Biomécanique clinique du rachis lombaire

Approche systémique

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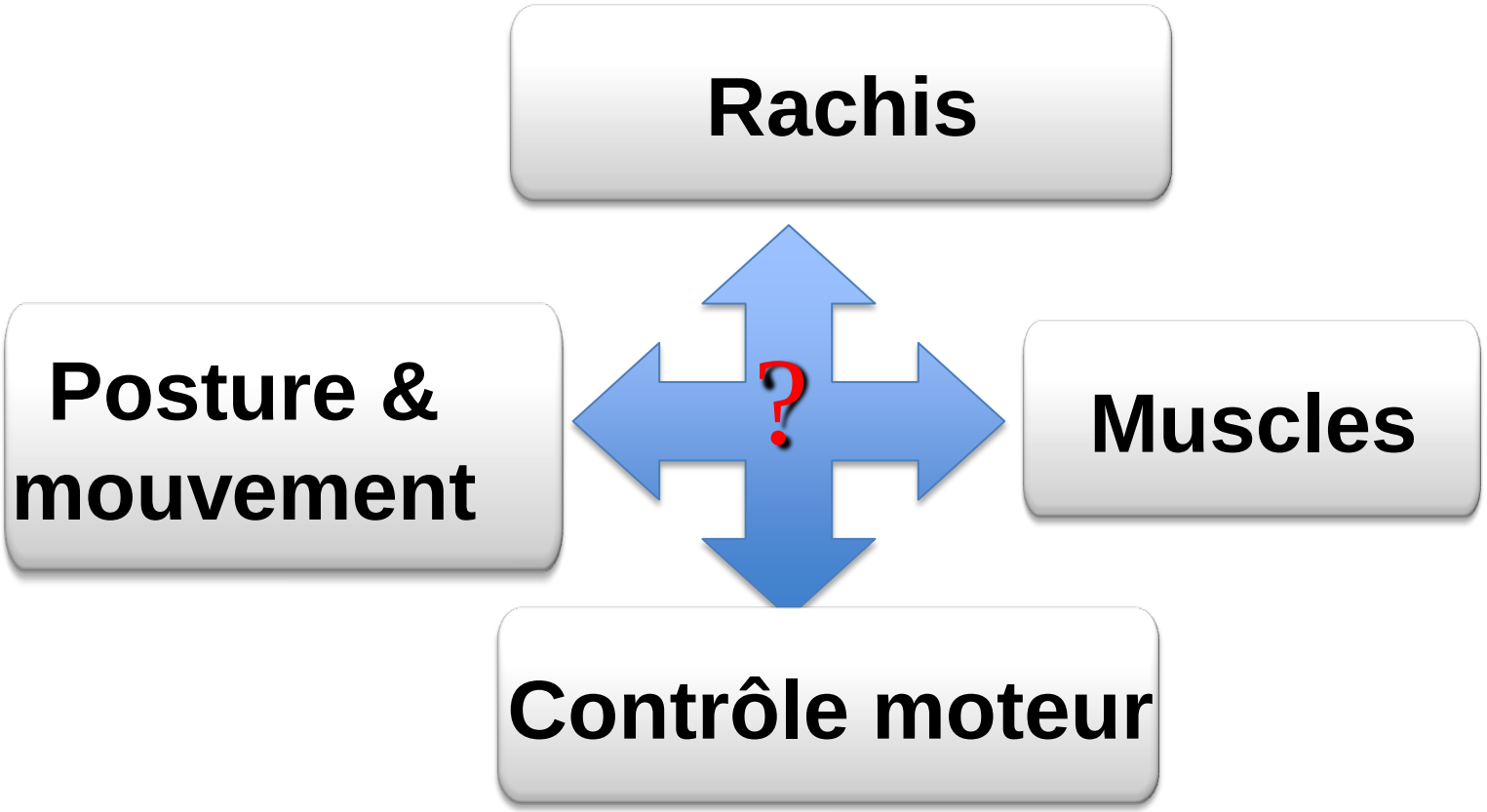
RÔLE DU RACHIS

SUPPORTER LES CHARGES MECANIQUES

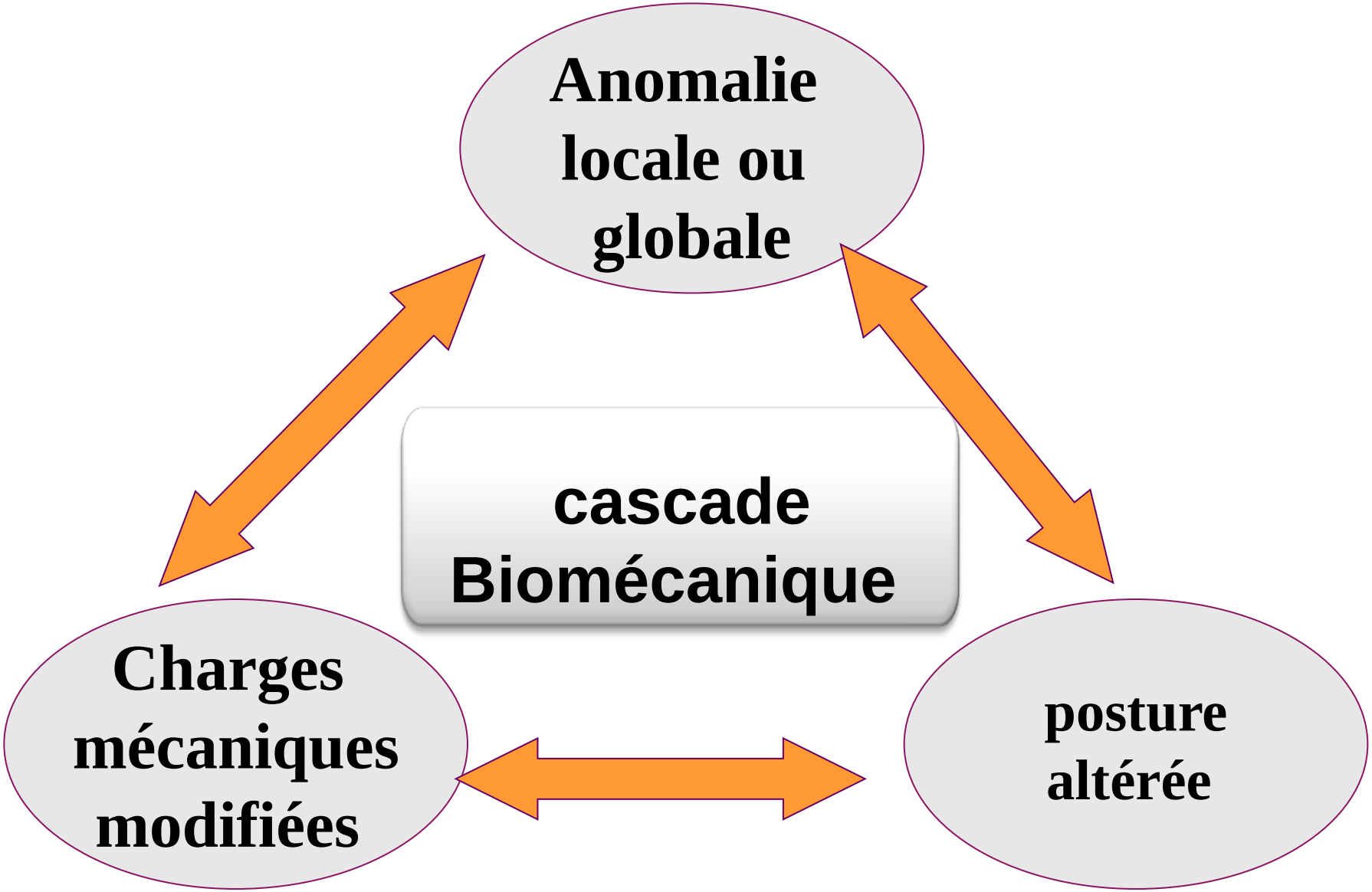
PERMETTRE LE MOUVEMENT

PRESERVER LA MOELLE EPINIERE

Biomécanique du rachis: Extrêmement complexe!



