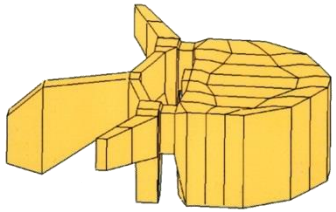
BIOMECHANIKA KRĘGOSŁUPA



Modelowanie

Istota i potrzeba modelowania

Cel opisu

Modelem danego rzeczywistego obiektu jest układ dający się wyobrazić lub materialnie zrealizować, który, odzwierciedlając lub odtwarzając obiekt, zdolny jest zastępować go tak, że jego badanie dostarcza nowych, nadających się do dalszego sprawdzenia informacji.

W. Sztoff

Model

modus (łac.) – miara, obraz, sposób

„model” – rzecz podobna pod jakimś względem do innej rzeczy

- ✓ **model materialny**
  - (makieta) – zmiana skali
  - (analog) – inne zjawisko fizyczne
- ✓ **model abstrakcyjny**

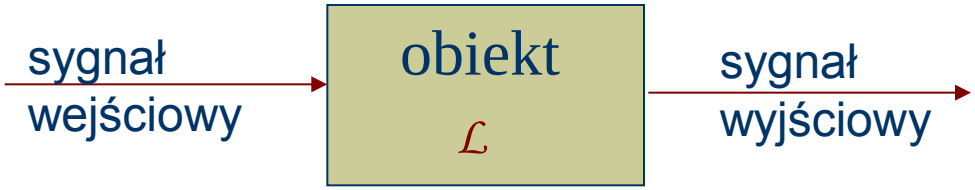
Model abstrakcyjny

„Model nie jest i nie może być odzwierciedleniem rzeczywistości, jest natomiast odzwierciedleniem naszej wiedzy o tej rzeczywistości” – *M. Dietrich*

Model nominalny (fizyczny)
Model matematyczny

Identyfikacja parametrów modelu

- **modele strukturalne**, których struktura połączeń elementów obiektu jest podobna do organizacji wewnętrznej badanego obiektu;
- **modele funkcjonalne**, przy tworzeniu których nie wnikamy w strukturę wewnętrzna obiektu.



Model fizyczny

Wyodrębnienie z rozważanego zjawiska rzeczywistego elementów istotnych z punktu widzenia celu modelowania:

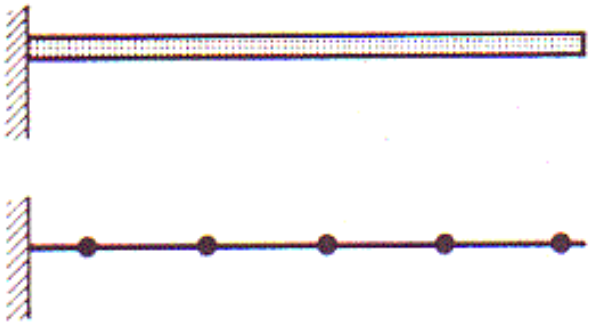
- ustalenie praw fizycznych,
- ustalenie cech jakościowych i charakterystyk ilościowych obiektu oraz sygnałów wejściowych.

Cechy jakościowe:

- liniowość – nieliniowość,
- dyskretna lub ciągłą „natura” obiektu,
- deterministyczny – losowy.

Liczba stopni swobody układu mechanicznego

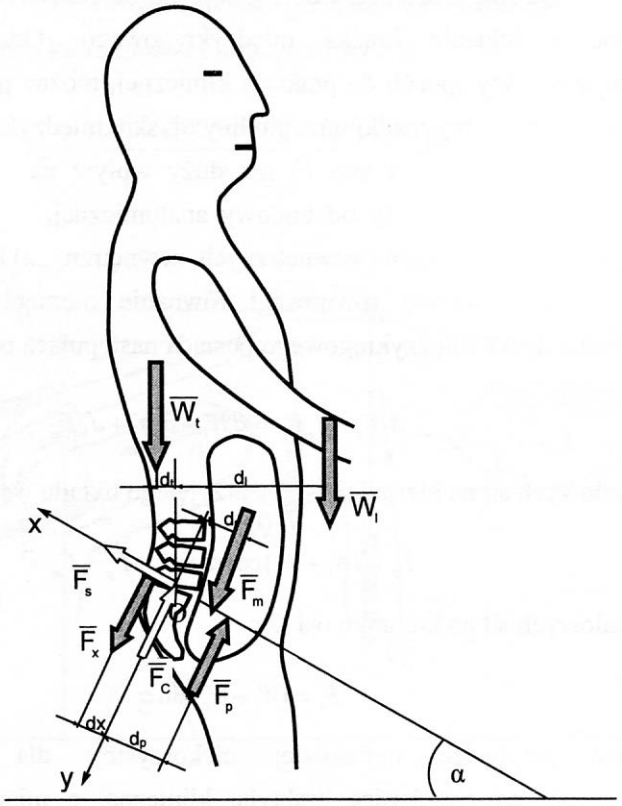
- Model dyskretny → równania różniczkowe zwyczajne
- Model ciągły → równania różniczkowe cząstkowe



Metody badania modeli matematycznych

- Metody analityczne
- Metody wykreślne
- Metody numeryczne
- Metody symulacyjne

Model Stotte'a

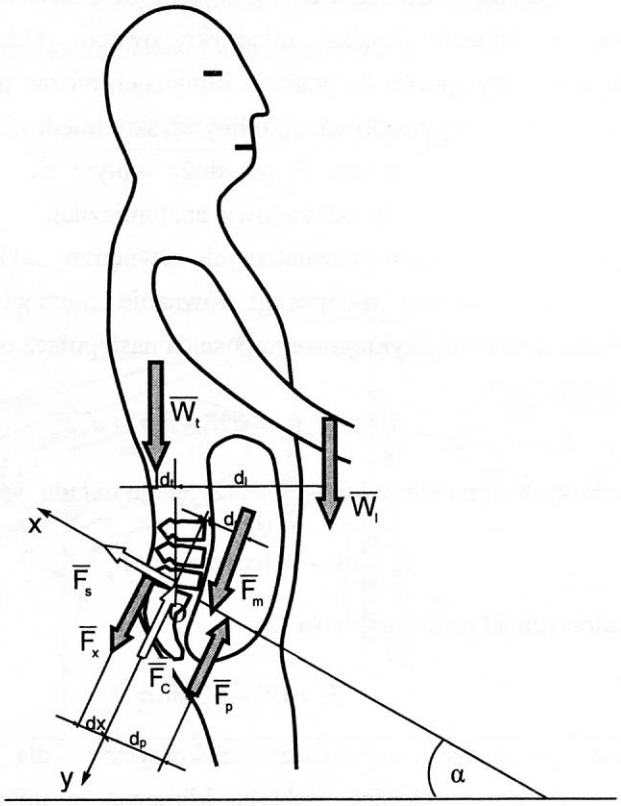


założenia:

- **obc. statyczne**
- **model płaski (pł. strzałkowa)**

α - kąt pochylenia kości krzyżowej

Model Stotte'a



W_t – ciężar ciała powyżej L5-S1

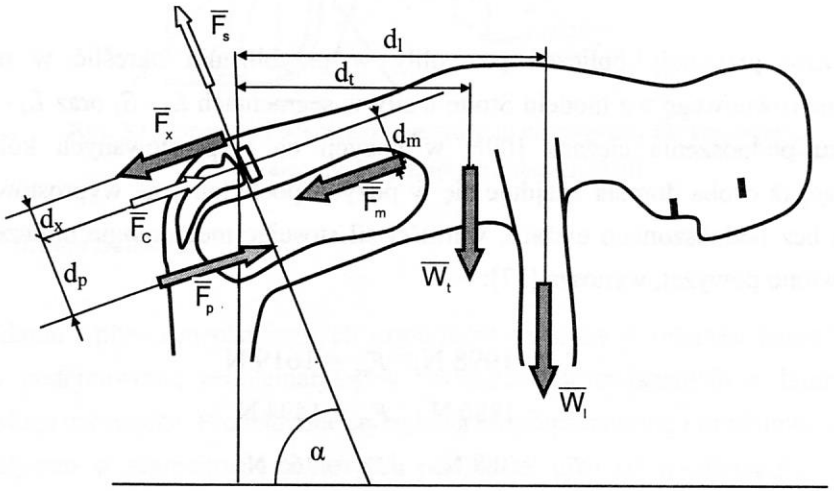
W_1 – ciężar ramion i przedmiotów

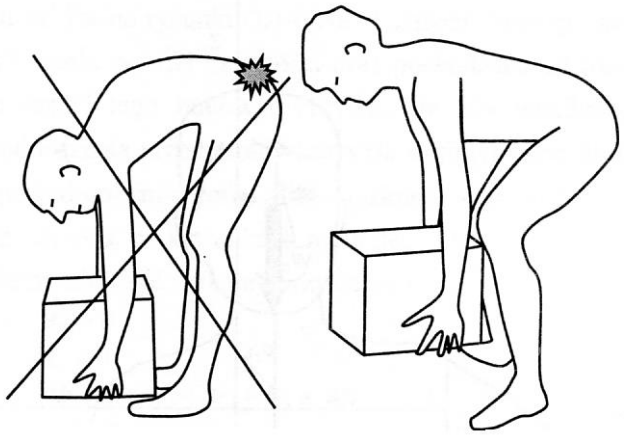
F_p – siła tłoczni brzusznej

F_m – składowa siły m. brzucha

F_x – siła prostowników grzbietu

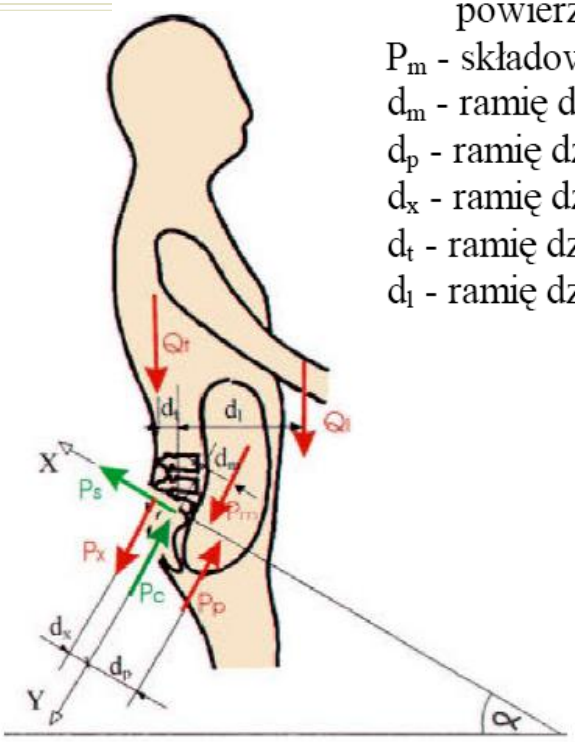
Model Stotte'a





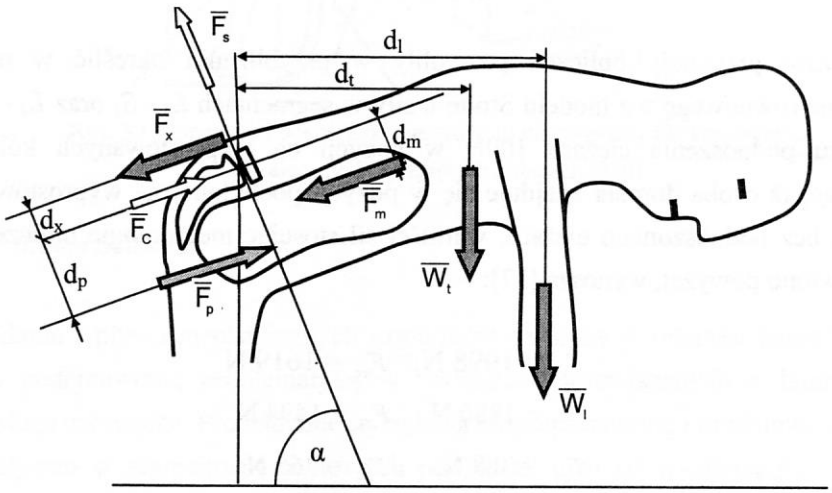
Model Stotte'a

P_p - siła pochodząca od ciśnienia jamy brzusznej (70 mmHg – 9,35 kN/m2 działa na czynnej powierzchni S = 0.035 m^2 i wywołuje siłę - 326 N),
P_m - składowa siły wzdłużnej mięśni brzucha - 75 N,
d_m - ramię działania siły wzdłużnej mięśni brzucha - 10 cm,
d_p - ramię działania siły pochodzącej od ciśnienia jamy brzusznej - 9cm,
d_x - ramię działania siły prostowników grzbietu - 4,8 mm,
d_t - ramię działania siły ciężkości tułowia,
d_l - ramię działania siły ciężkości kończyn górnych.



$$P_x d_x + P_p d_p = Q_l d_l \pm Q_t d_t + P_m d_m$$
$$P_c = (Q_l + Q_t)\cos\alpha + P_x - P_p + P_m$$
$$P_s = (Q_l + Q_t)\sin\alpha$$

