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Presentation of Posture and Movement Physiology Laboratory

Alain Hamaoui, Head of Lab

PhD in Biomechanics and Movement Physiology

alain.hamaoui@univ-jfc.fr

CENTRE UNIVERSITAIRE JEAN-FRANÇOIS CHAMPOLLION

PoM Lab
Posture and Movement Physiology

Journal of Ergonomics

Open Access

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Presentation outline

I. Presentation of University JF Champollion

II. Posture and Movement Physiology Lab (PoM) history

III. PoM team

IV. PoM Equipement

IV. PoM main research topics

1) " Interaction between posture et respiration "

2) " Muscular tension and postural equilibrium "

3) " Ergonomic of the seated posture"

PoM Lab

University Champollion, Albi, France

- Located in the sunny area of the south of France, close to Toulouse city
- More than 3000 thousand students in Sciences (mathematics, physics, biology...) , Humanities, Languages, Law, Sport Sciences.

History of PoM Lab

PoM Lab
Posture and Movement Physiology

2006: University Champollion supported the project of creating a movement analysis lab focused on health topics

2007: first facilities and research équipement

2009-12: development of partnerships with rehabilitation centers, hospitals, companies, labs.

2014-15: building new lab : 250m²

=> high scale research projects

=> gait analysis for rehabilitation centers

=> consulting in ergonomics for manufacturing companies

Université de Toulouse

BOSCH

UNIVERSITÉ PARIS SUD

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PoM Lab team

PoM Lab
Posture and Movement Physiology

Permanent staff:

1 associate professor
1 physician in rehabilitation
1 PhD student
1 master student

Associated staff:

1 professor in biomechanics
1 professor in muscle physiology
1 associate professor biomechanics

Next year:

1 engineer in electronics
1 new PhD student (position opened)
2 master students

PoM Lab Equipment

PoM Lab
Posture and Movement Physiology

Biomechanics:

Force plates (two prototypes)
Force sensors
Accelerometers
Electrogoniometers
Inertial sensors

Neurophysiology:

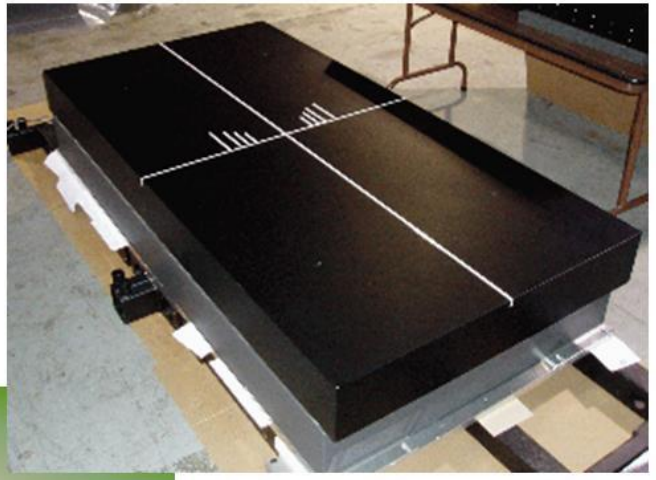
Wireless EMGs
Vibrators (prototypes)

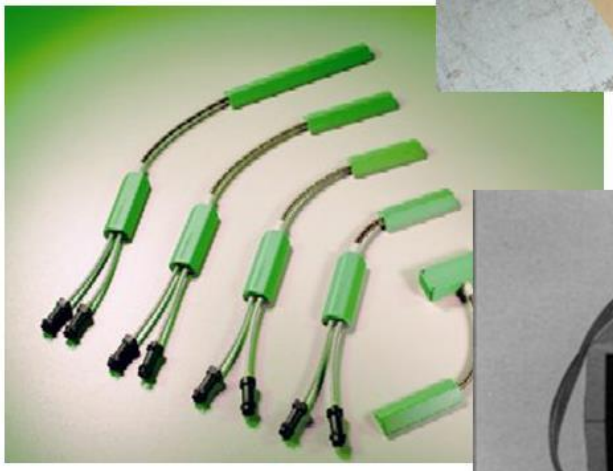
Respiratory physiology:

Sensing belts (prototype)
Research spirometer

Software:

Labview, Matlab, Statistica
Gimp, CamStudio, Sketchup...