Rôle de l'ingénieur biomécanicien: observer, quantifier, modéliser


Anomalie locale ou globale
cascade Biomécanique
Charges mécaniques modifiées
posture altérée

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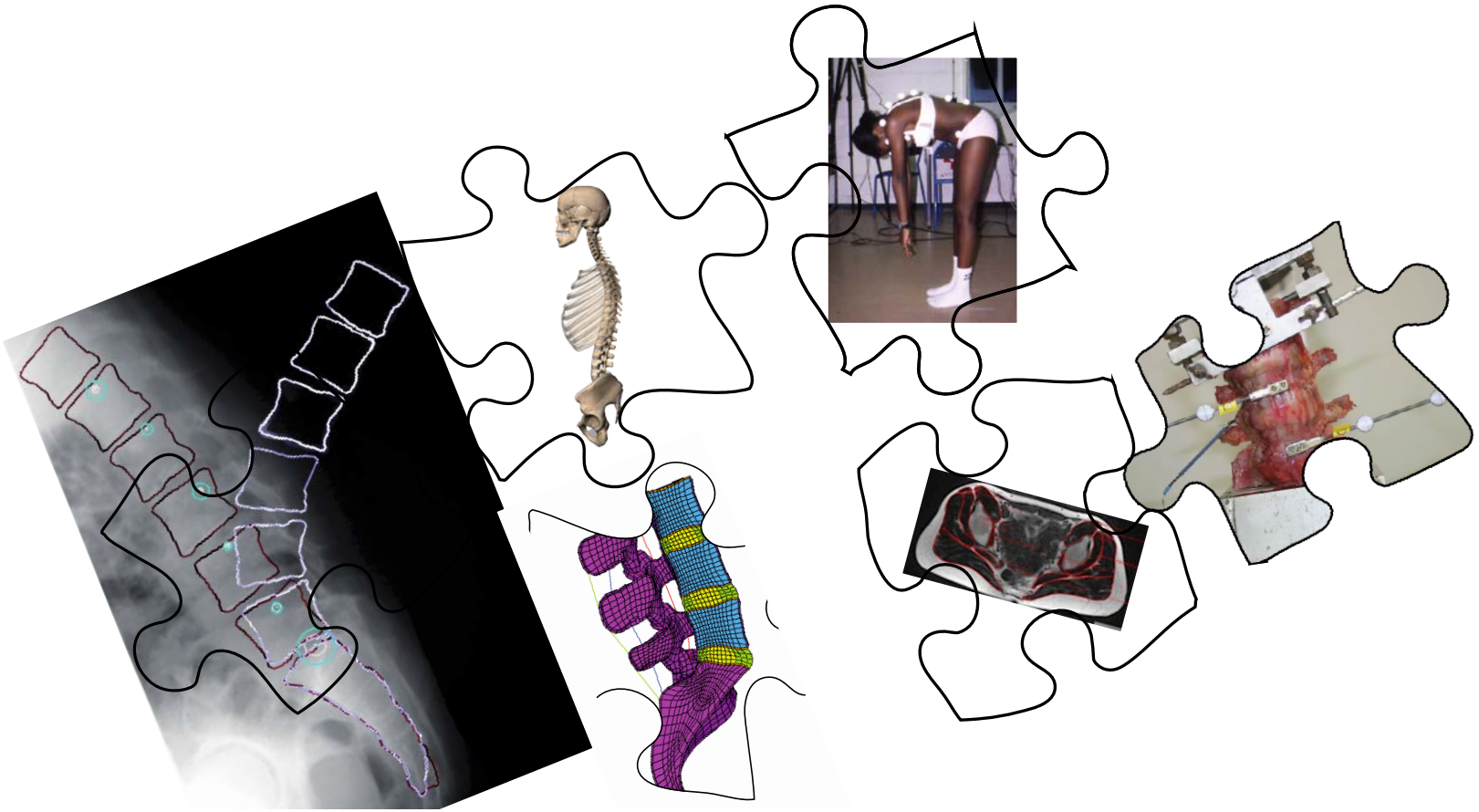
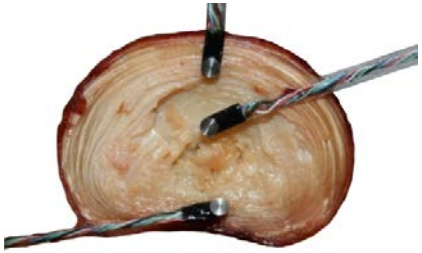
MOYENS COMPLEMENTAIRES D'EXPLORATION