Model Stotte'a

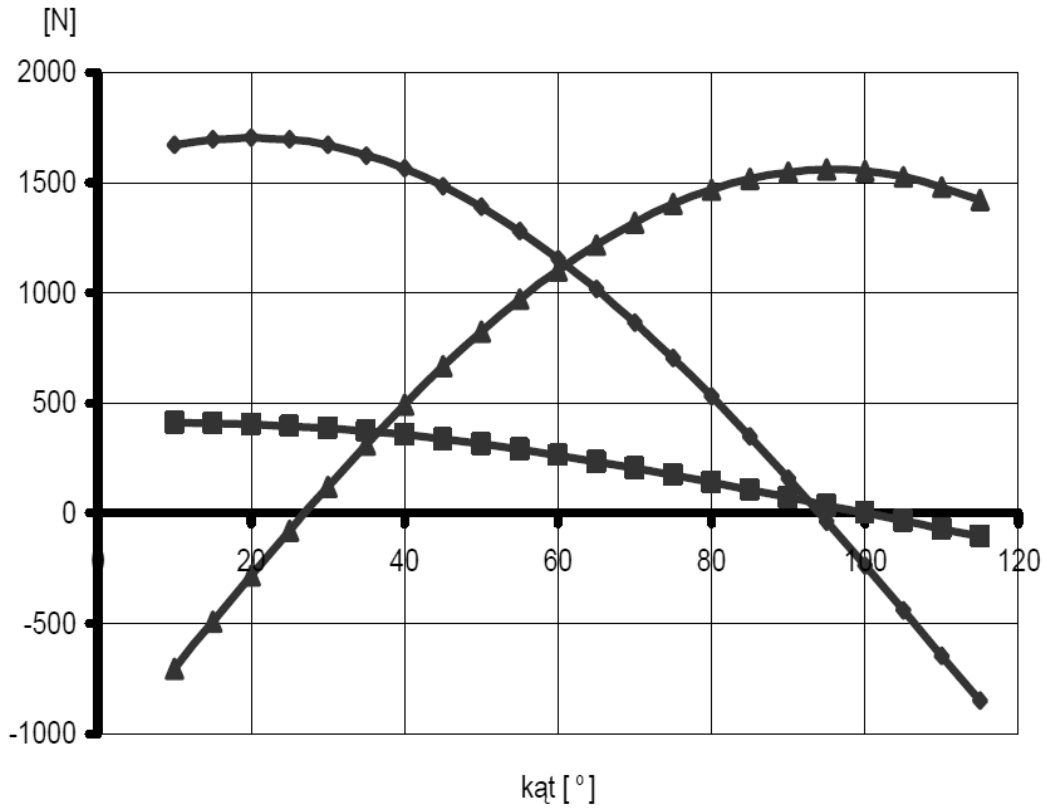


d_l = 100 mm
d_t = 240 mm
W_t = 337 N (45,2% ciężaru ciała)
W_l = 173 N (73 N czyli 9,8% cc + 100 N)

$$F_{x5} = \frac{W_l d_l + W_t d_t + F_m d_m - F_p d_p}{d_{x5}} = 3144 \text{ N}$$

F_{c5} = 3059 N
F_{s5} = 482 N

Model Stotte'a

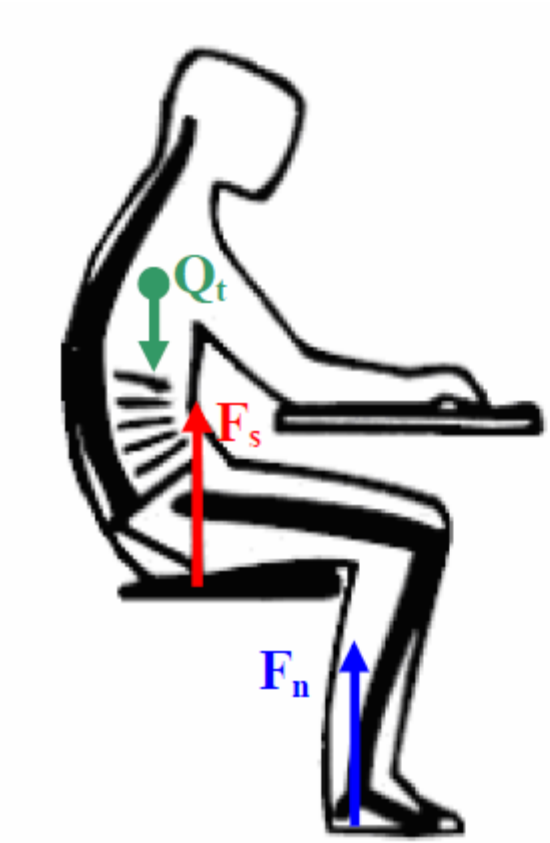


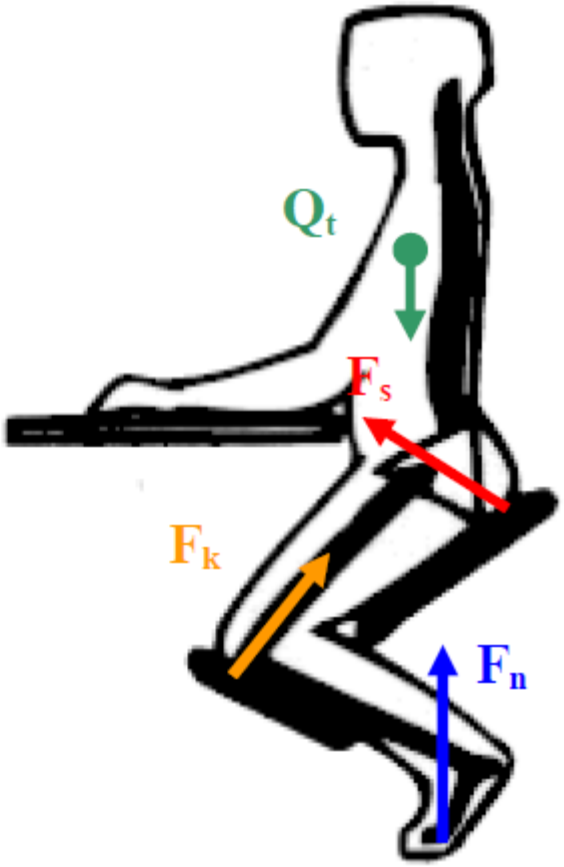
masa ciała 76 kg
wzrost 180 cm

Wykres sił działających na poziomie L5 – S1
w zależności od kata pochylenia tułowia

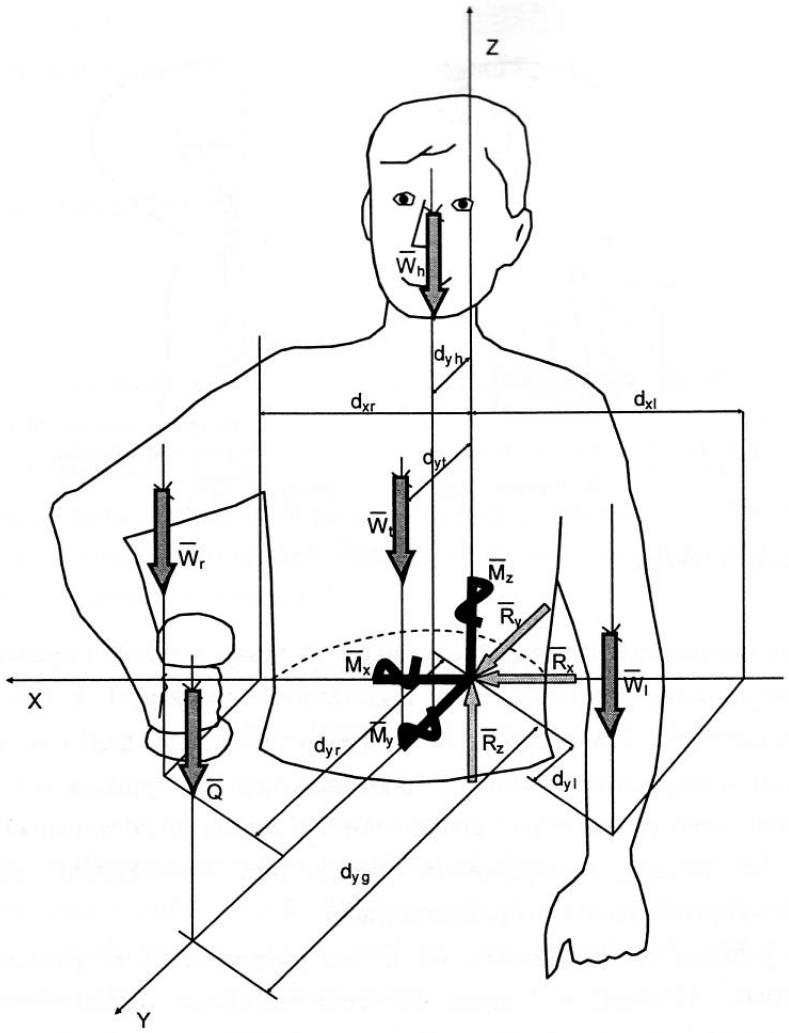
0º - poziomo

Oddziaływanie siedziska na operatora (przy komputerze)