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PoM research topics

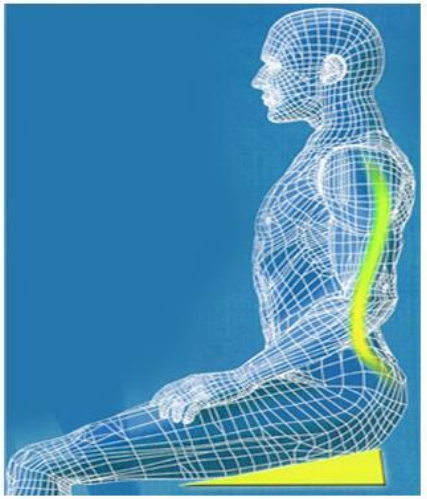
The general aim of the team is *" to highlight the contributing factors to motor control, via a combination of biomechanical and physiological approaches"*

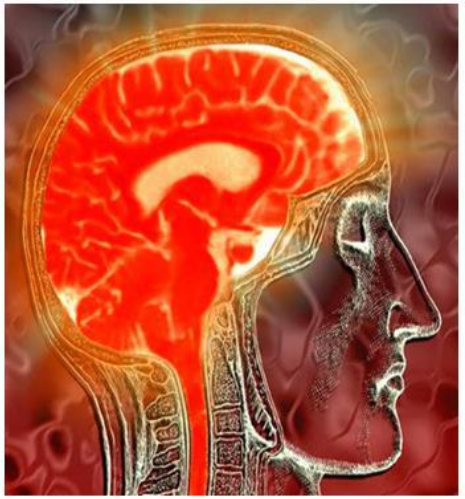
Two fundamentals topics:

- Interactions between posture and respiration
- Muscular tension and postural equilibrium

One applied topic:

- Ergonomics of the seated posture





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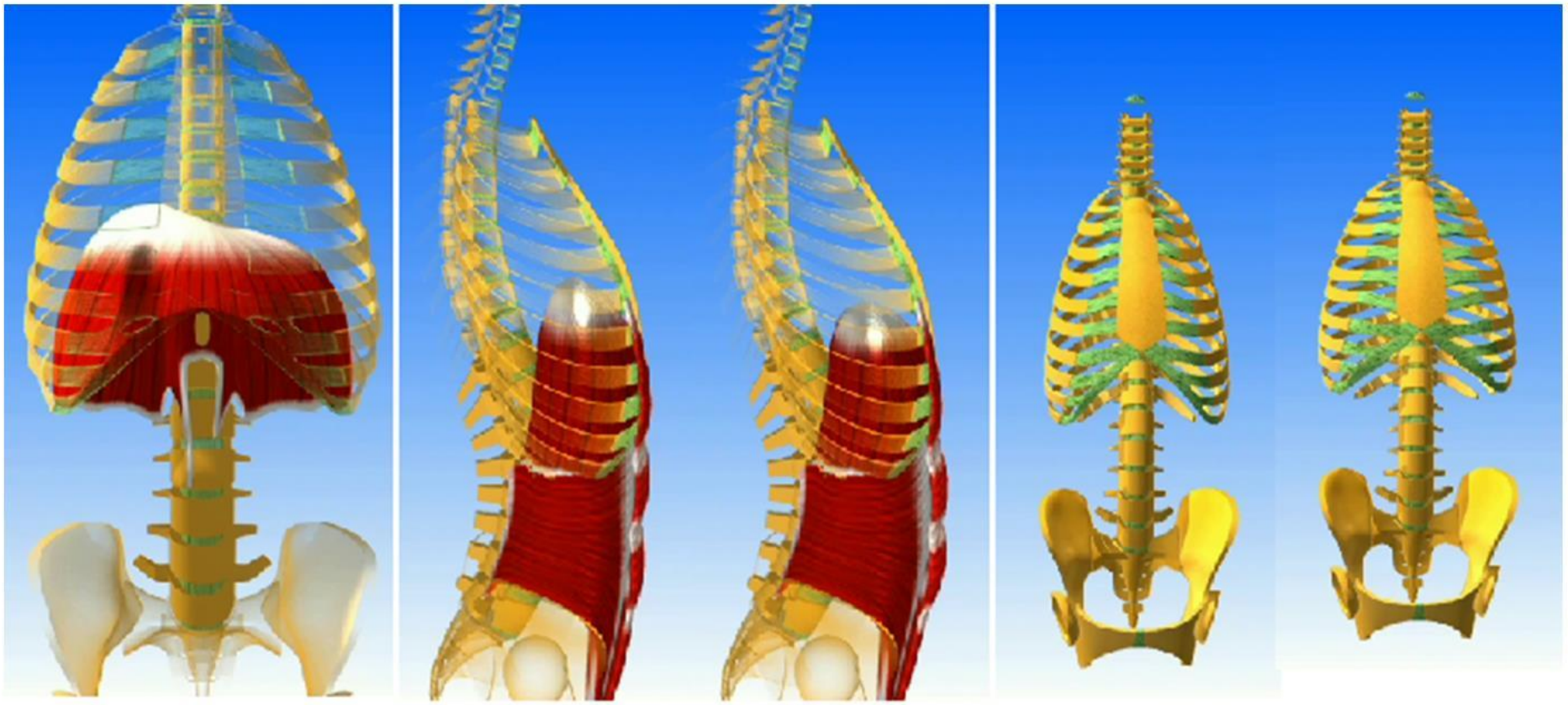
Interaction between posture and respiration