EN LIEN ETROIT ENTRE INGENIEURS ET CLINICIENS

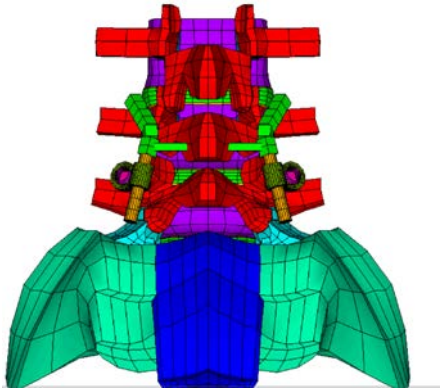
Rachis lombaire

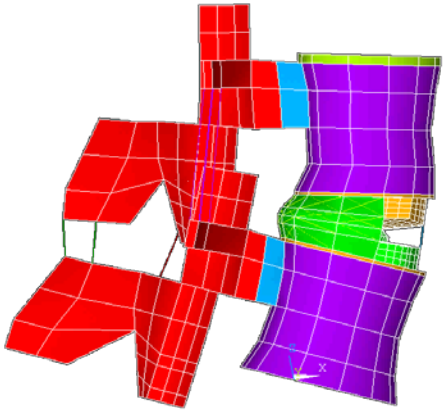


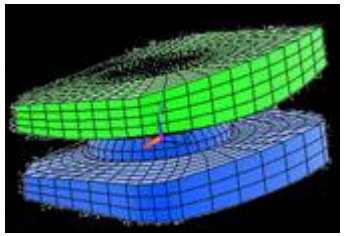
Intradiscal pressure

Facets loads

Modèles : support de réflexion



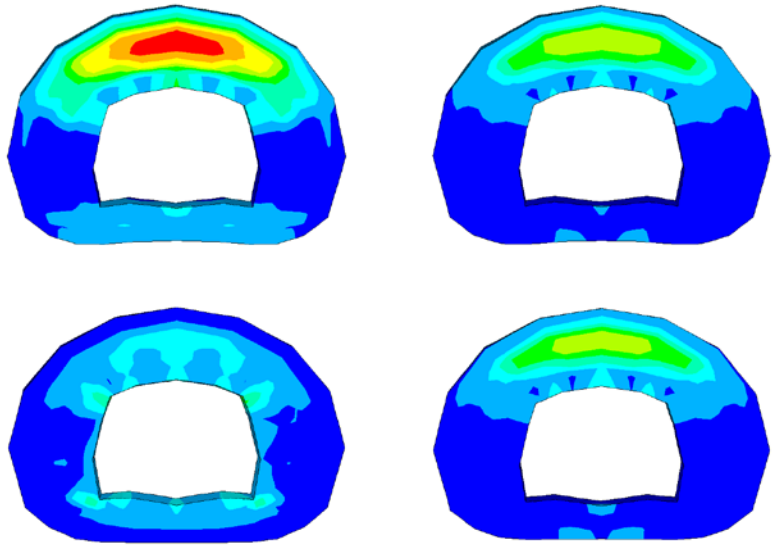




ANALYSE DES CONTRAINTES MECANIQUES DANS DIFFERENTES CONFIGURATIONS

Niveau susjacent

Niveau instrumenté

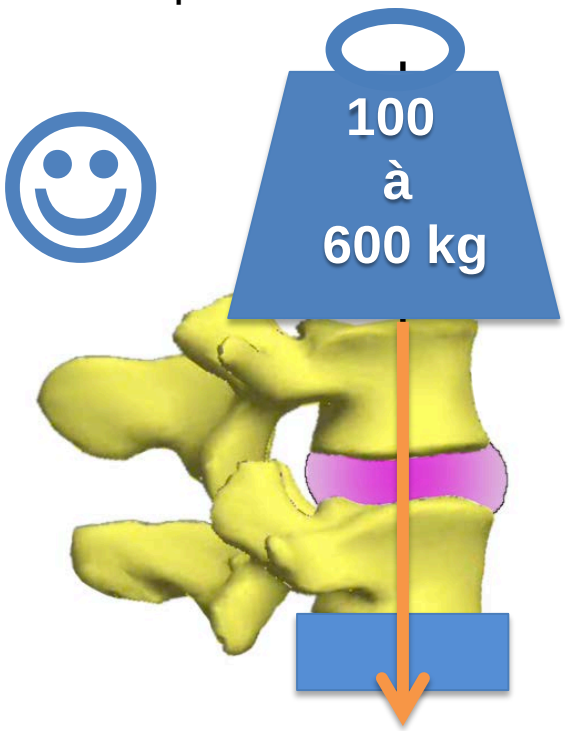


Lafage *et al.* Spine 2007, Charles et al. Spine 2013

Bases biomécaniques: limites physiologiques

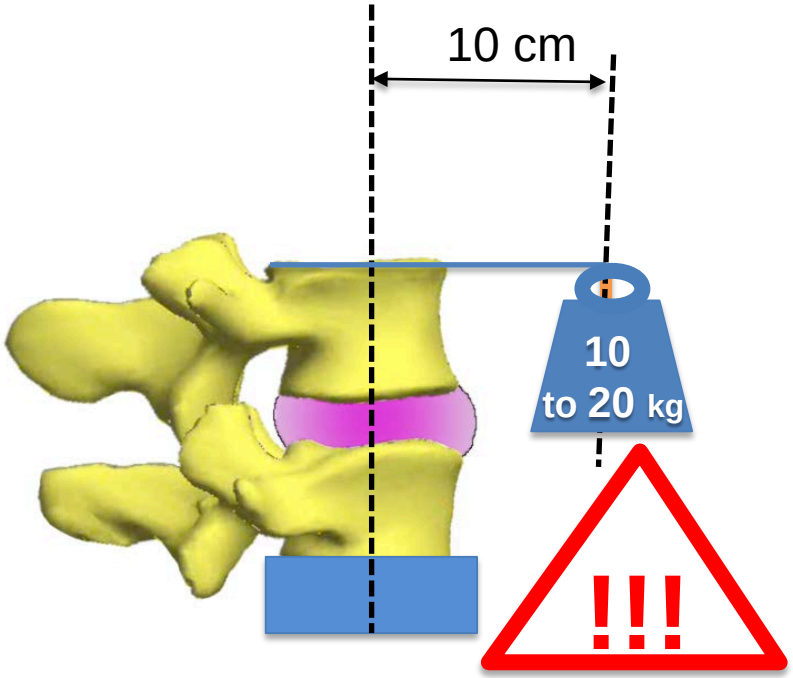
Example sur Unité fonctionnelle

Compression : 3000 à 6000 N



Nachemson 1976, Kapandji 1994, Wilke et al. 1999

Flexion, torsion : 10 à 20 Nm

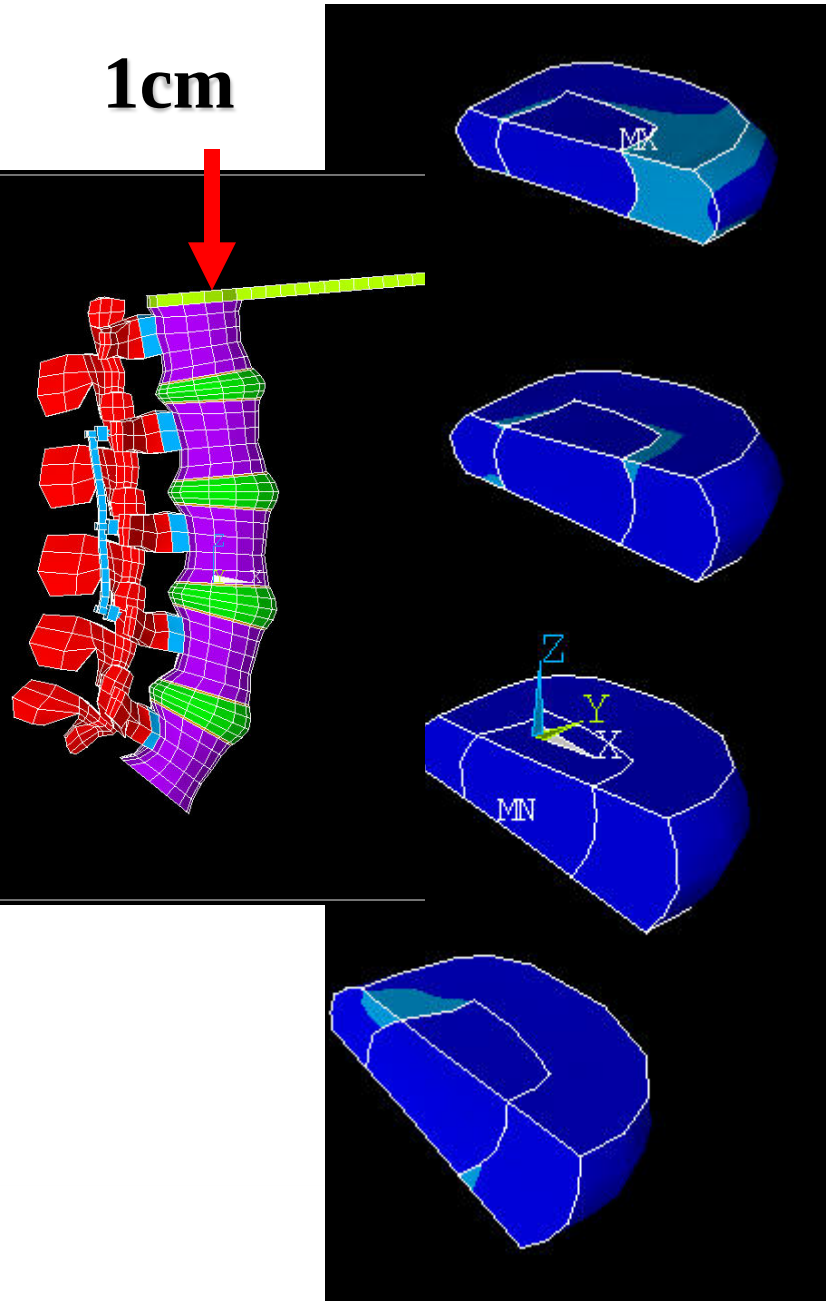


Lavaste et al. 1998

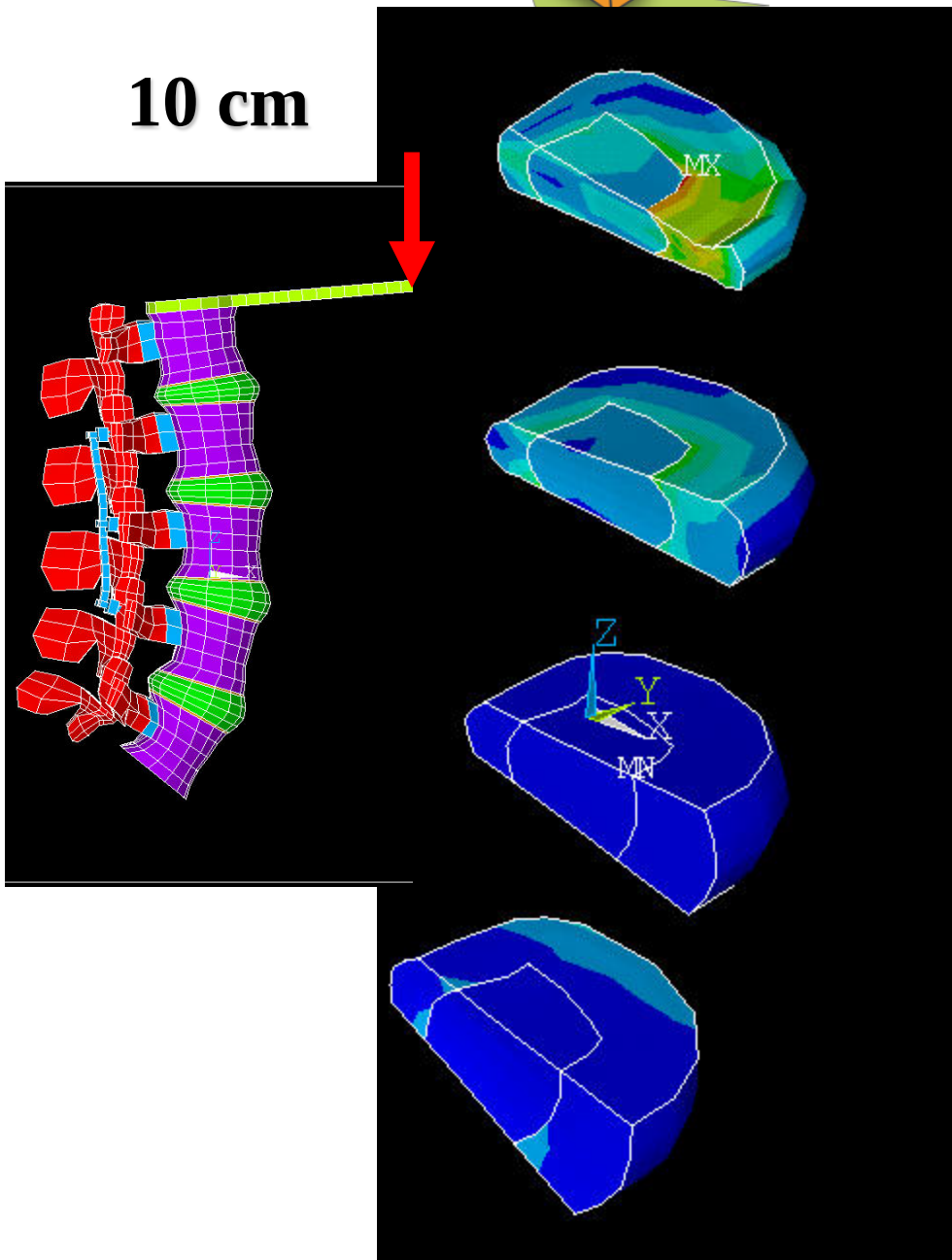
LE ROLE DES MUSCLES EST ESSENTIEL!!