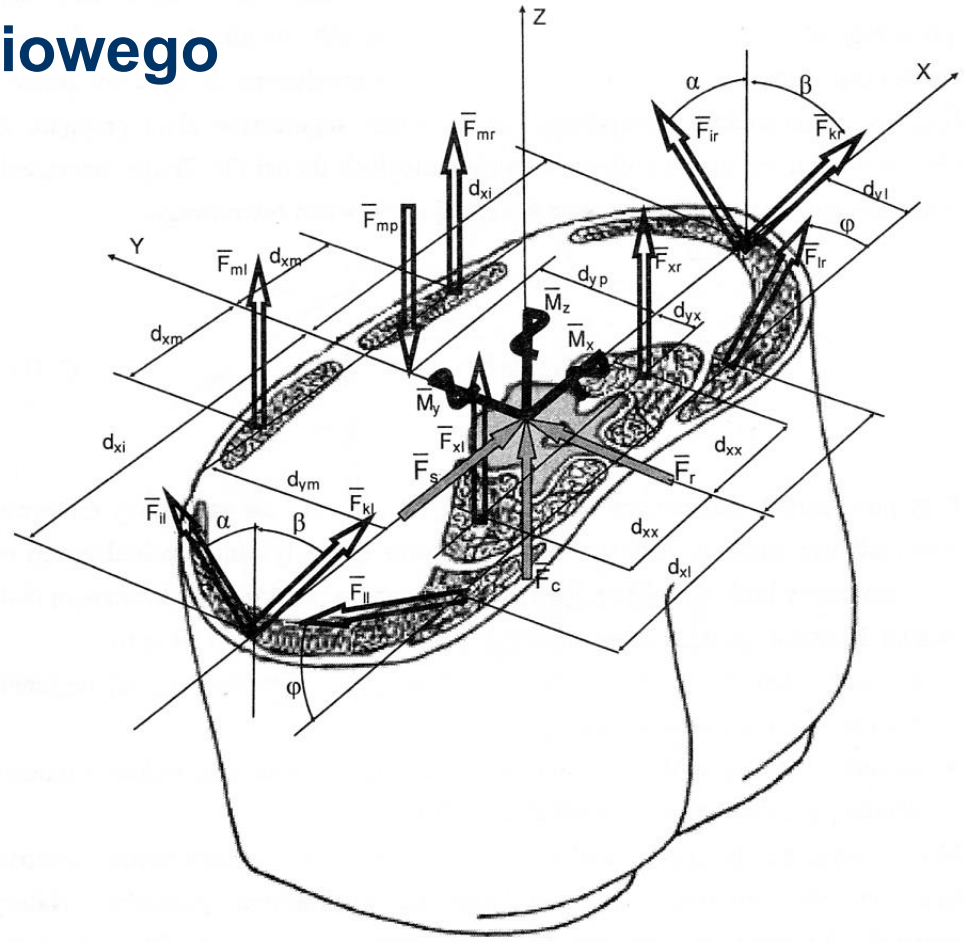
Model Schultza



układ sił
na poziomie kręgu
L3

Model Schultza

Przekrój odcinka lędźwiowego na poziomie L3

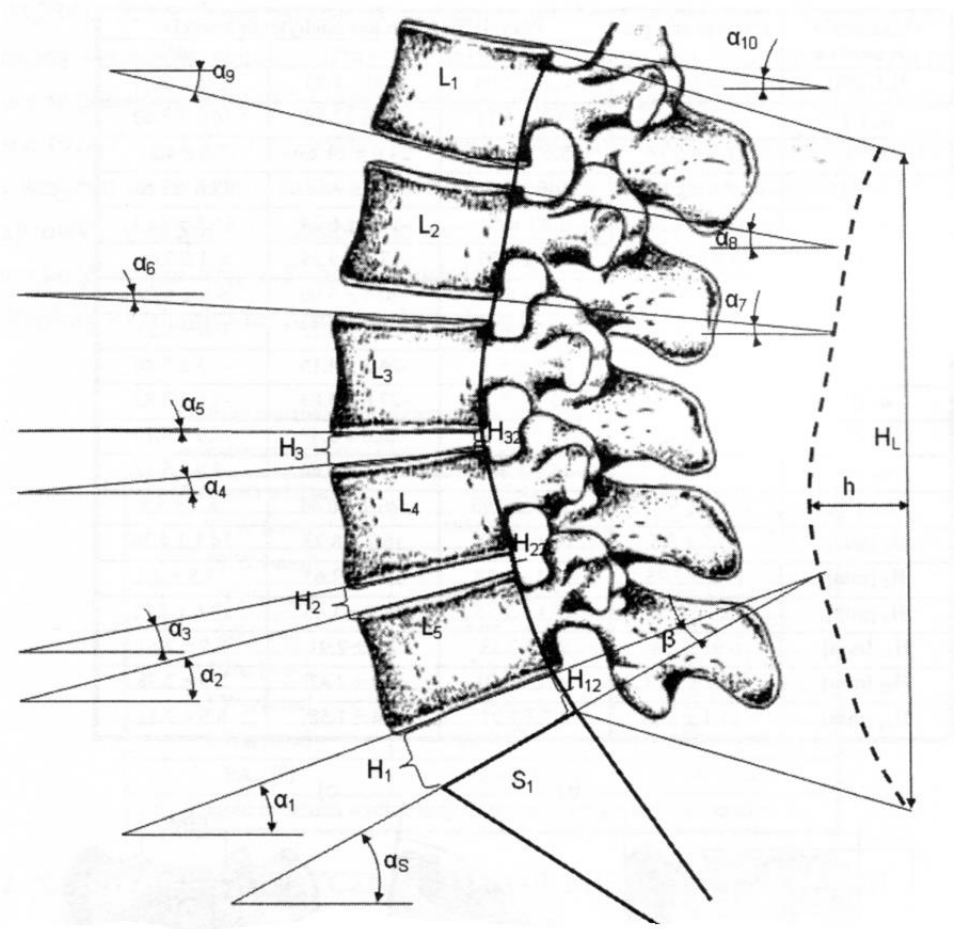


6 równań równowagi

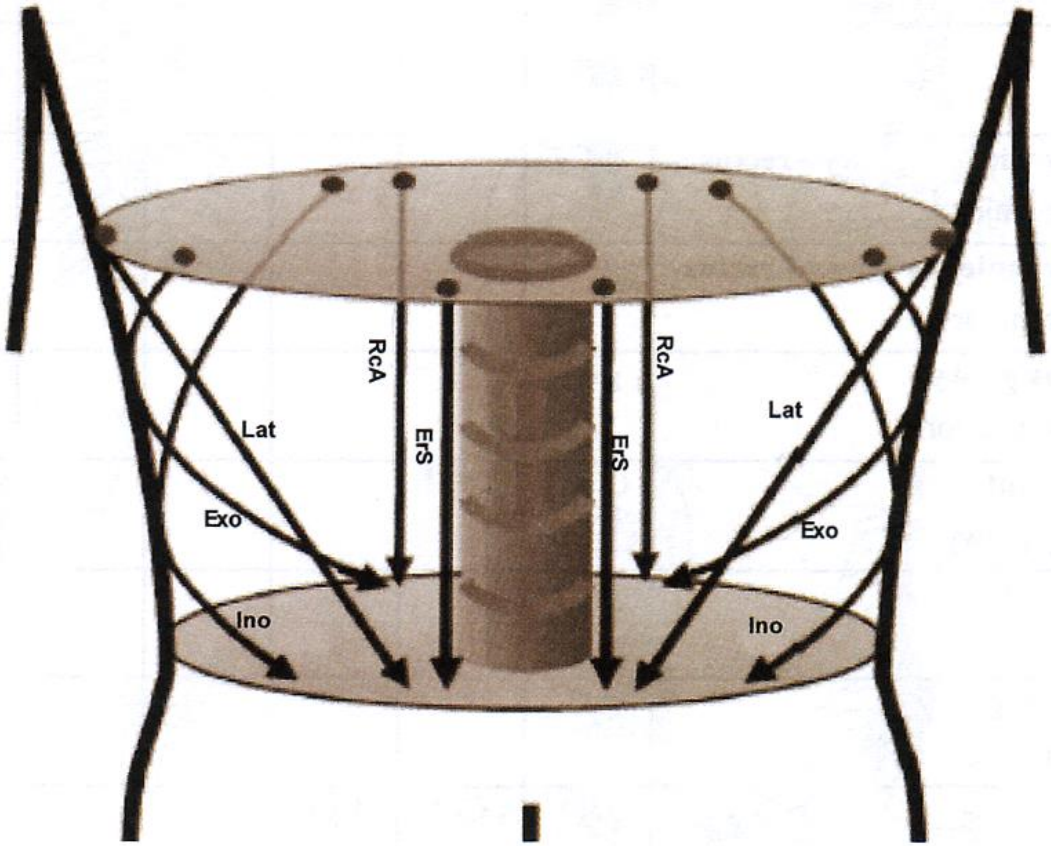
14 niewiadomych sił (obc. symetryczne 8)

OPTYMALIZACJA

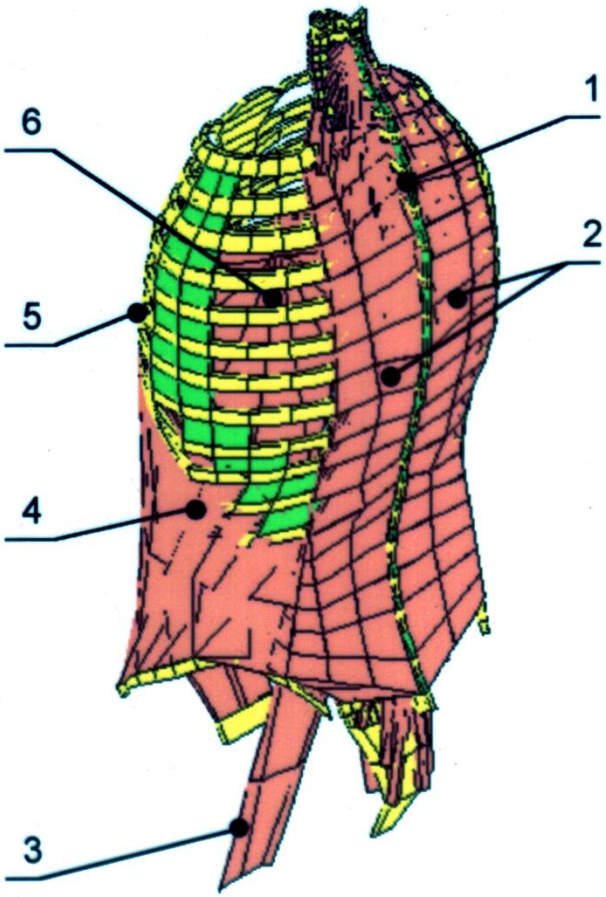
Parametry geometryczne kregosłupa lędźwiowego

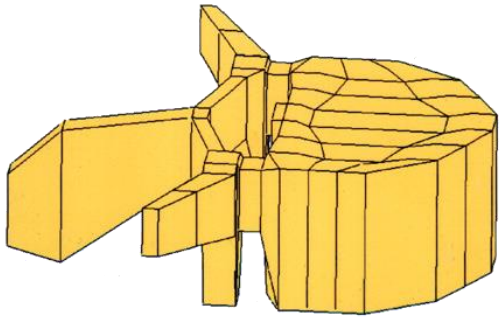


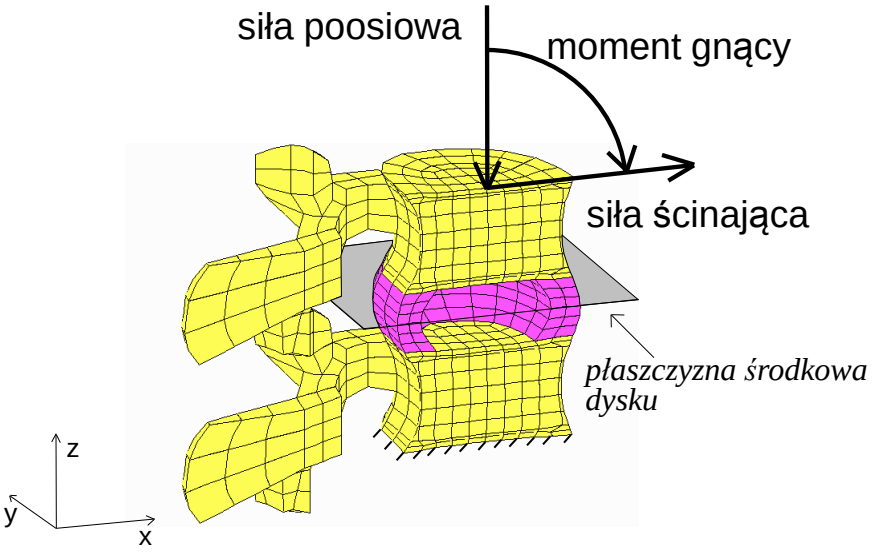
Model odcinka lędźwiowego



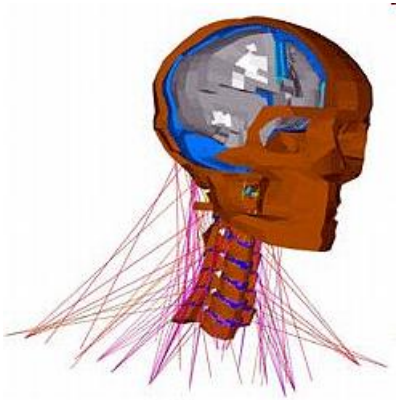
Metoda Elementów Skończonych (MES)

