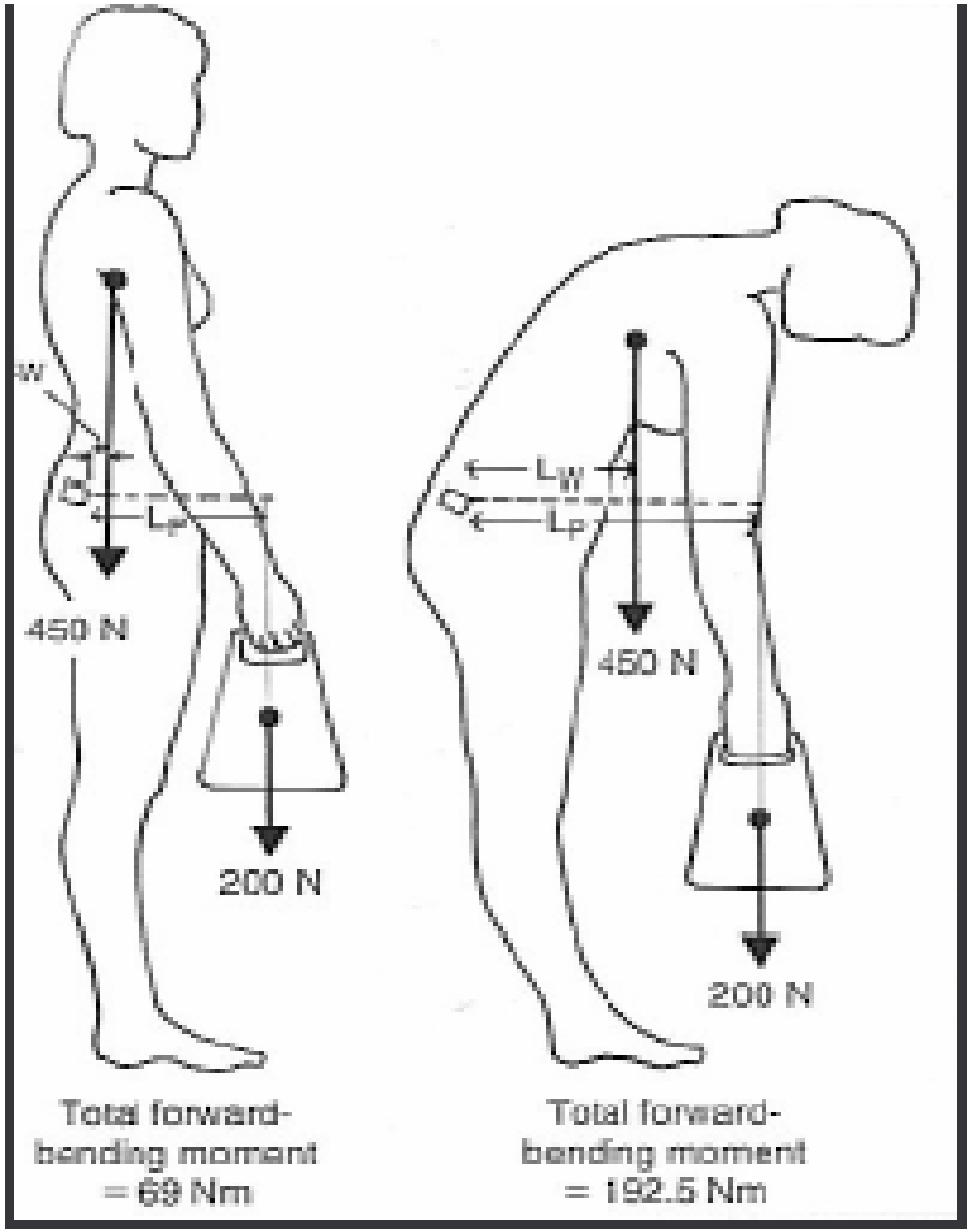
From: Peeler

Influence of the Size of the Object on the Loads on the Lumbar Spine