Contraintes disques adjacents

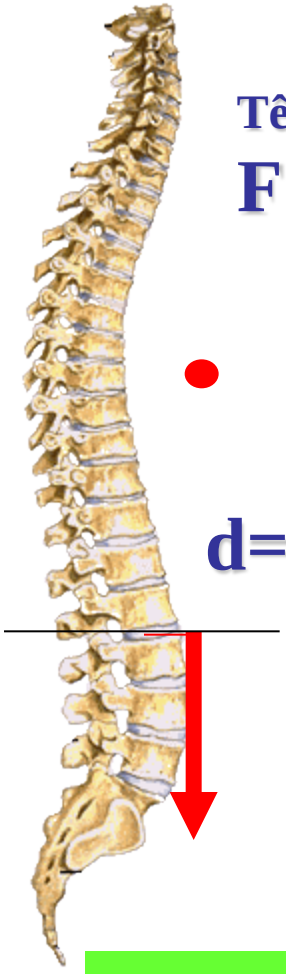
1cm



10 cm



Effet d'un trouble postural



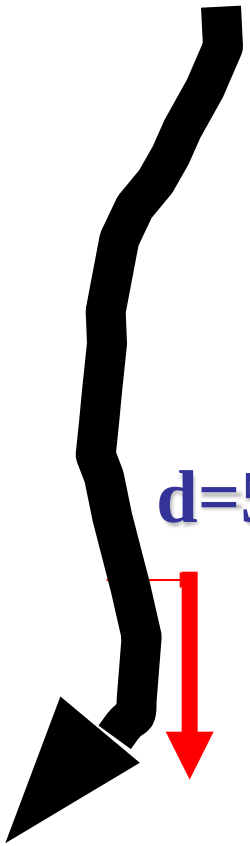
Tête + tronc

F ~ 350 N

d=1 cm

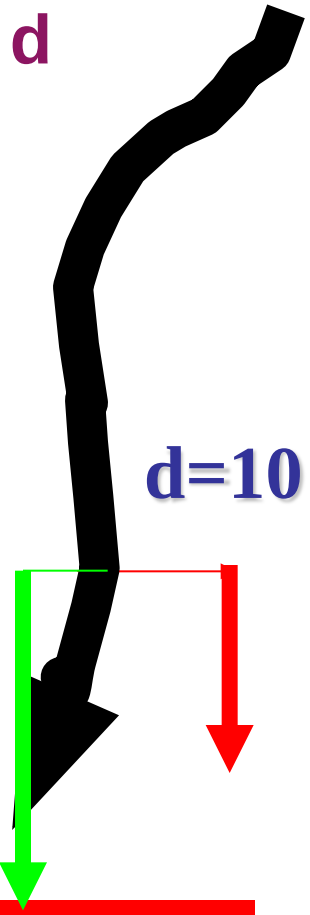
M = 3,5 Nm

M = F x d



d=5 cm

17,5 Nm

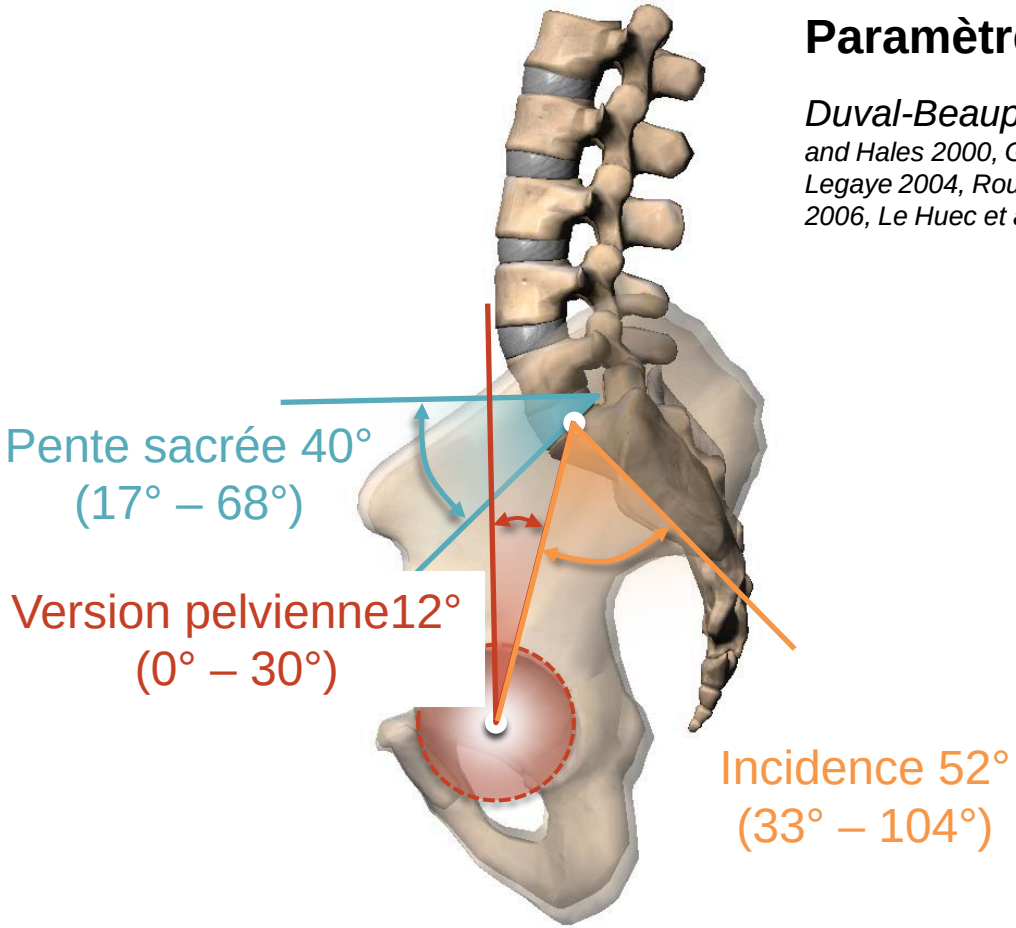


d=10 cm

35 Nm

Heureusement, nous avons des muscles !!!