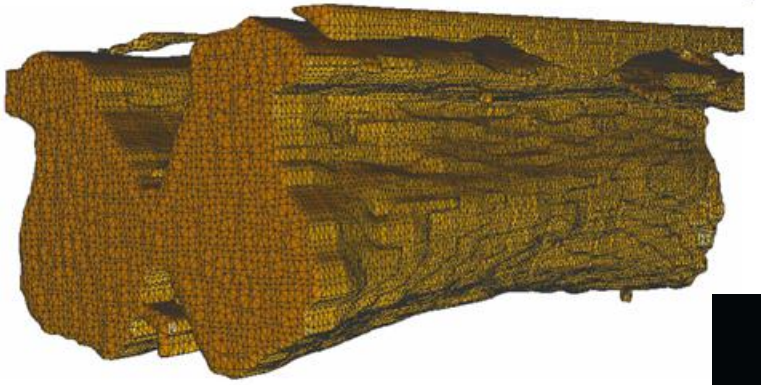


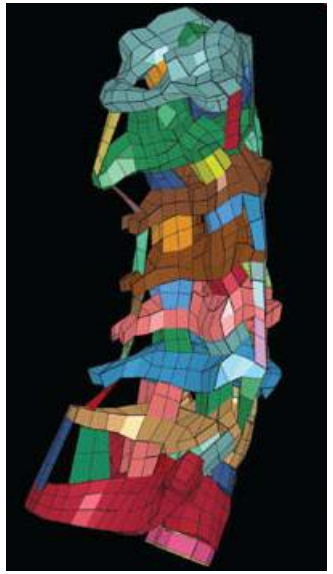


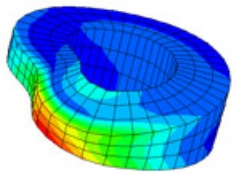


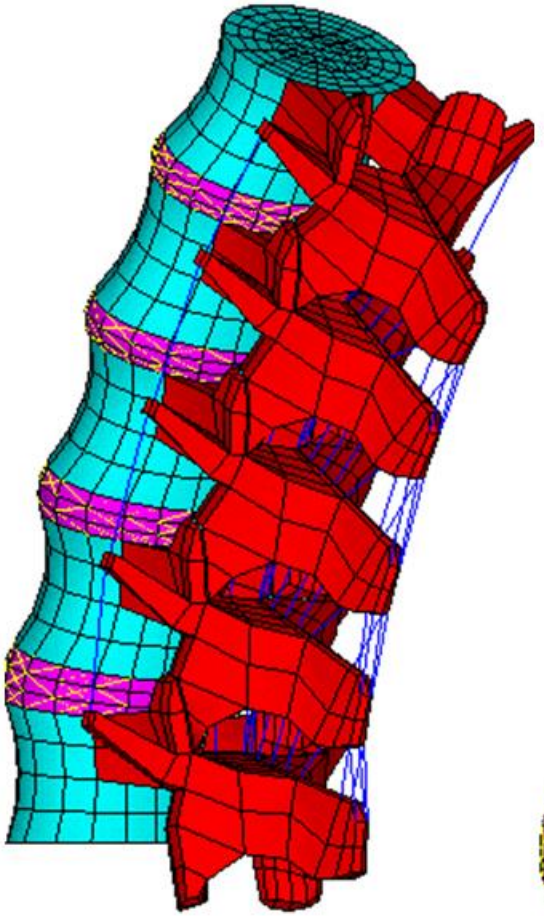
Modele MES



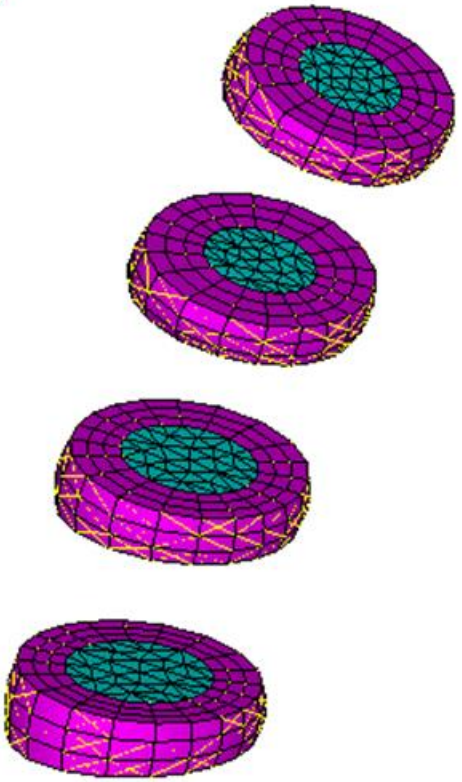




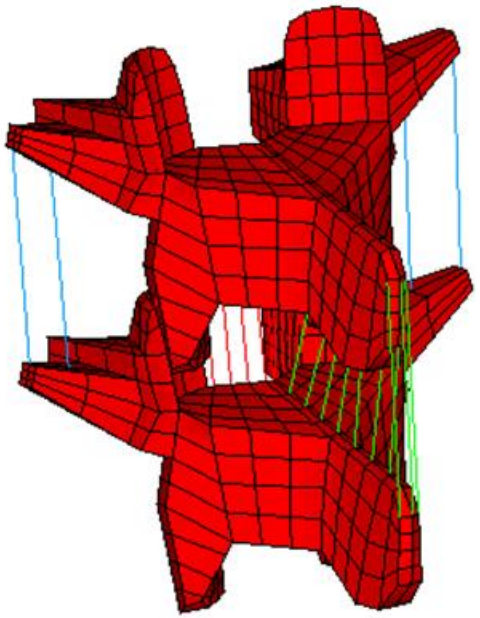




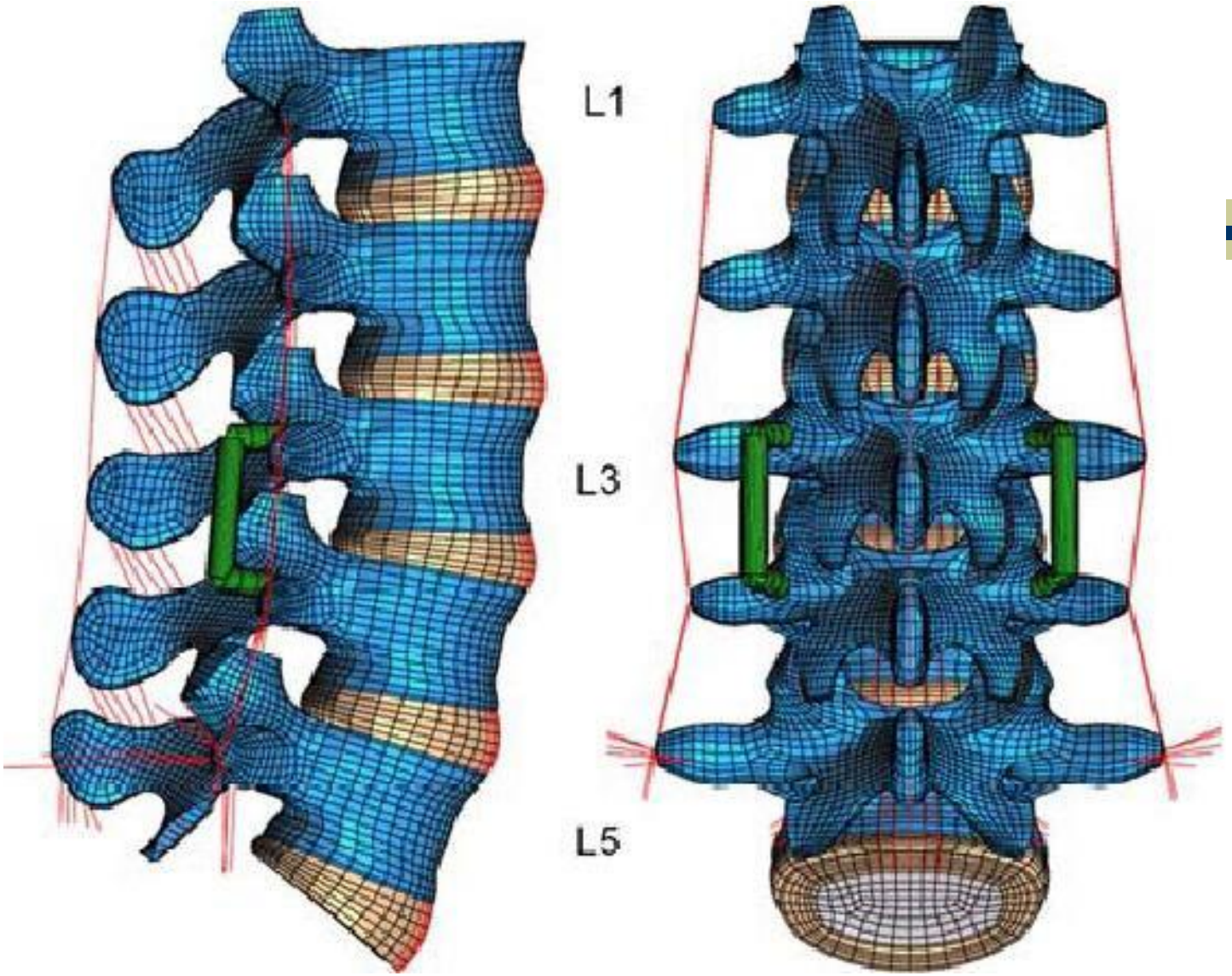
Lumbar Spine L1 to L5

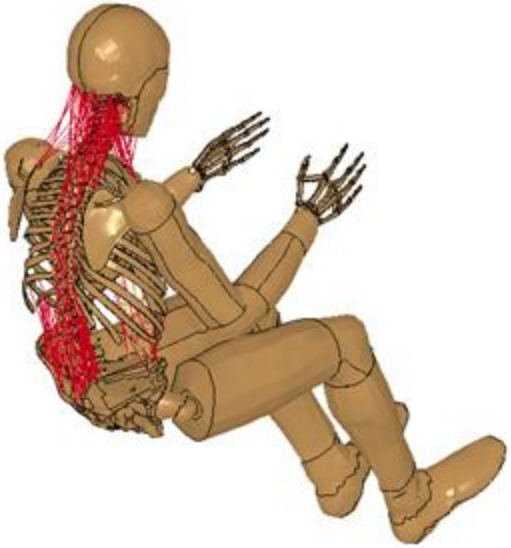


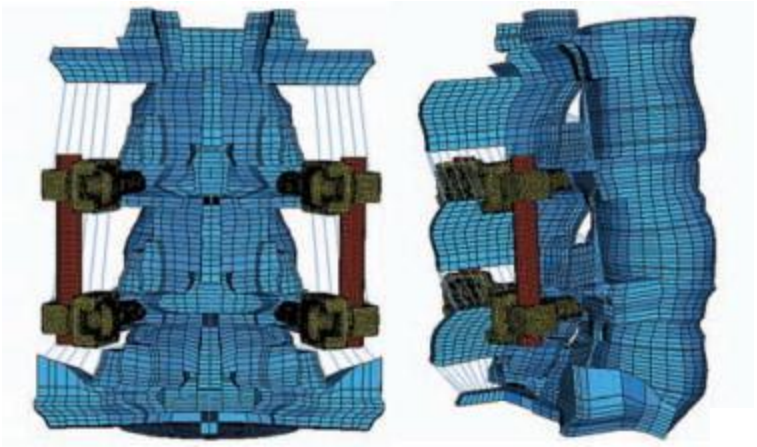
Intervertebral discs

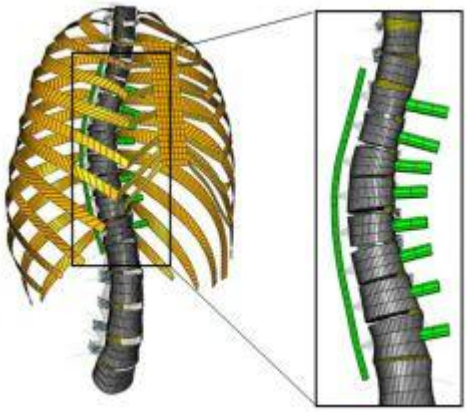


Posterior Elements