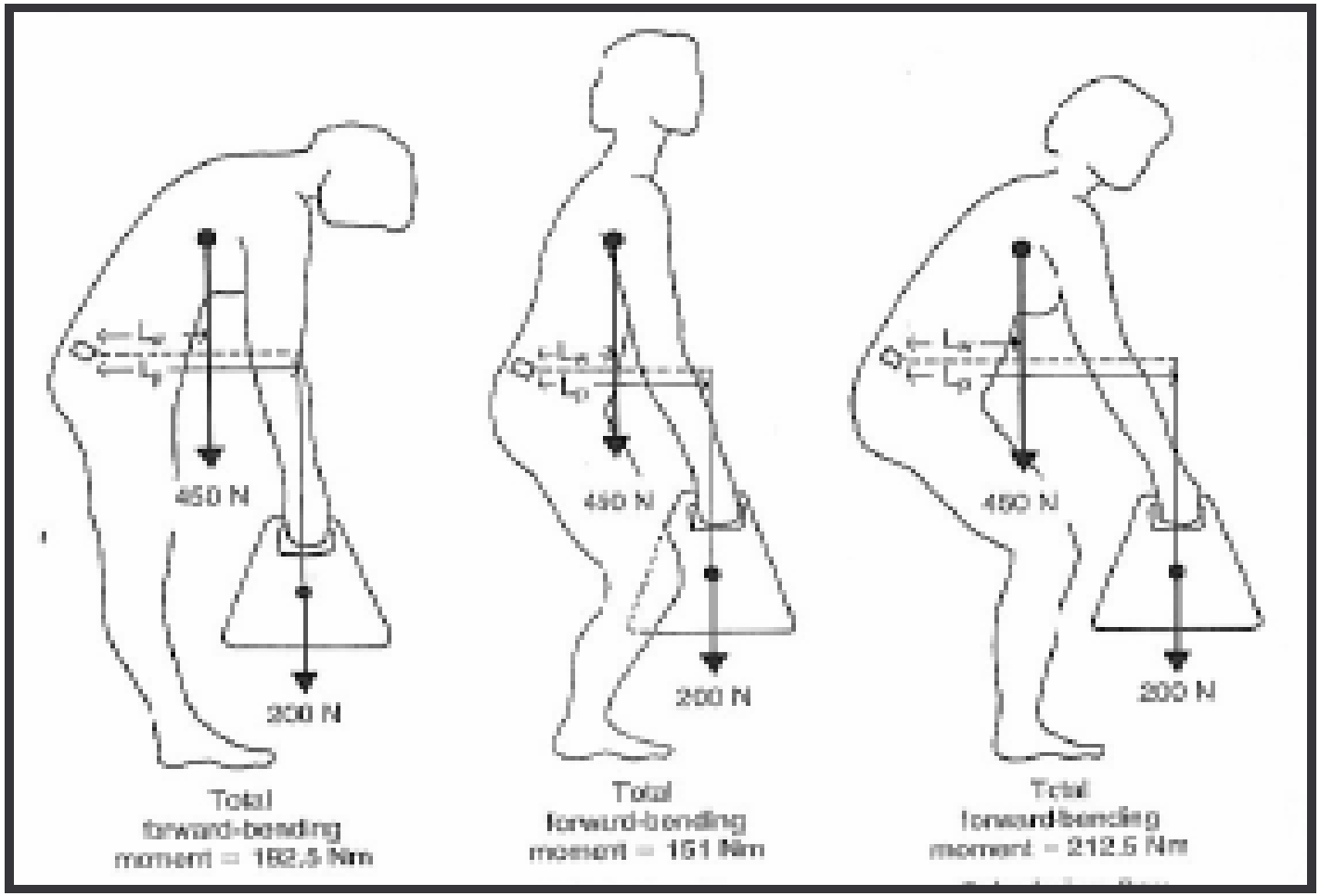
From: Peeler

Influence of Upper Body Positioning on the Loads on the Lumbar Spine During Lifting