Vertèbre pelvienne
Une clef pour l'ajustement postural

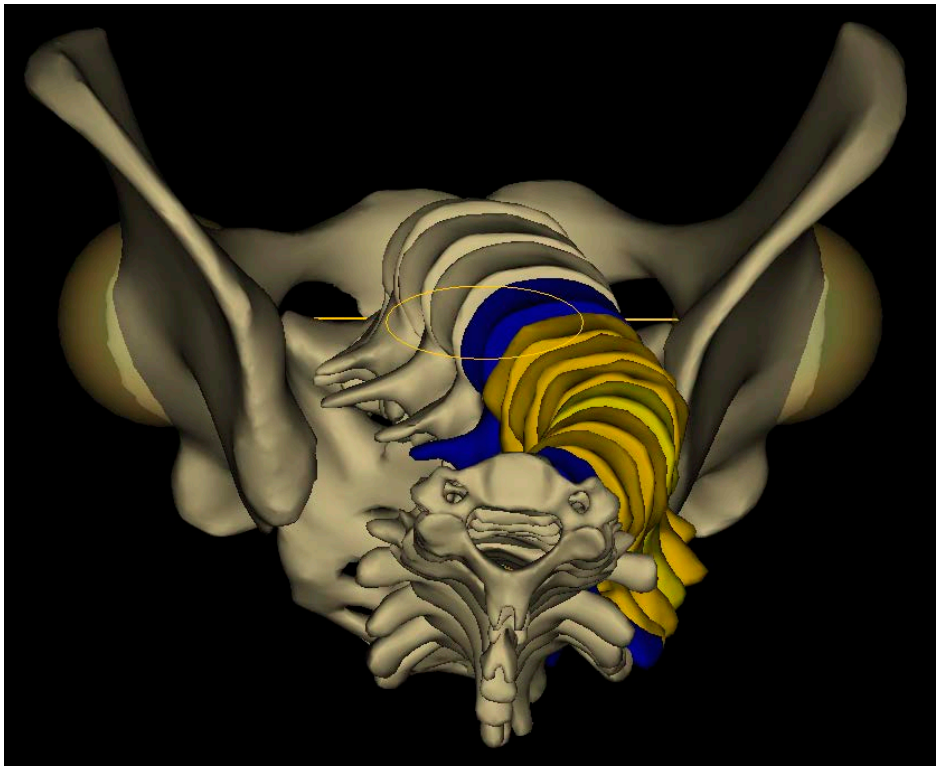


Paramètres pelviens

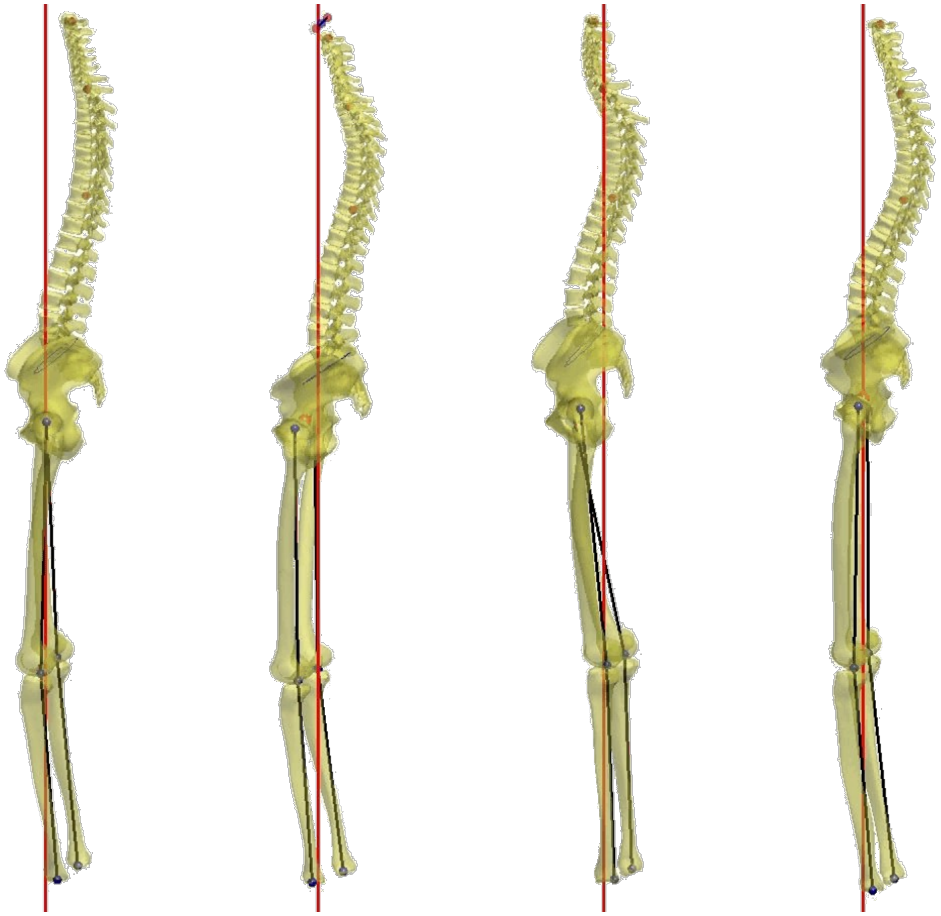
Duval-Beaupère et al. 1992, Legaye et al. 1998, Jackson and Hales 2000, Guigui and Morvan 2002, Duval-Beaupère and Legaye 2004, Roussouly et al. 2005, Vialle et al. 2005, Schwab et al. 2006, Le Huec et al. 2011

EOS: Un nouveau regard

Dubousset, Charpak, Skalli et al, 2005

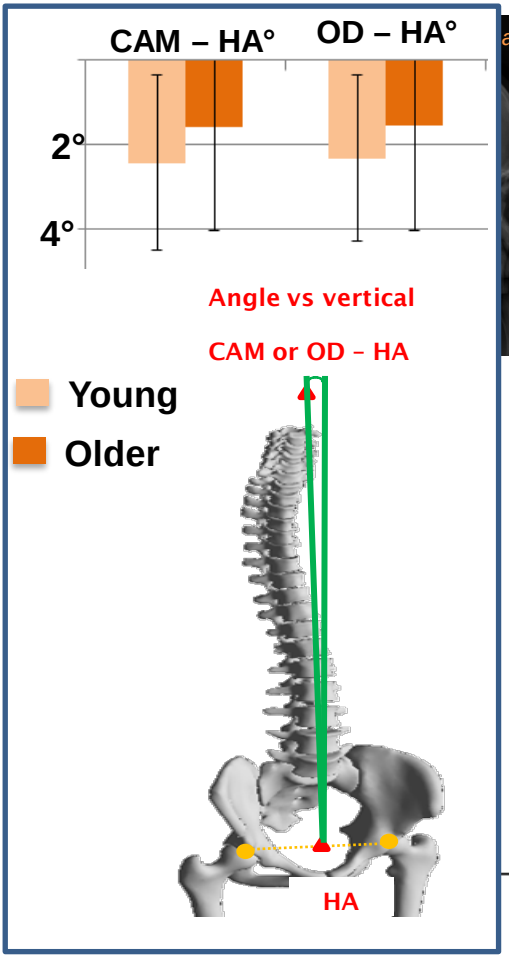


Humbert & al, Med. Eng. & Phys, 2009



Analyse quantitative de l'évolution normale et pathologique, objectivation de l'effet d'un traitement

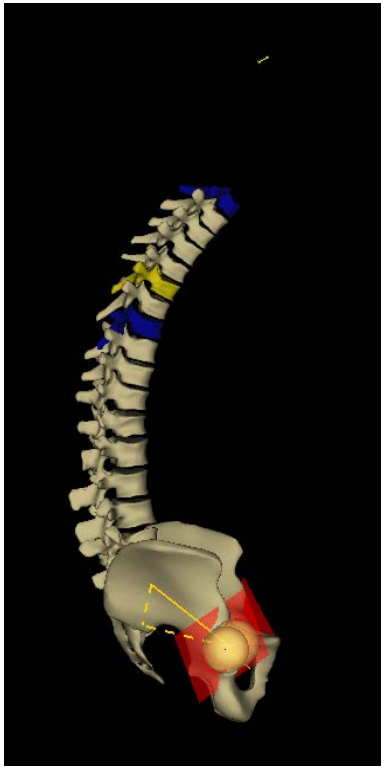
Un invariant: “Tête au dessus du bassin”



chez le sujet vieillissant
Amabile et al. ESJ 2018

Avant après chirurgie de scoliose
Alzakri et al. (en révision)

Entre pleine inspiration et pleine expiration Attali et al (soumis)



MECANISMES DE COMPENSATION
(Très variable!)

Rachis lombaire,
rachis cervical,
rétroversion pelvienne
Membres inférieurs

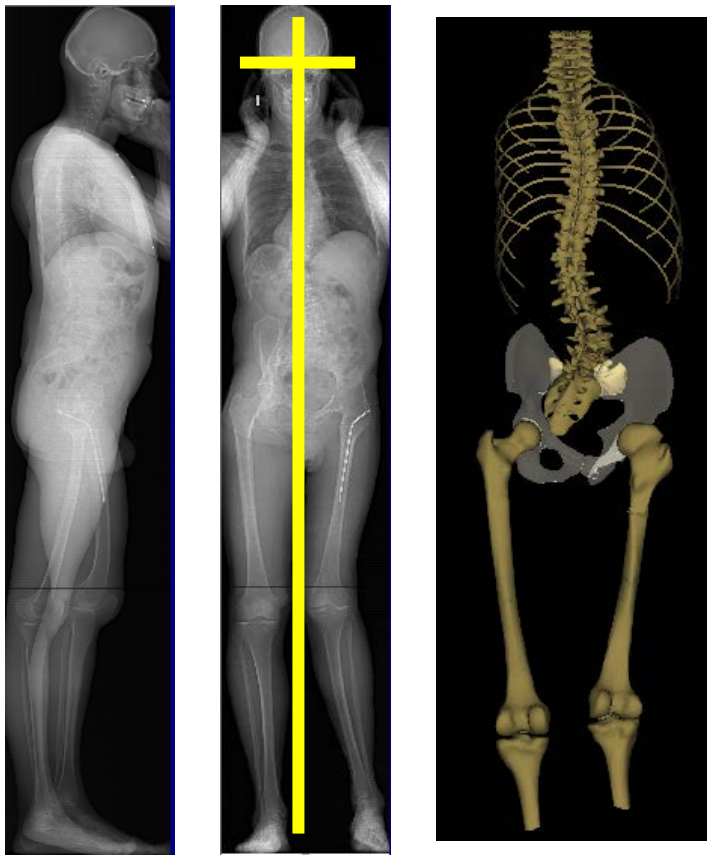
A new quasi-invariant parameter characterizing the postural alignment of young asymptomatic adults

Celia Amabile[1,2] · Hélène Pillet[1] · Virginie Lafage[2] · Cédric Barrey[1,3] · Jean-Marc Vital[4] · Wafa Skalli[1]