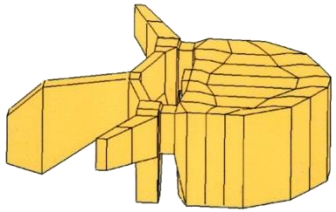

L1
L3
L5





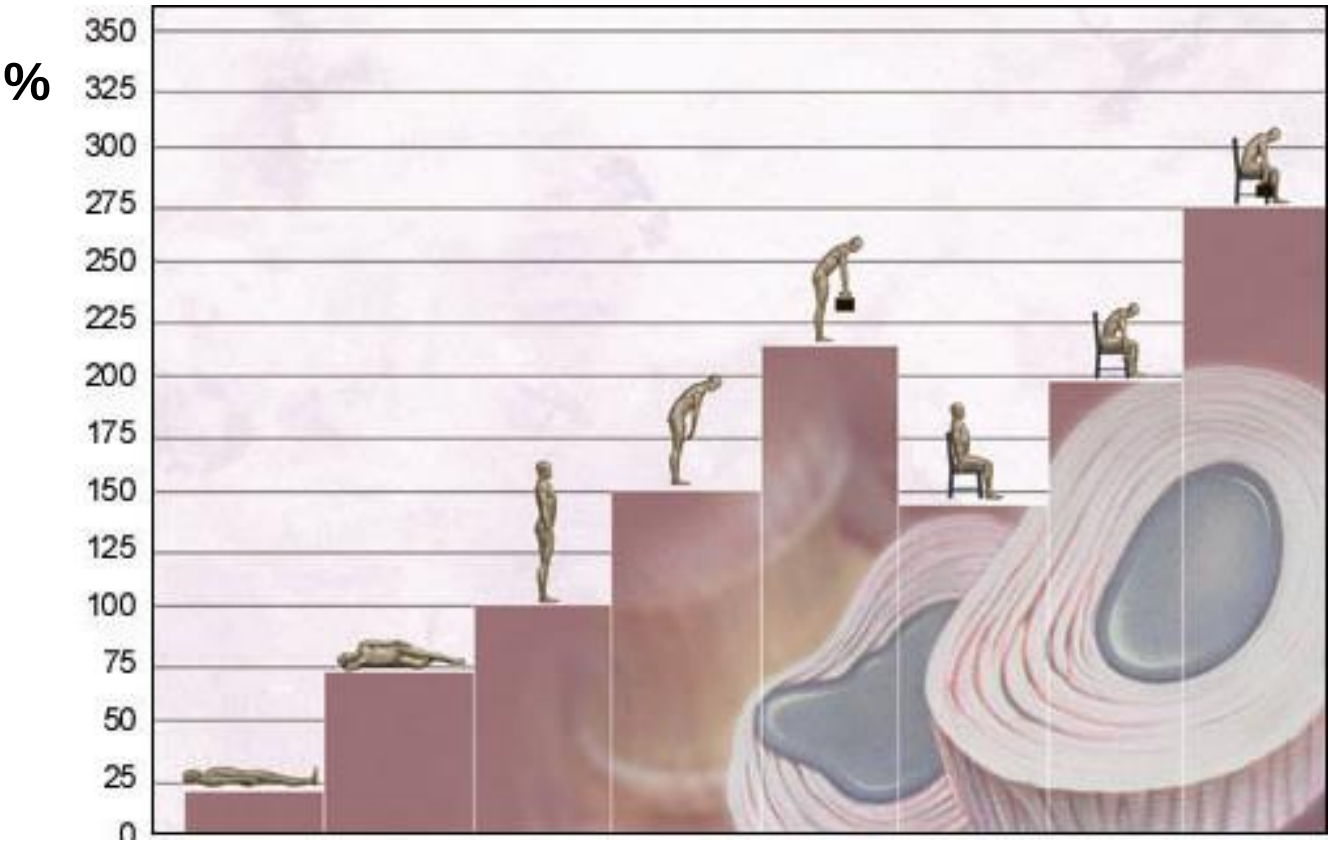


BIOMECHANIKA KRĘGOSŁUPA

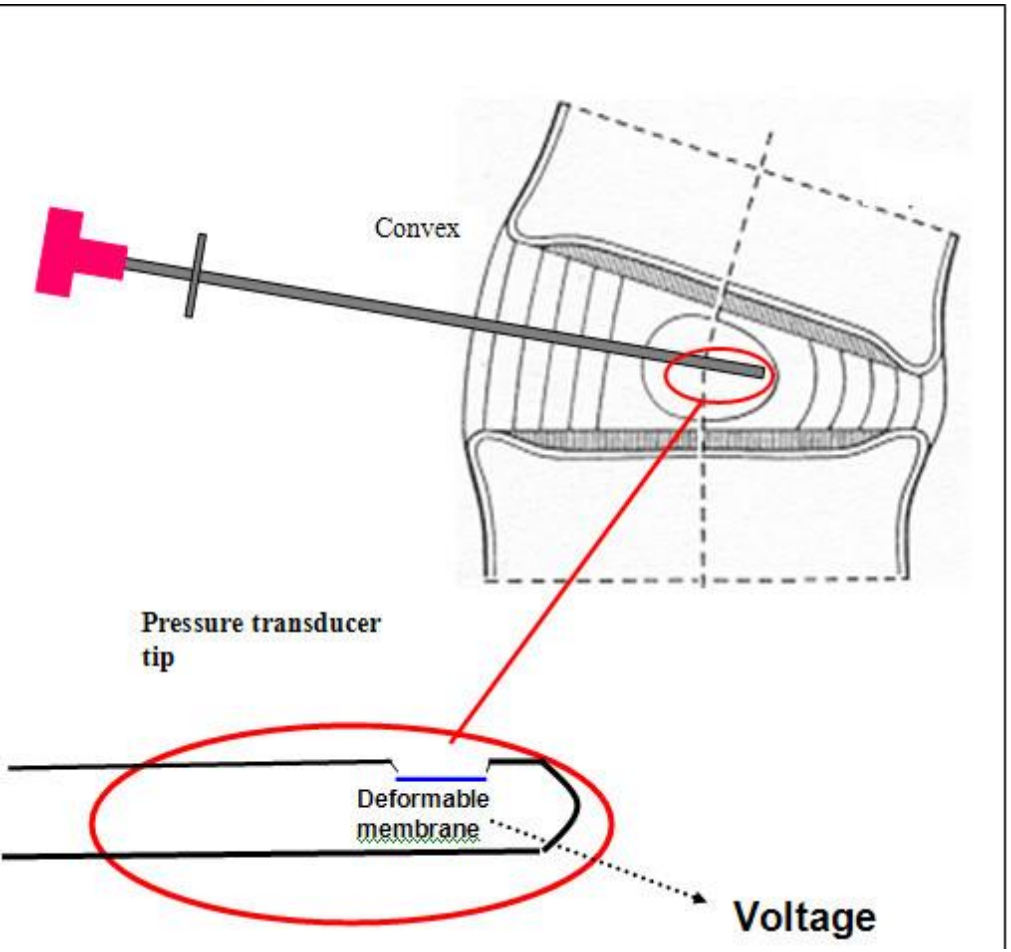


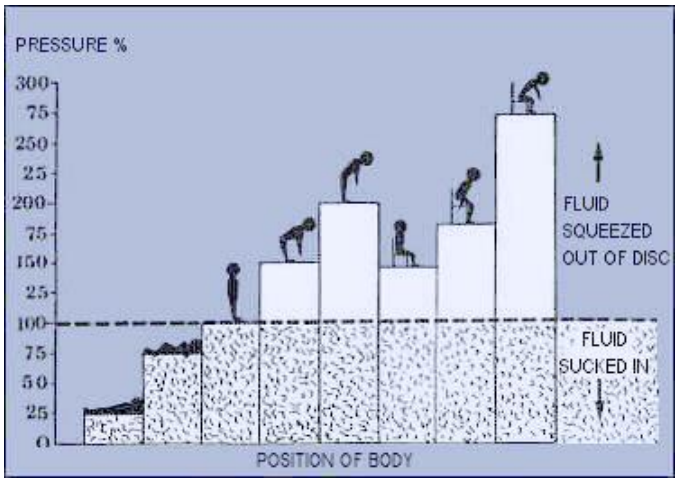
Ciśnienie
w krążku międzykręgowym

Zmiany ciśnienia w krążku L3 – L4 *in vivo* [A. Nachemson]

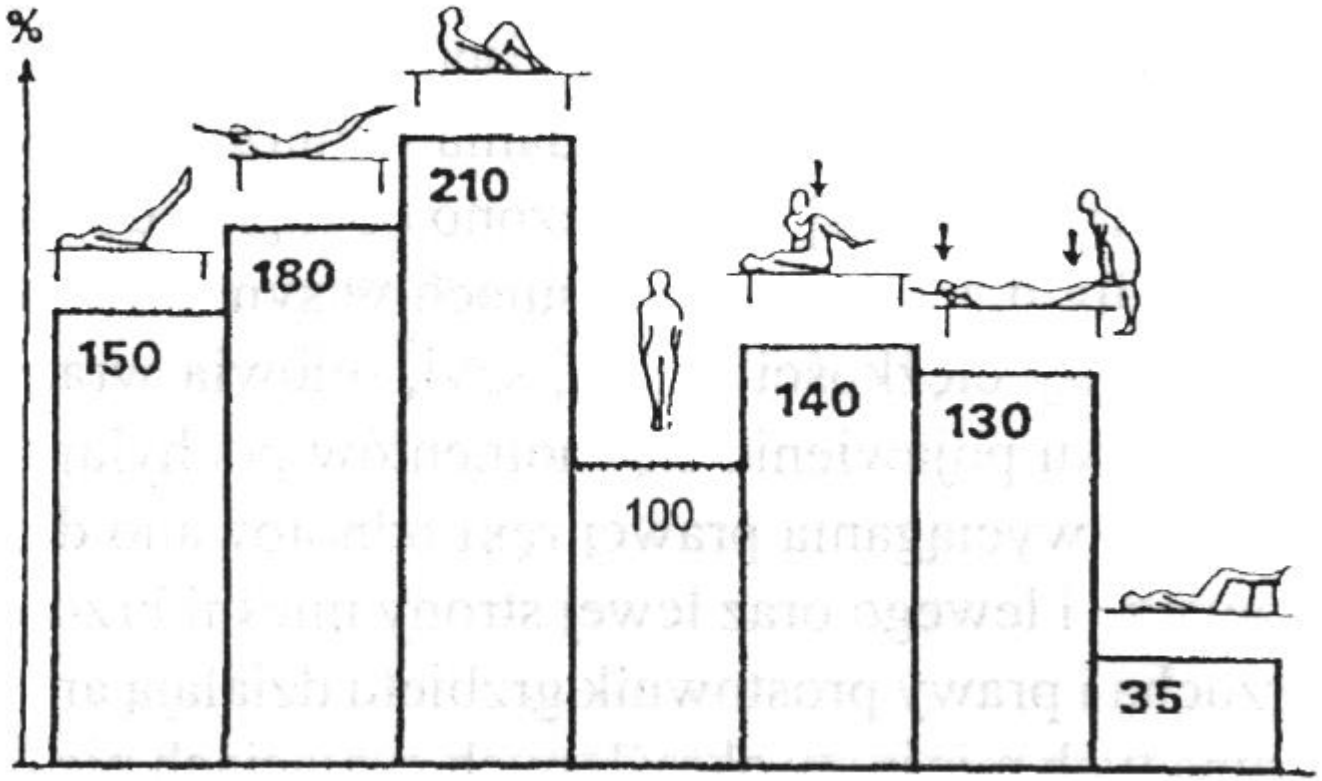


Metoda pomiaru ciśnienia w krążku *in vivo*

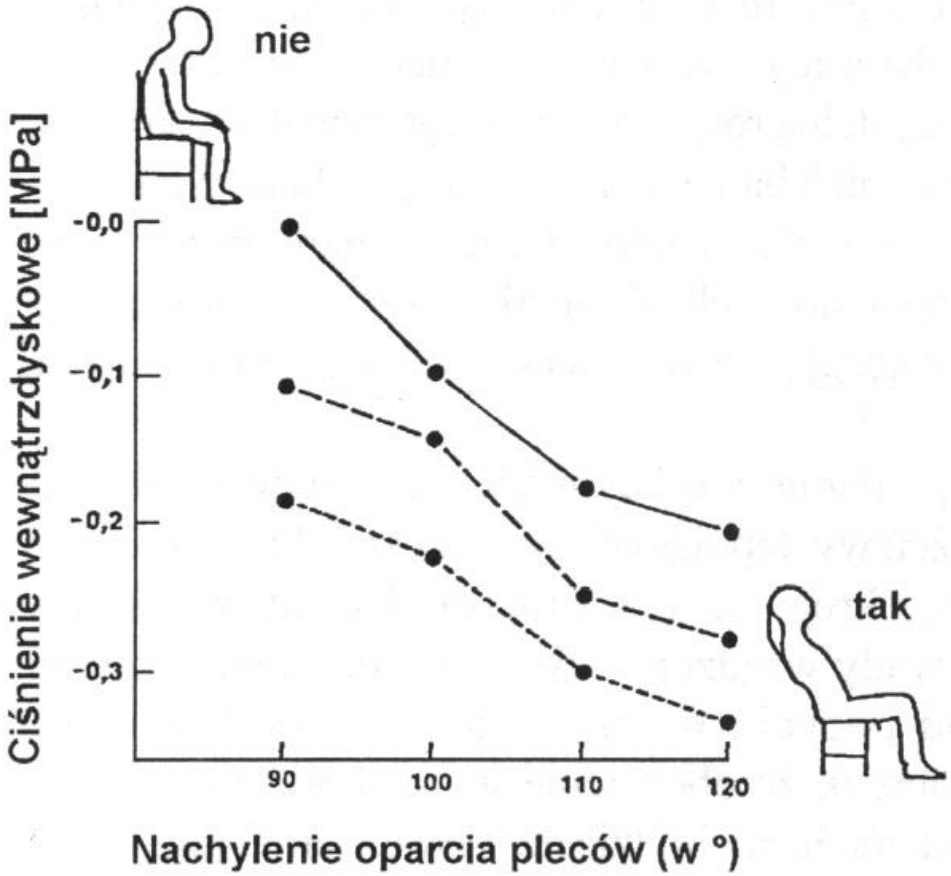




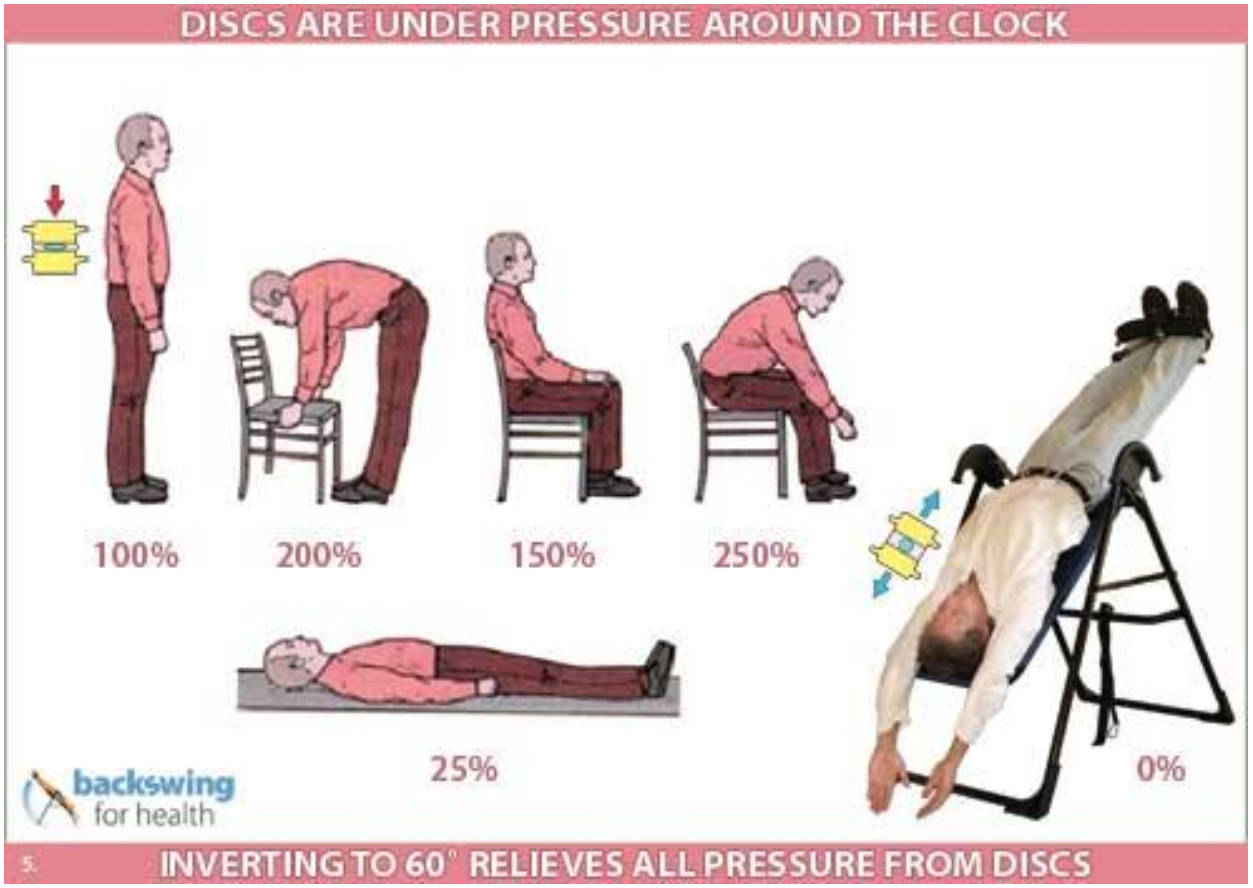
Porównanie ciśnienia w krążku L3 – L4 *in vivo* [A. Nachemson]