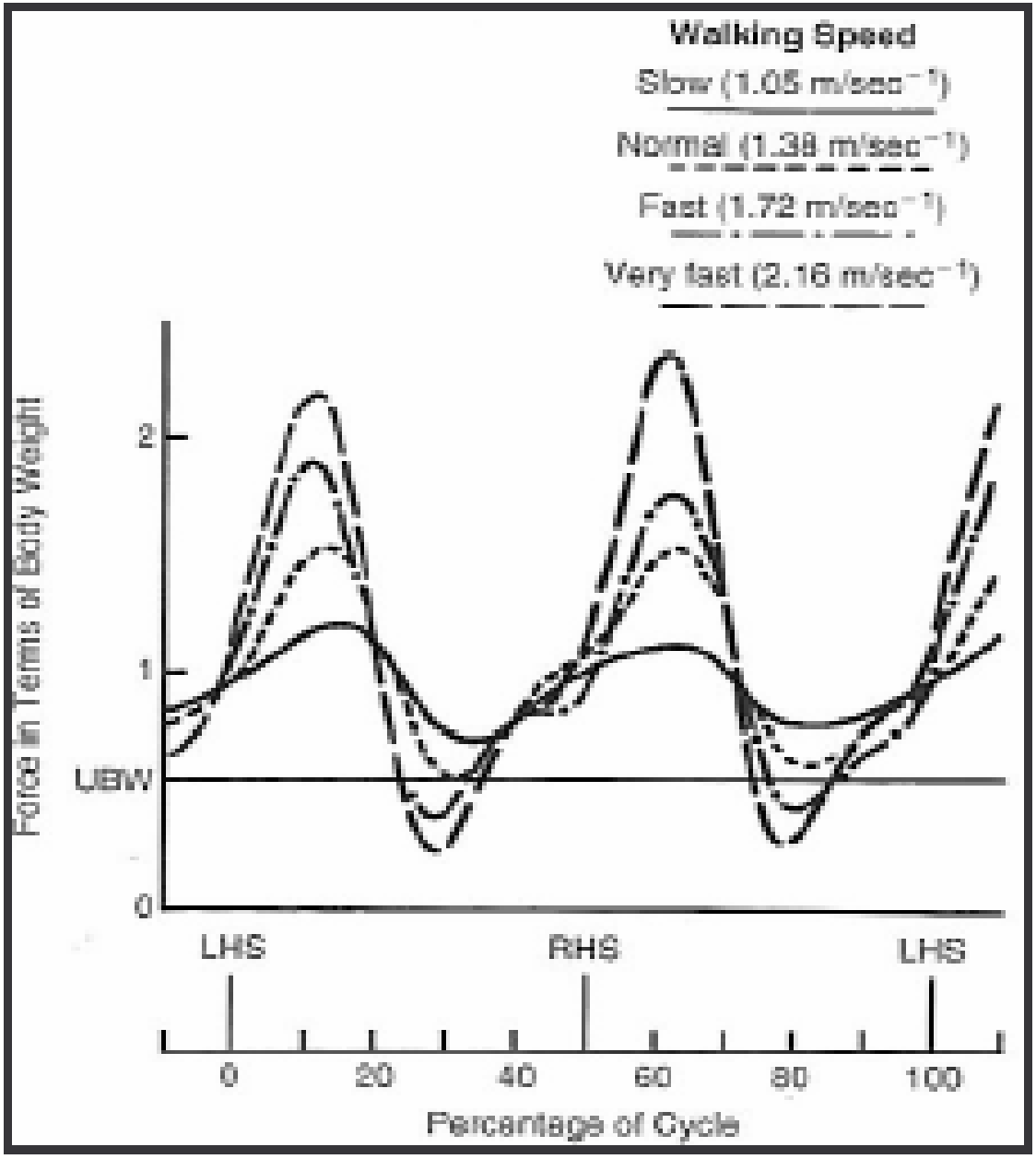
From: Peeler

Different Lifting Techniques



From: Peeler

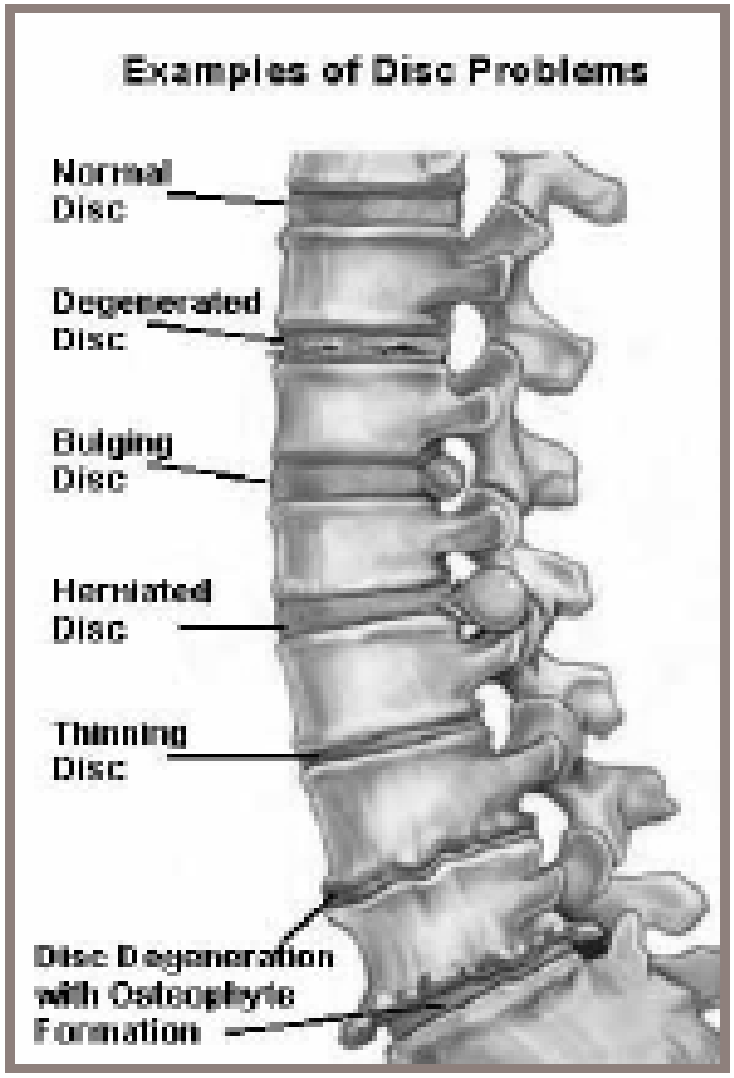
Influence of Body Position - Dynamic



From: Peeler

Low Back Pain

- Most frequent cause of activity limitation in people under age 45
- Direct annual cost of treating low back pain patients
  - $11.4 billion in 1994
  - Not including the secondary costs of lost work and activity
- Mechanical loading conditions associated with back pain
  - Frequent bending and twisting
  - Heavy physical work
  - Sedentary environment
  - Vibration



Spondylosis (spinal OA)

- degenerative disorder that may cause loss of normal spinal structure and function.
- Although aging is the primary cause, the location and rate of degeneration is individual.
- The degenerative process of spondylosis may impact the cervical, thoracic, and/or lumbar regions of the spine affecting the intervertebral discs and facet joints

From: Peeler