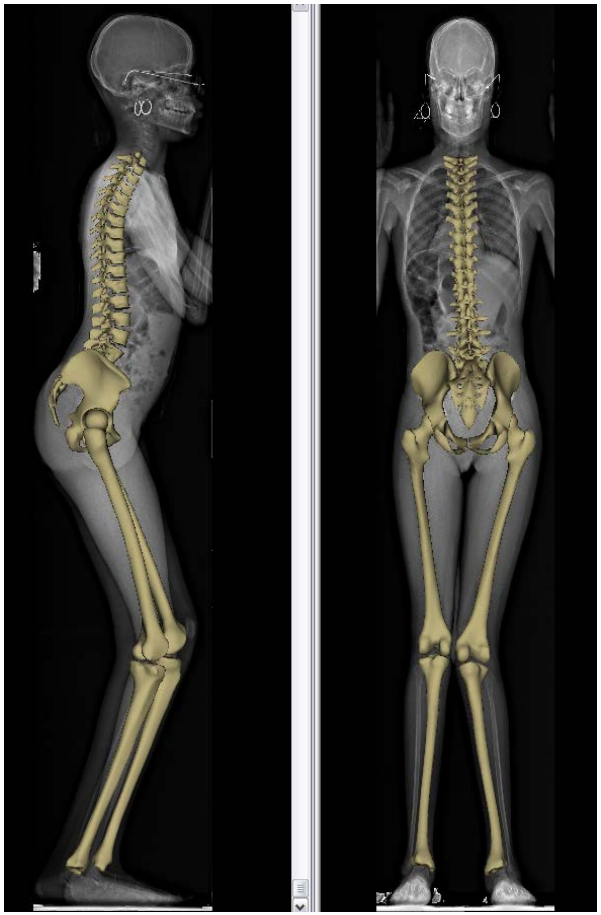
Confirmé sur plus de 300 sujets

Steffen et al. 2009, Amabile et al, 2016, 2018

Adaptation et remodelage osseux

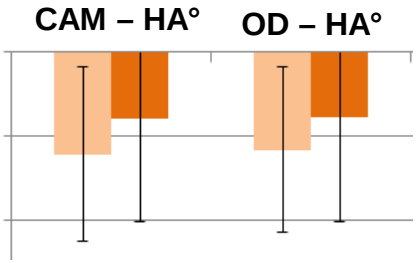


Arthrodèse de hanche après ostéotomie à 5 ans

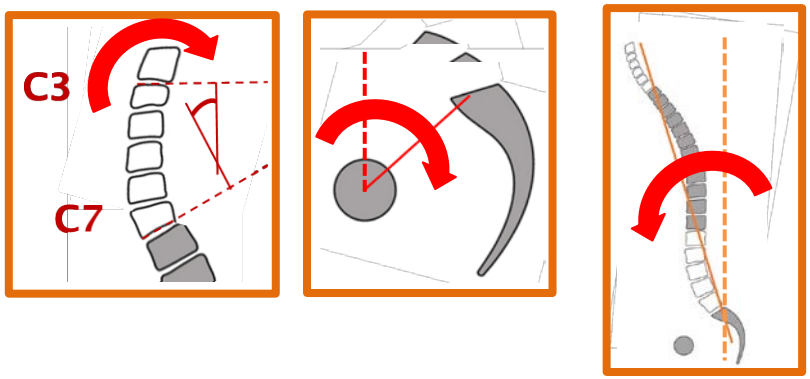


Mécanismes de compensation Pour le sujet âgé

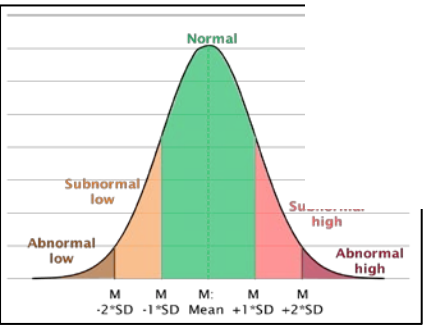
Amabile et al, ESJ 2018



Repartition of values for elderly:
% of abnormal / subnormal / normal values

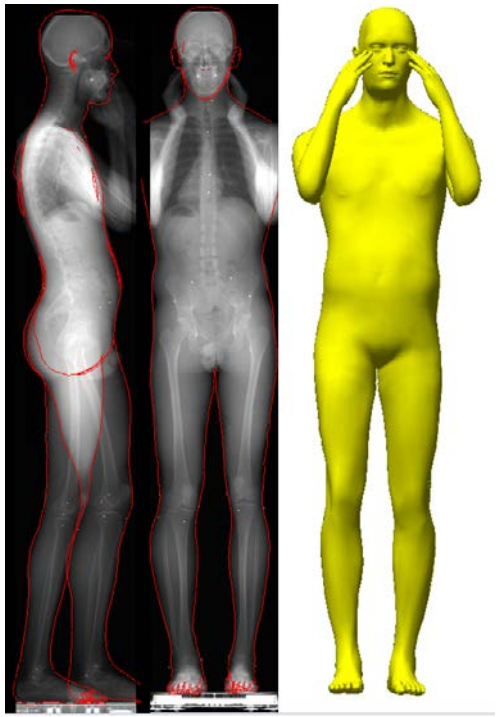


Par rapport à une cohorte de sujets jeunes



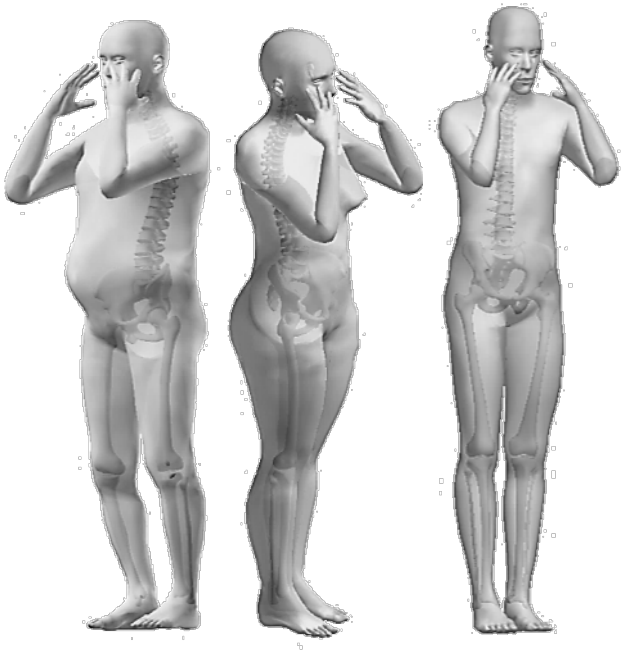
Sp

Evolution récente: barycentremétrie EOS



Reconstruction précise de l'enveloppe externe

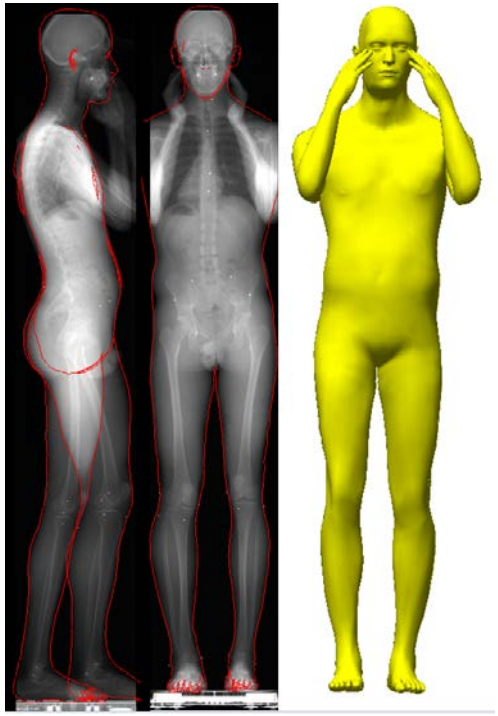
Nerot, Rouch P, Skalli W.
J. Biomech 2015



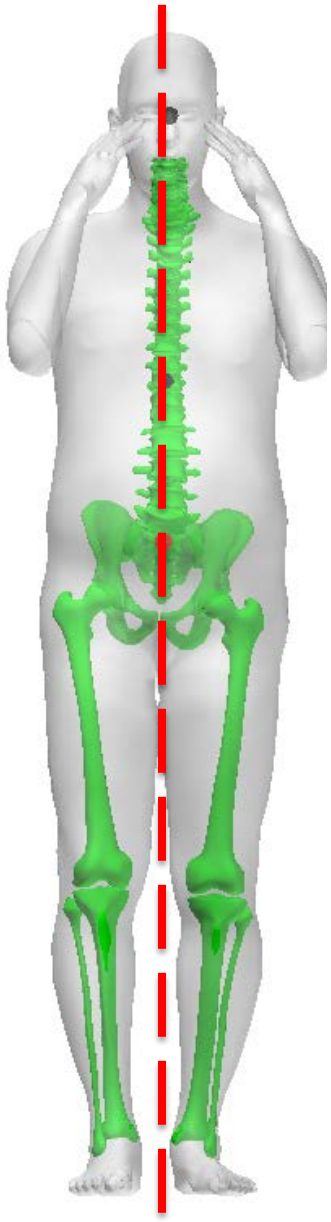
Volume personnalisé
de chaque segment
+ modèle de densité