Wpływ zmian pochylenia pleców na zmiany ciśnienia



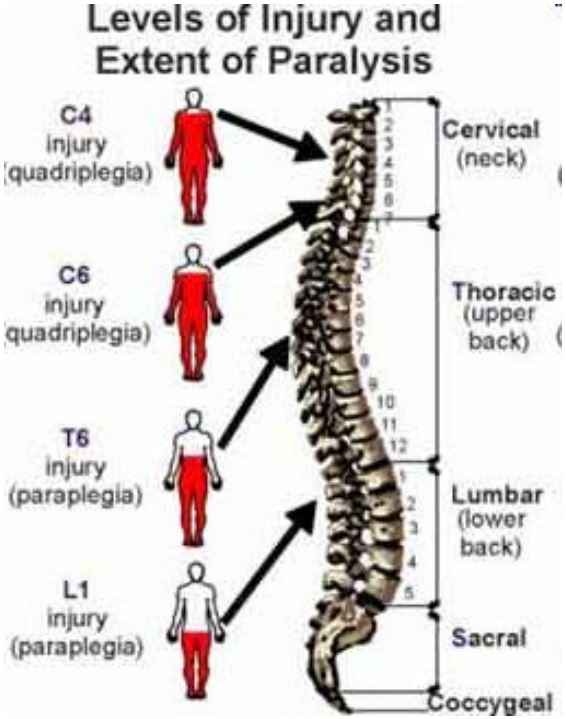
Obciążenia krążka



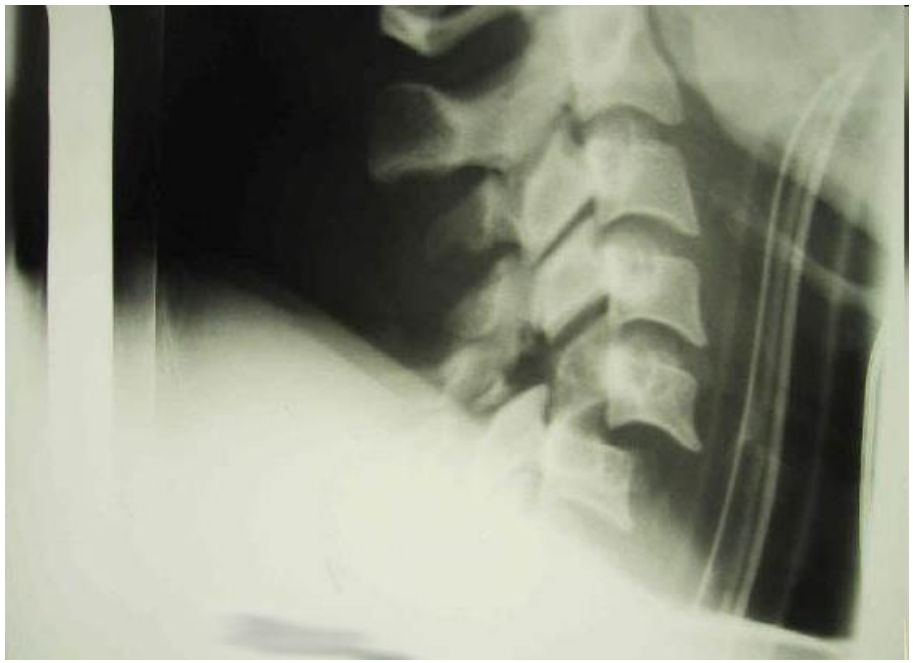
BIOMECHANIKA KRĘGOSŁUPA

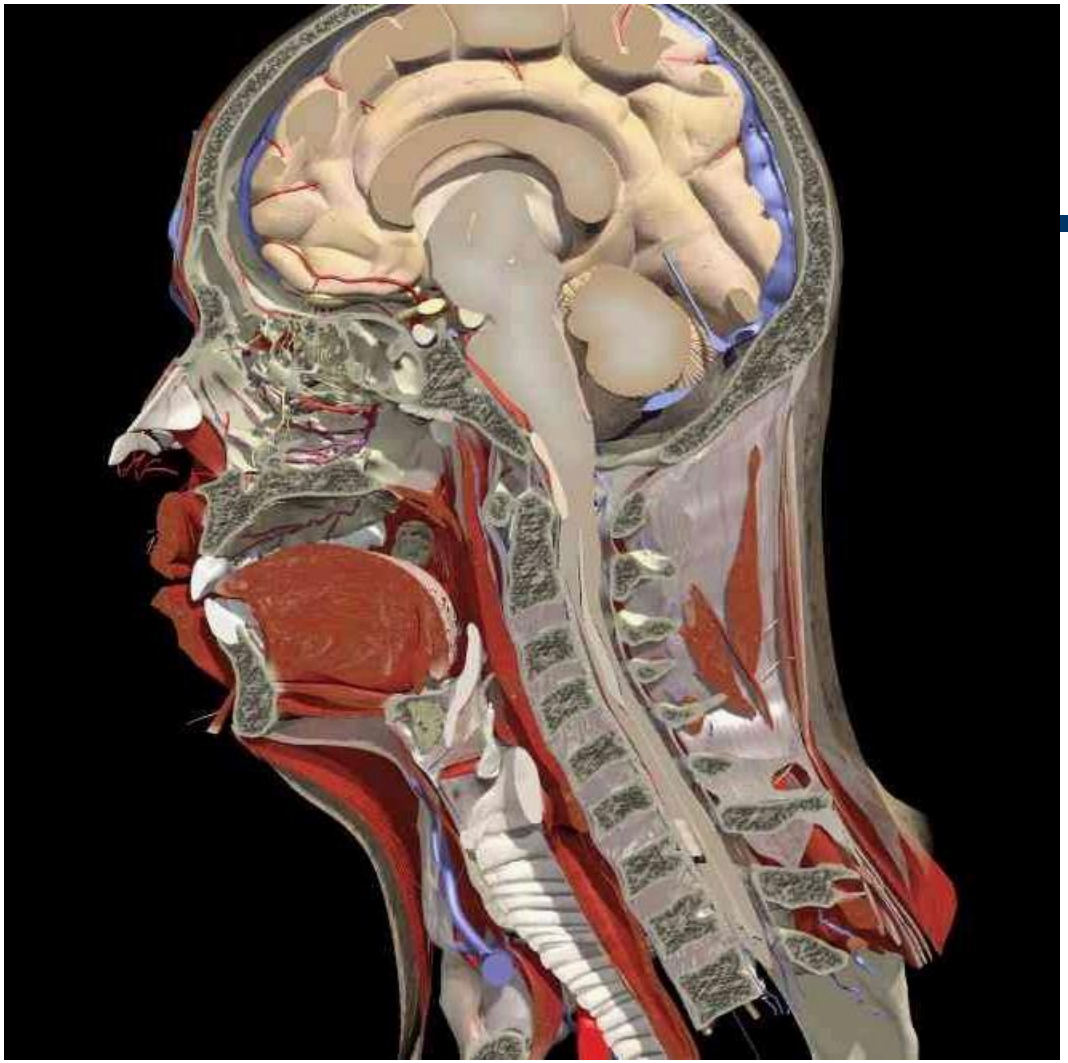
Urazy i schorzenia kręgosłupa


Quadriplegia
Paraplegia
c7
t1
LOCATION and RESULT
of SPINAL CORD INJURY

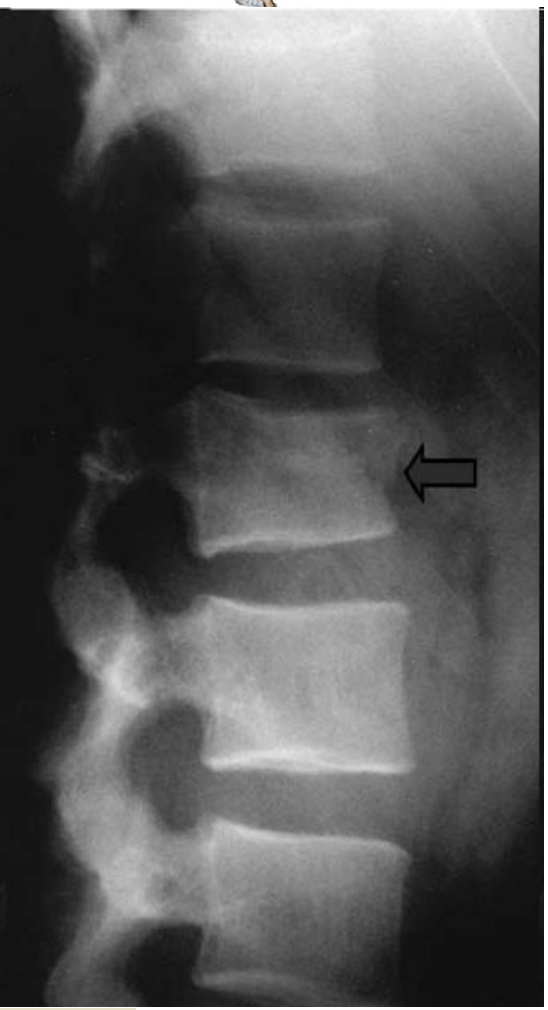

Levels of Injury and
Extent of Paralysis
C4
injury
(quadriplegia)
C6
injury
(quadriplegia)
T6
injury
(paraplegia)
L1
injury
(paraplegia)
Cervical
(neck)
Thoracic
(upper
back)
Lumbar
(lower
back)
Sacral
Coccygeal

Cervical spine injury, the patient was quadriplegic





Compression Fracture



This usually results from a hyperflexion (front to back) injury where part of the spinal column is forced forward and downward.

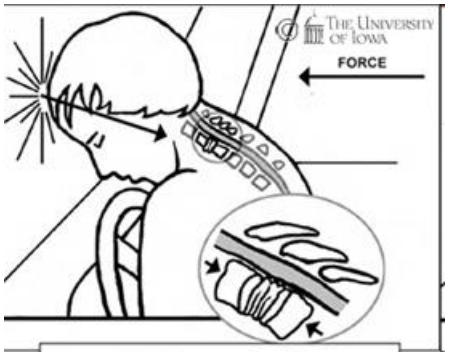


Figure 4. Compression Fracture

Burst Fracture

A burst fracture is a very serious form of compression fracture. In this type of fracture the bone is shattered from the injury. Bone fragments may pierce the spinal cord. The injury usually occurs from a downward or upward force along the spine. Burst fractures often result in serious spinal cord injury.

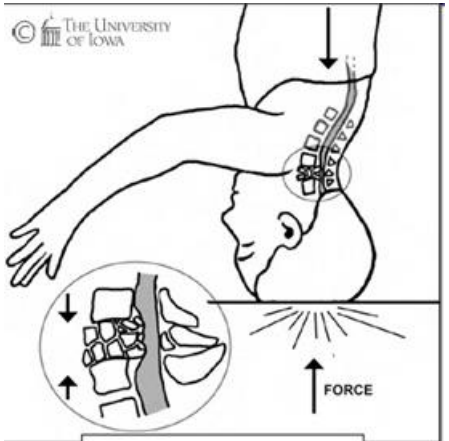


Figure 5. Burst Fracture

Subluxation

In subluxation, the joints in the back part of the vertebrae are weakened by the abnormal movement of the bones. It is a partial dislocation of the vertebrae. This happens if the muscles and ligaments in the spine are injured and may also cause injury to the spinal cord.

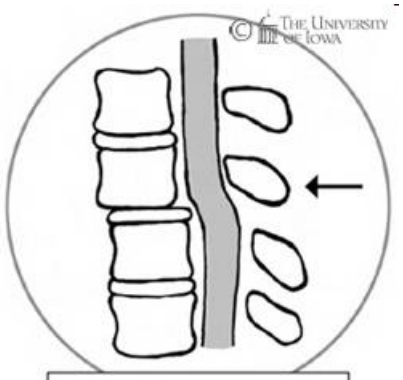


Figure 6. Subluxation

Dislocation

A dislocation also may occur when ligaments are torn or badly stretched from the injury. This allows too much movement of the vertebrae. The vertebrae may "lock" over each other on one or both sides. A spinal cord injury may occur, depending on how much extra movement is allowed by the torn ligaments. The vertebrae that are not lined up correctly are returned to a normal position by a "reduction". Traction or surgery is often required for a reduction. A brace, halo vest, or surgery to fuse the vertebrae is sometimes needed to keep the vertebrae lined up correctly.

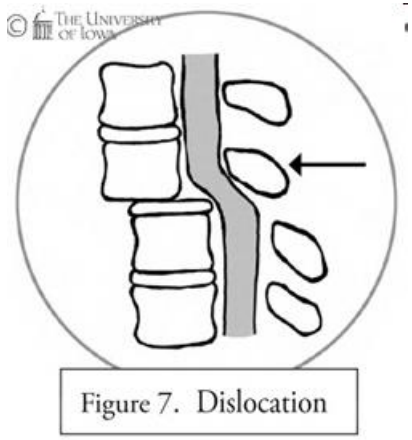


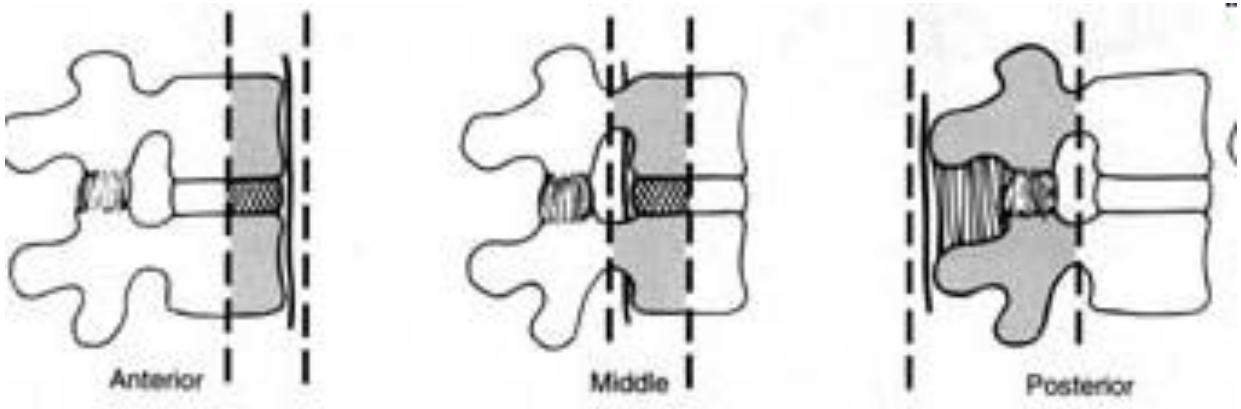
Figure 7. Dislocation

Fracture-Dislocation

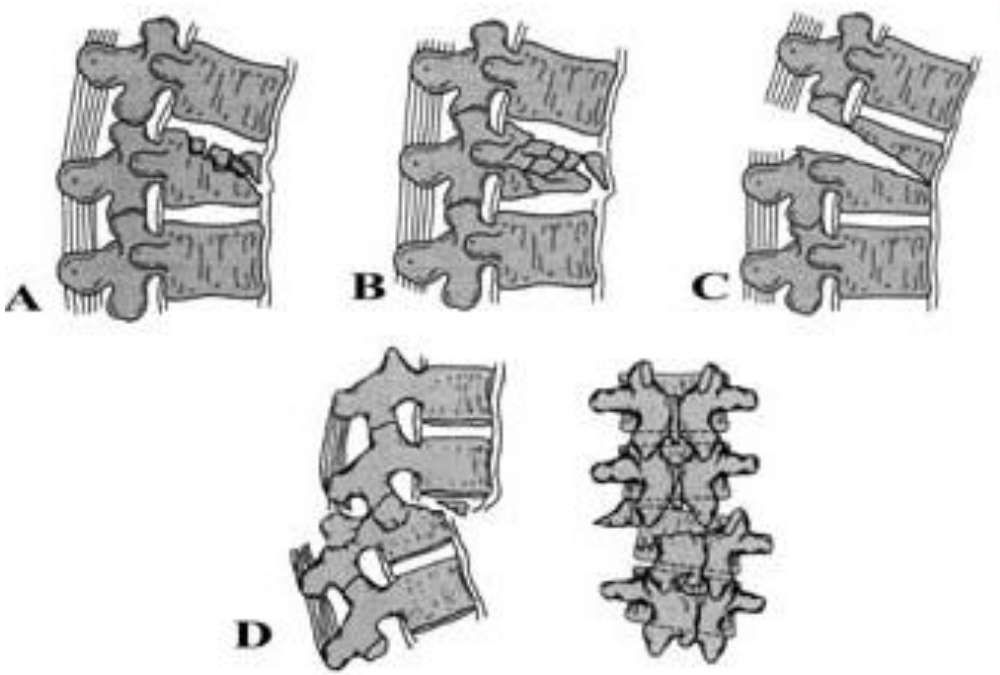
This occurs when there is a fracture and a dislocation of the vertebrae. There is usually serious ligament and soft tissue injury and this may also cause injury to the spinal cord.

Figure 8. Fracture-Dislocation

A three-column structure



Denis classification of thoracolumbar trauma



(A) Compression fracture.
(B) Burst fracture.
(C) Flexion--distraction injury.
(D) Lateral and posterior view of a fracture dislocation.

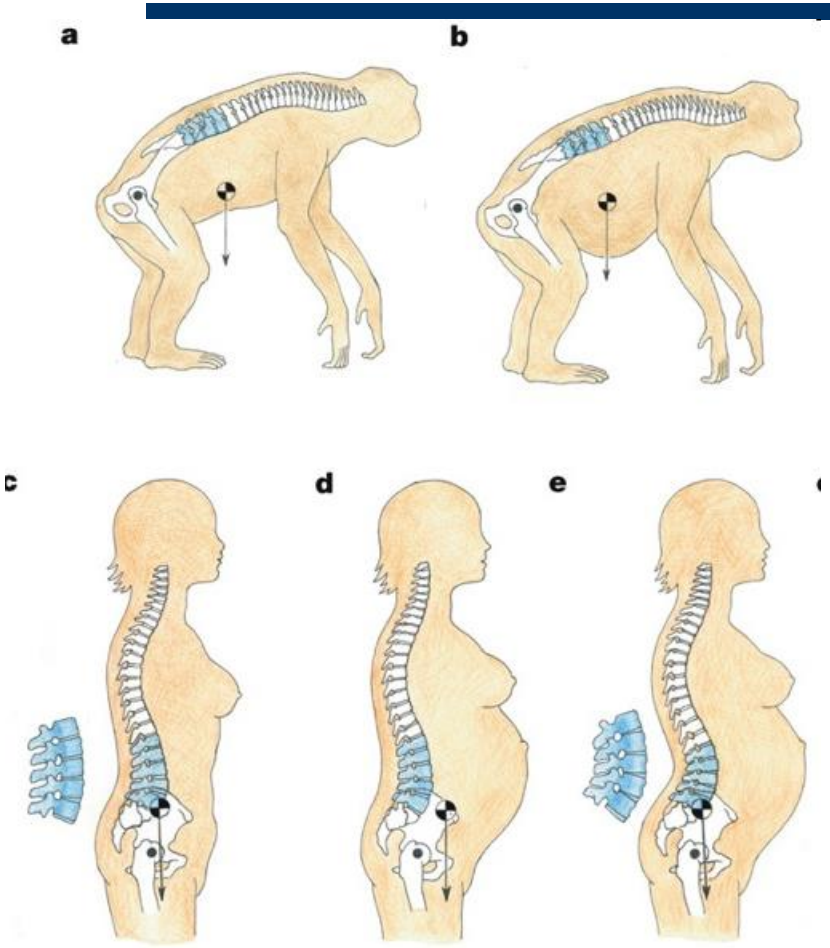
CLASSIFICATION OF LOWER CERVICAL SPINE INJURIES

A COMPRESSION INJURIES

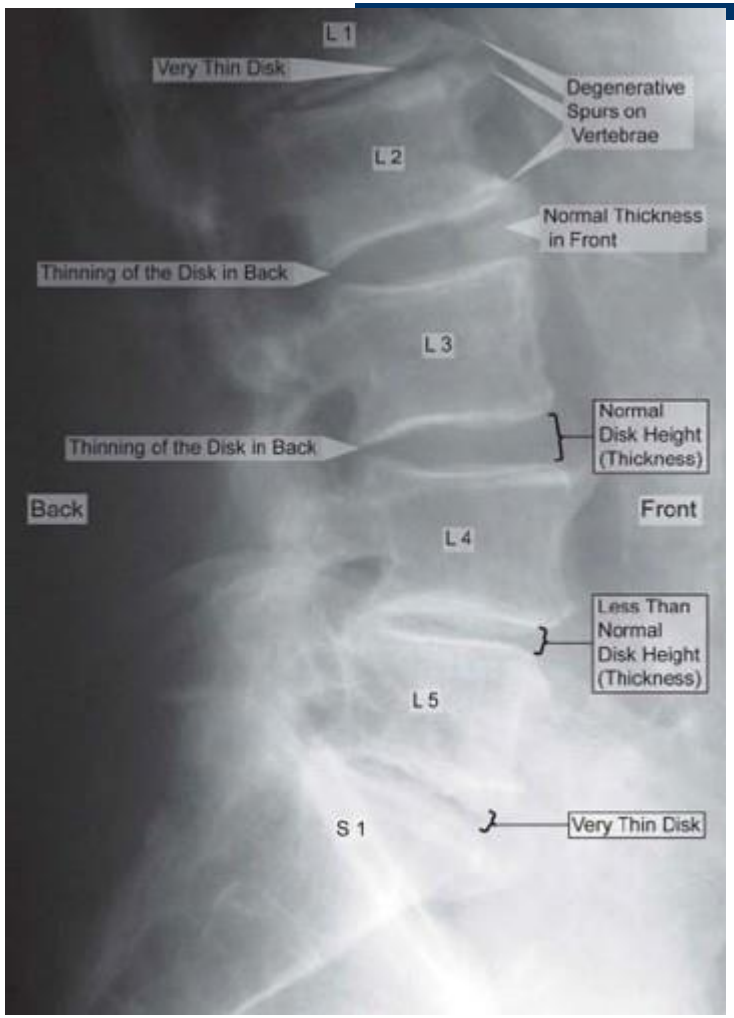
B FLEXION-EXTENSION-DISTRACTION INJURIES

C ROTATION INJURIES

Ciąża



Schorzenia kręgosłupa



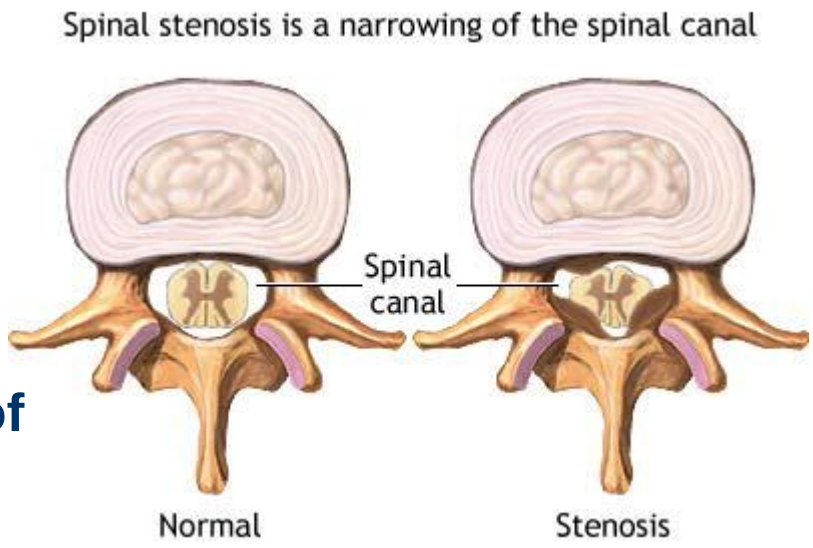
Schorzenia kręgosłupa

Dyskopatia

Intervertebral disc herniation, commonly known as a slipped or ruptured disc. A herniated disc is a painful back condition that occurs when some of the disc material in the backbone pops out of place and bulges into the spinal canal, creating pressure on the spinal cord and pain that typically goes all the way down the leg. It is also known as a herniated lumbar or ruptured disc.

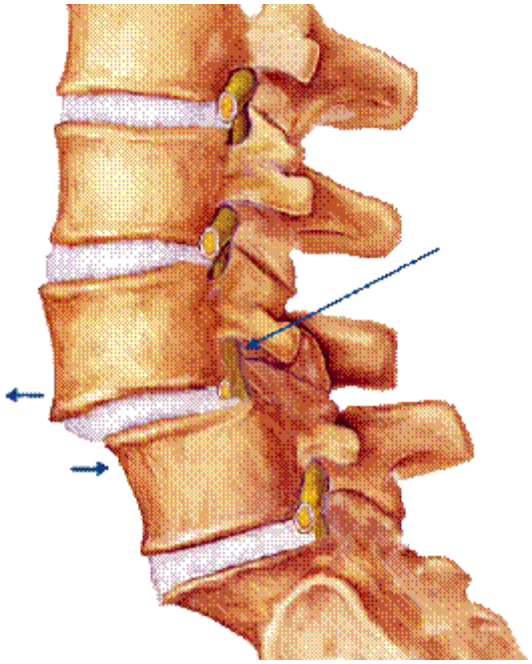
Zwężenie kanału kręgowego

Spinal Stenosis. The spinal canal runs through the vertebrae and contains the nerves supplying sensation and strength to the legs. Between the vertebrae are the intervertebral discs and the spinal facet joints. As people age, there can be a drying out and shrinking of the disc spaces between the bones (80% of the disc is made up of water). You can feel pain anywhere along your back or leg when the nerve is pressed in this way.



Kręgozmyk

Degenerative spondylolisthesis (spon-duh-low-lis-thee-sis) is a condition in which a vertebra in the spine slips forward out of alignment. It is caused by degeneration of both the disc and the facet joint, which allows the vertebra to move out of place.



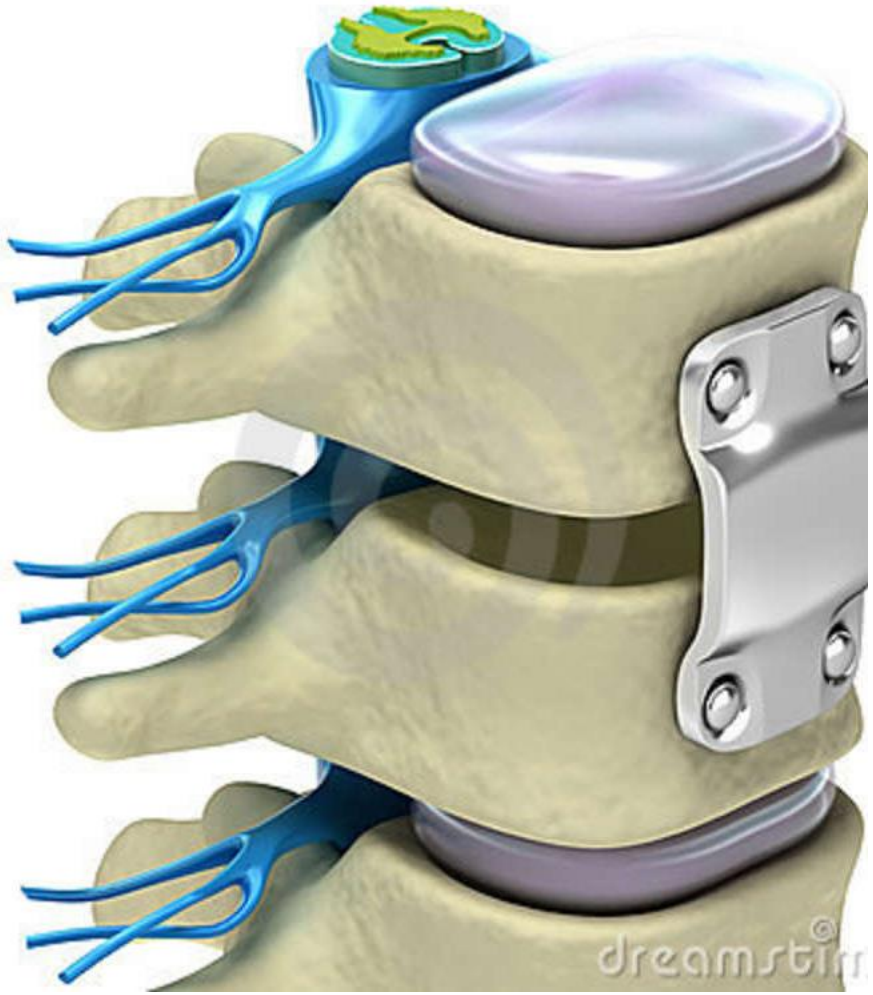
Spinal Fixation System (Titannium)