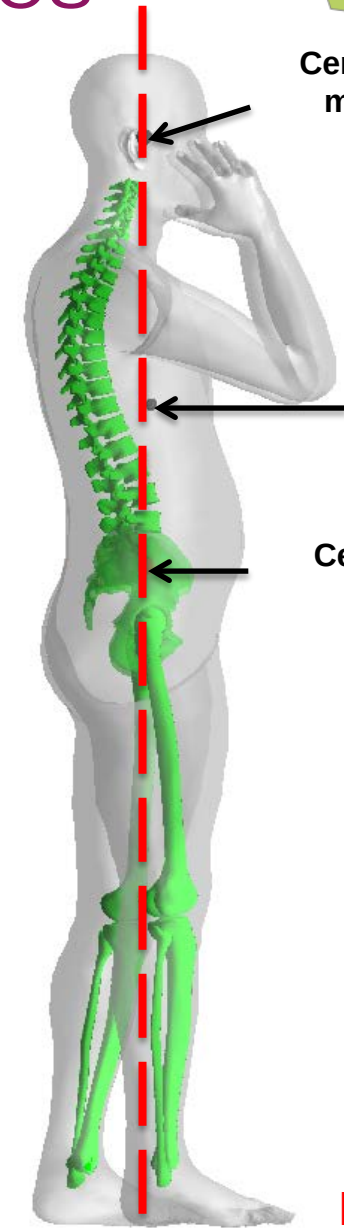
Masse et centre de masse de chaque segment corporel

Evolution récente: barycentremétrie EOS



Sans plateforme additionnelle





Centre de masse tête

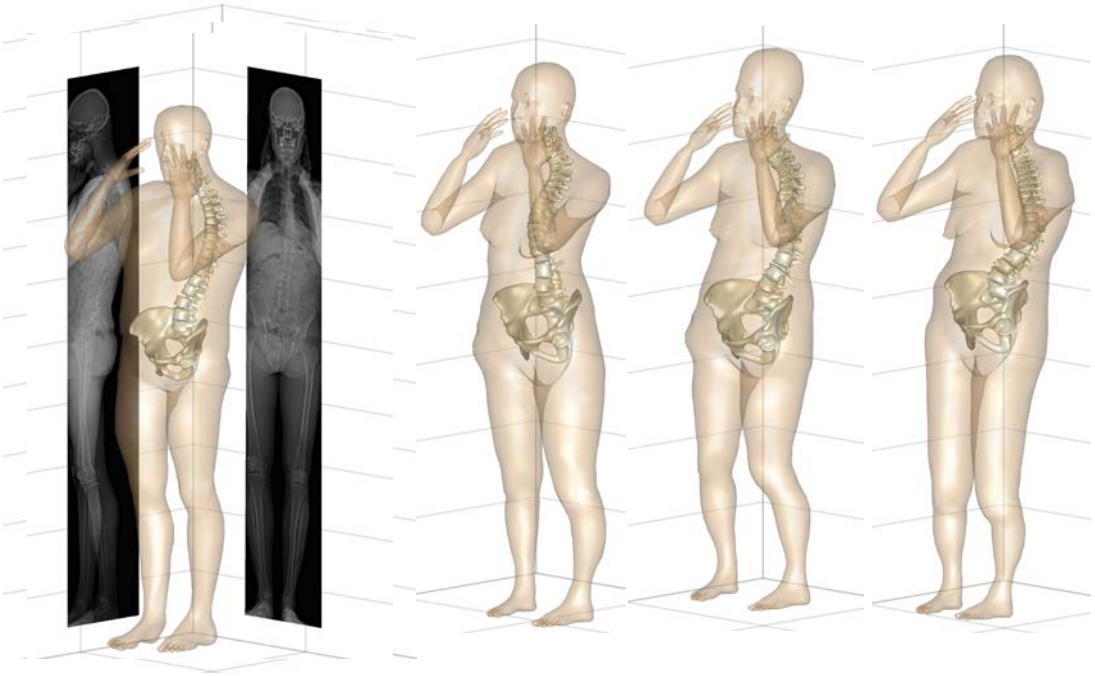
Centre de masse segment au dessus des têtes fémorales

Centre de masse global

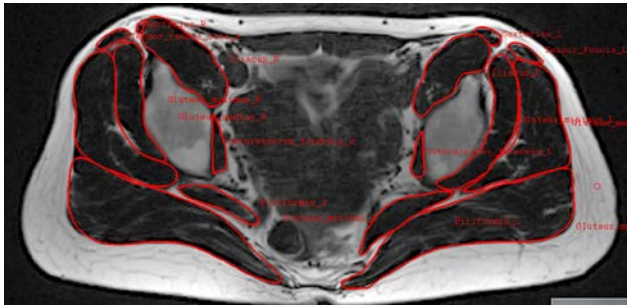
Ligne de gravité

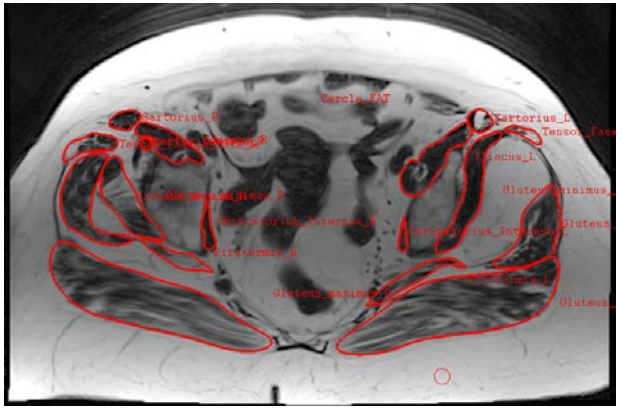
VIEILLISSEMENT: EQUILIBRE POSTURAL NORMAL ET ALTERE

Thèses C. Amabile, E. Ferrero



Rôle des muscles

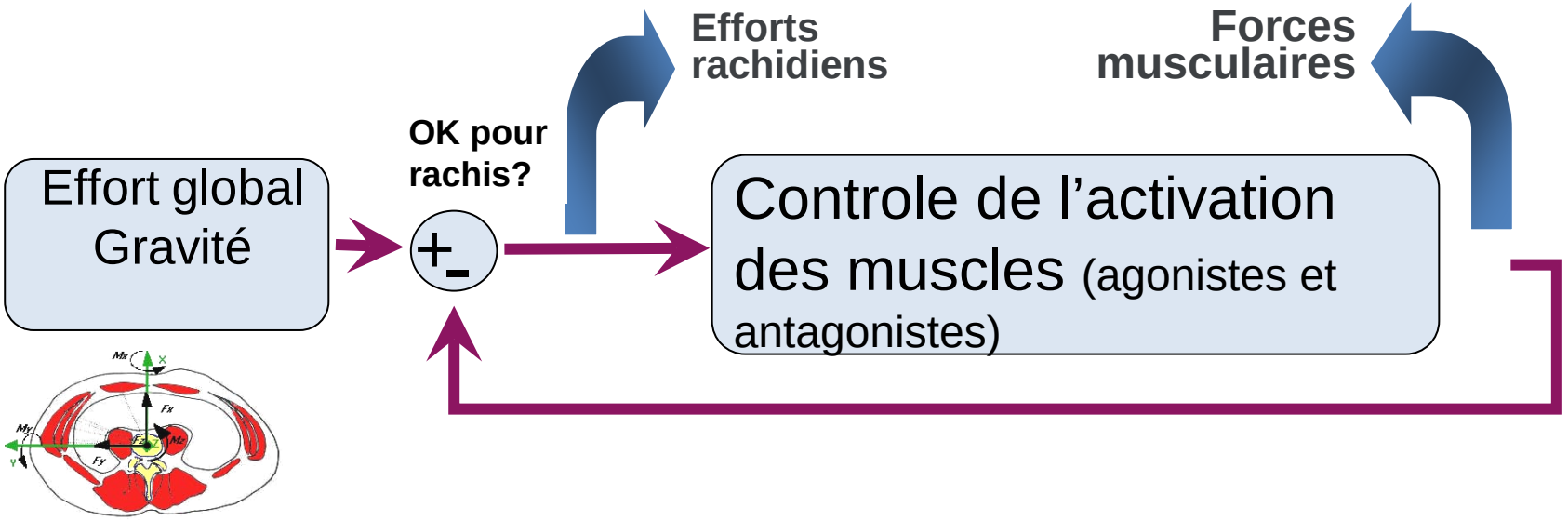




Coll. JM Vital: Thèses V. Pomero, O. Gilles, B. Moal, C. amabile, V. Pomero

Modèle de controle musculaire

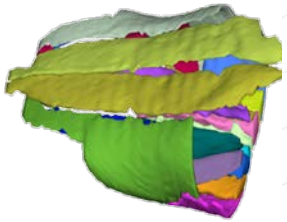
Pomero et al. CMBBE 2004,
Van Den Abbeele et al, Clin. Biom.2017