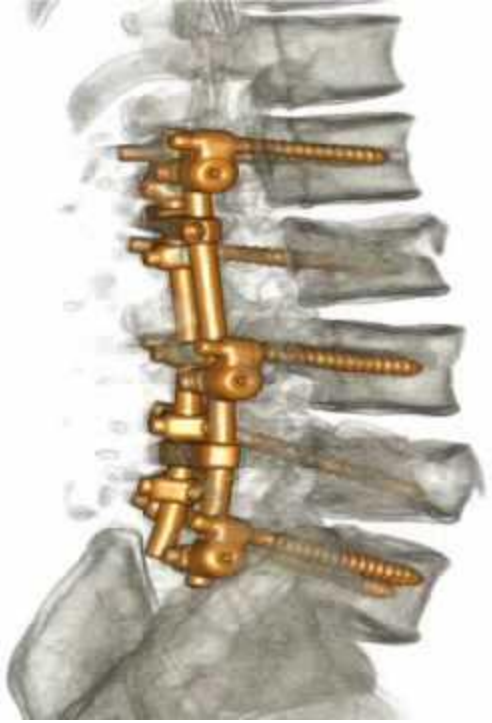
Thoracic Plates

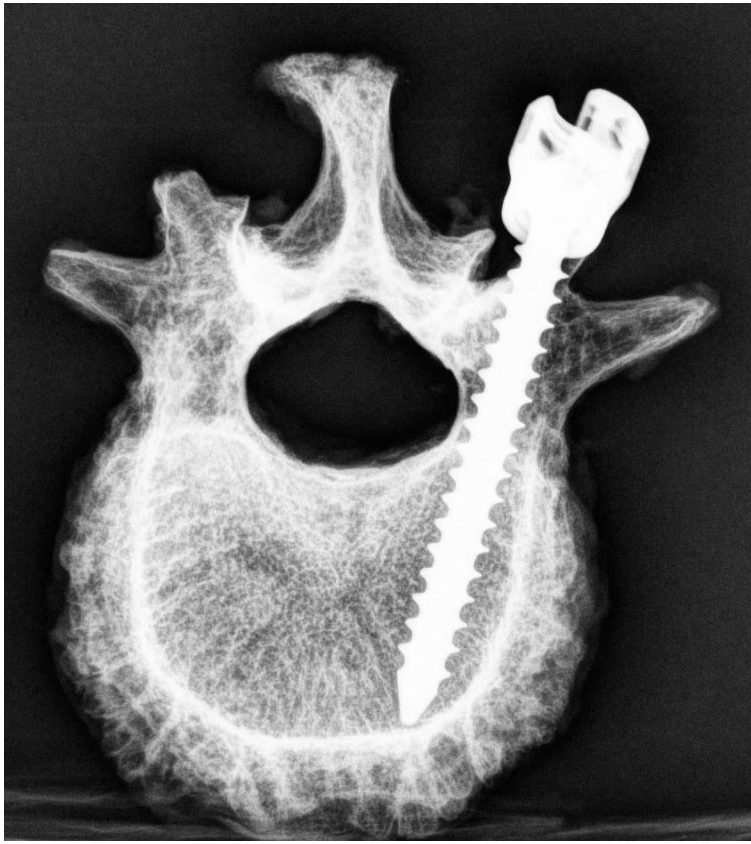
Spinal Fixation System

Optima® ZS Spinal Fixation System

Blackstone Spinal Fixation System

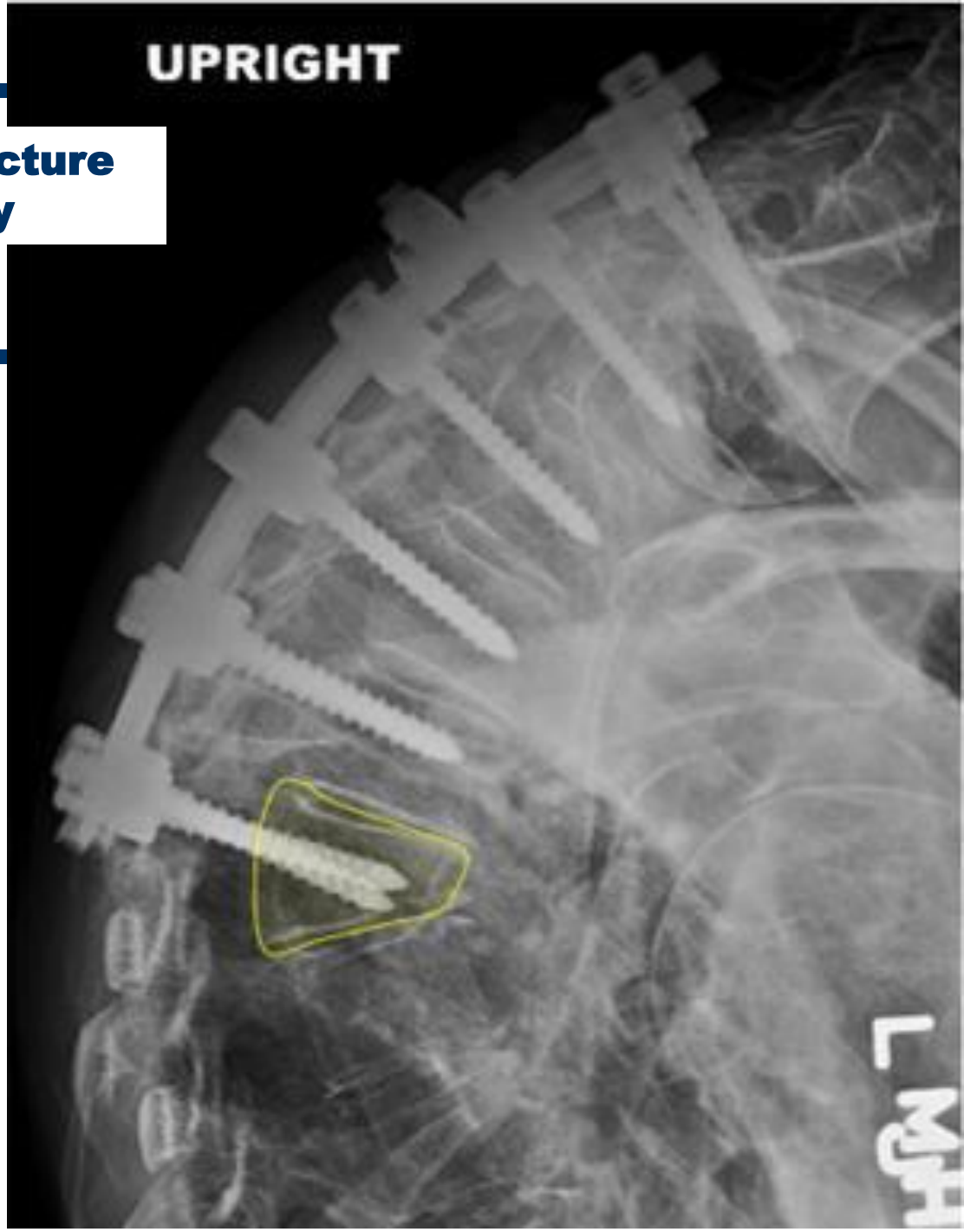

dreamstime





Fusion cage

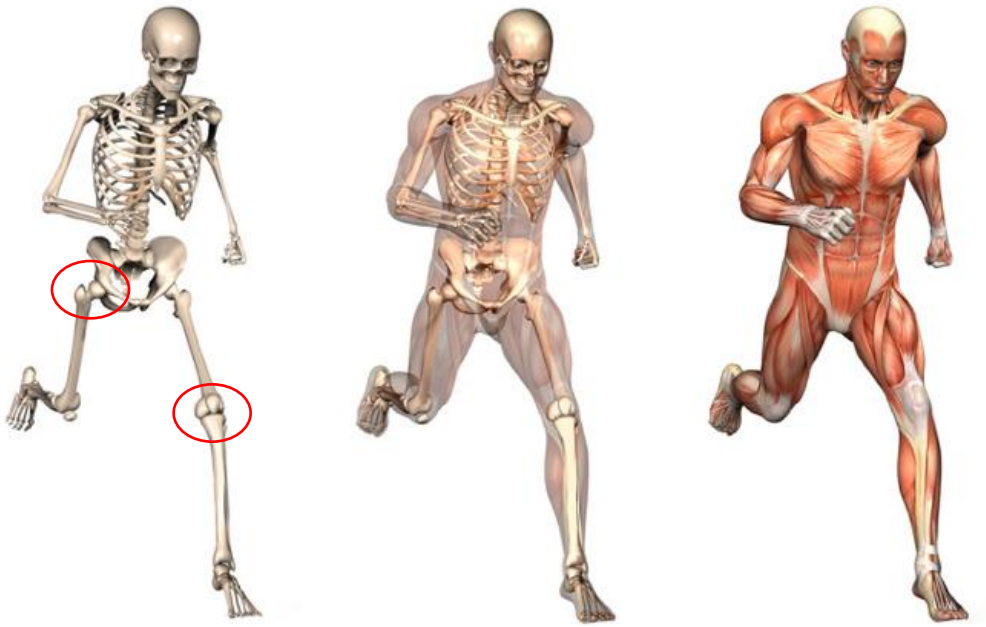
An X-ray of a compression fracture following spinal fusion surgery



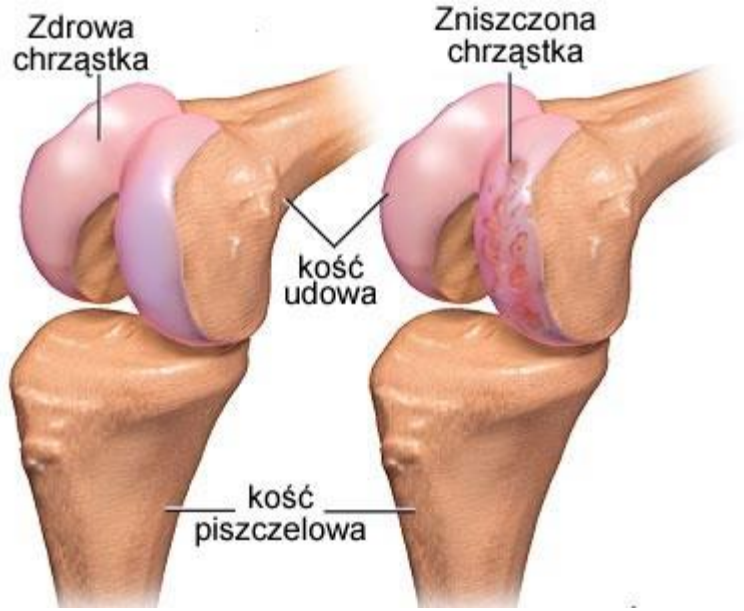
BIOMECHANIKA KRĘGOSŁUPA

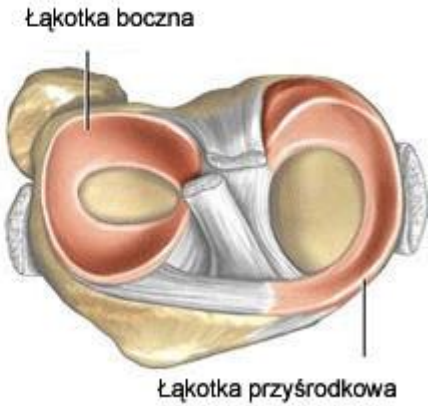
Ograniczenia w poruszaniu

Słabe punkty

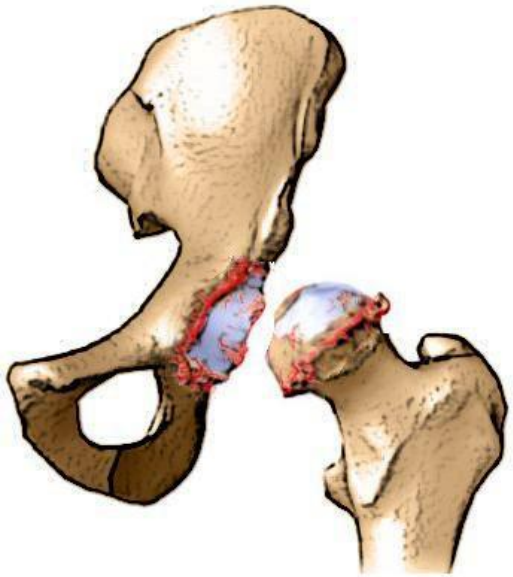


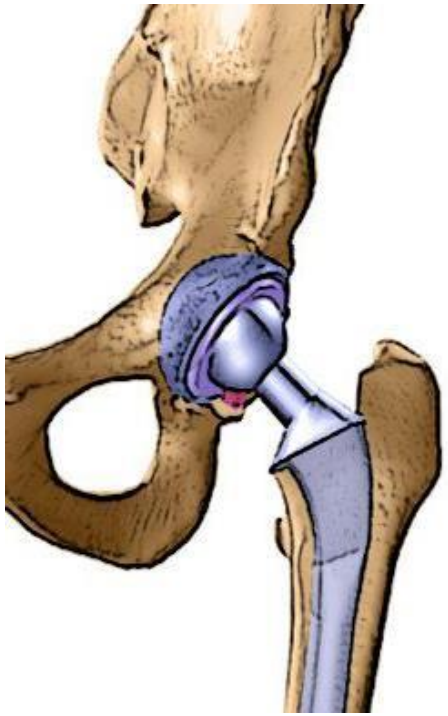
Staw kolanowy





Staw biodrowy





Ścięgno Achillesa