Modélisation Musculosquelettique personnalisée

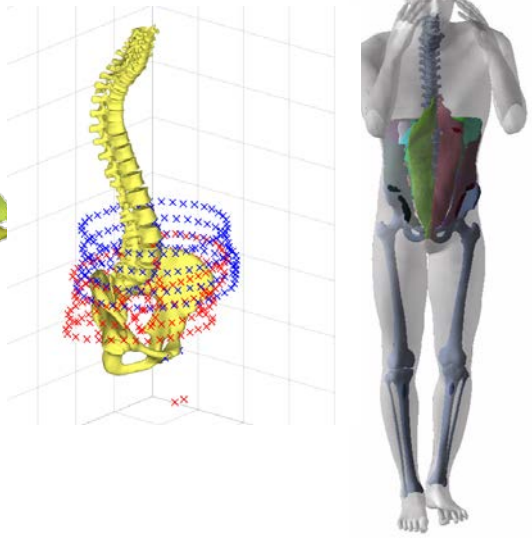
Reconstruction 3D EOS (debout)

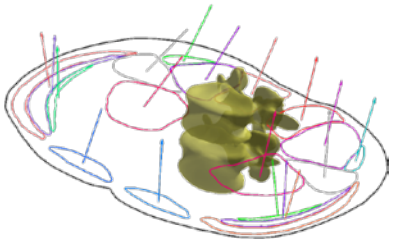
Reconstruction 3D IRM (couché)



Jolivet *et al.* 2008
Moal *et al.* 2015

fusion EOS IRM
Hausselle *et al.* 2014

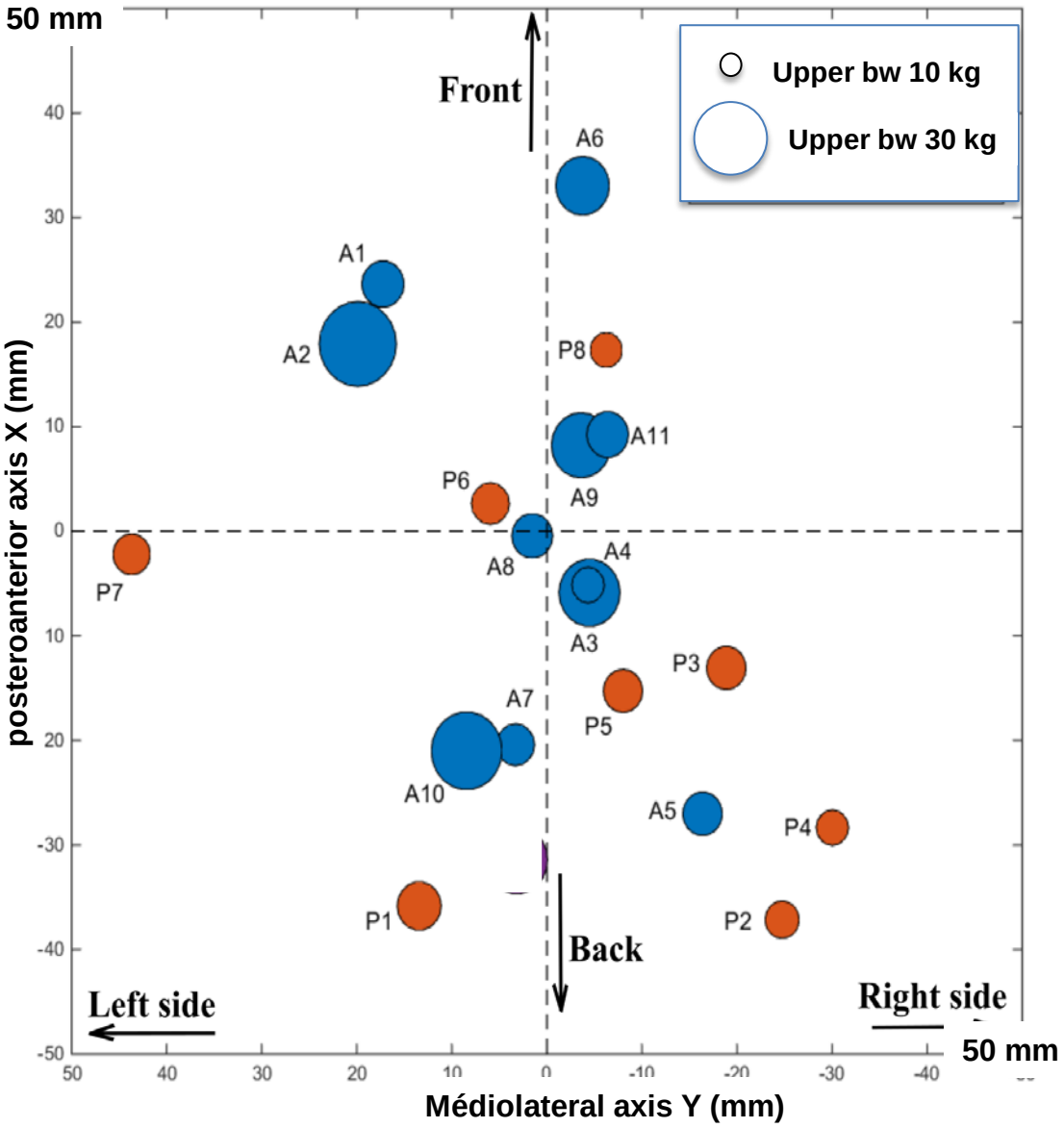




Données d'entrée pour modèles de commande musculaires

Thèses C. Amabile, M. Van Den Abbeele

Localisation du centre de masse au dessus du disque L3-L4



VARIABLE

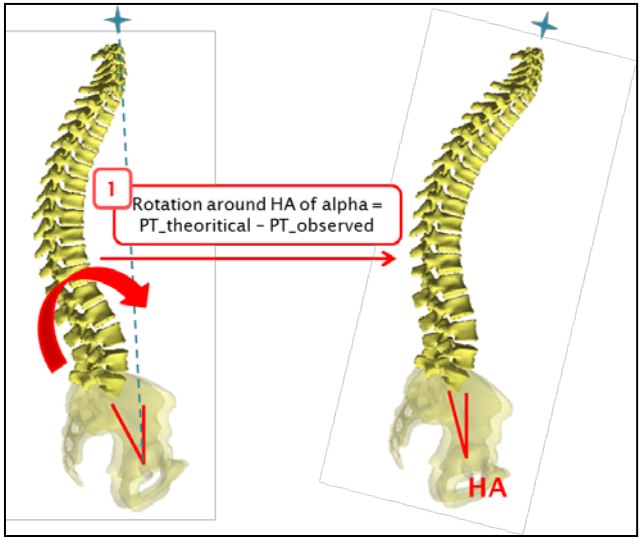
Aged asymptomatic

Preoperative ASD

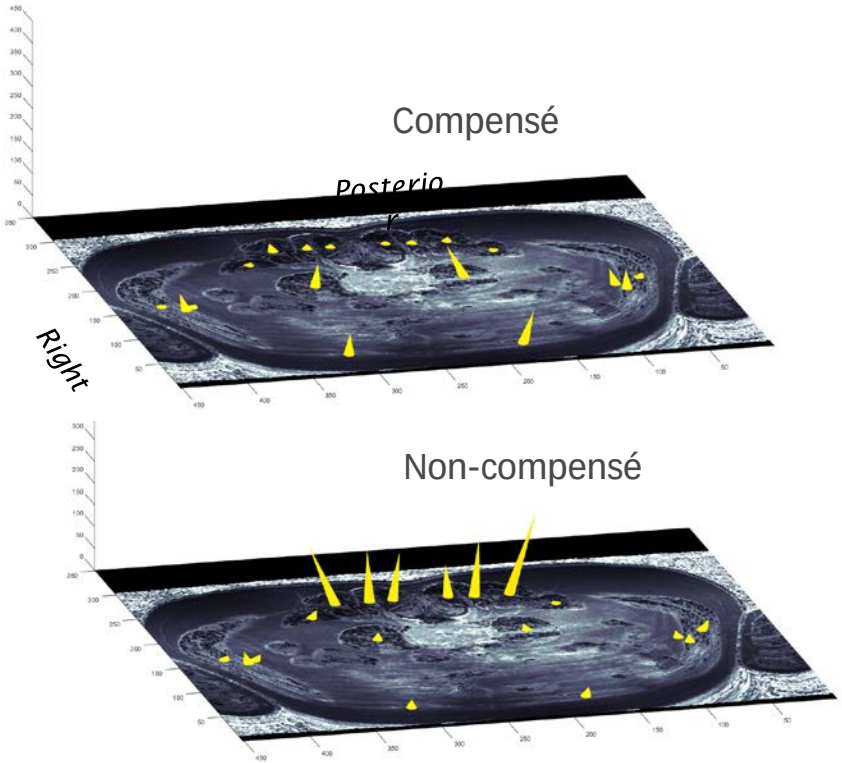
Mais pas tant que cela…

Modélisation musculaire associée

Compensé vs non compensé



Thèses C. Amabile, Amabile *et al.* 2016



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