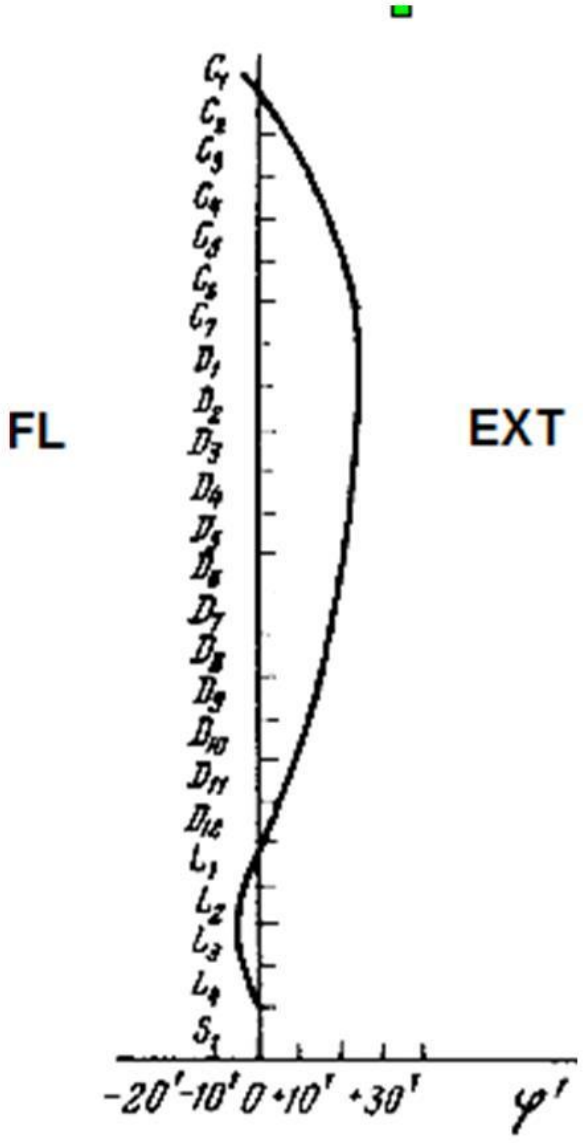
It is well known that respiration is associated cyclical with movements of the rib cage and abdomen (Derenne et al. 1978), inducing internal disturbances to posture (Gurfinkel et al., 1971; Bouisset et al., 1994)



from Thiriet and Rastello, 2008

Interaction between posture and respiration

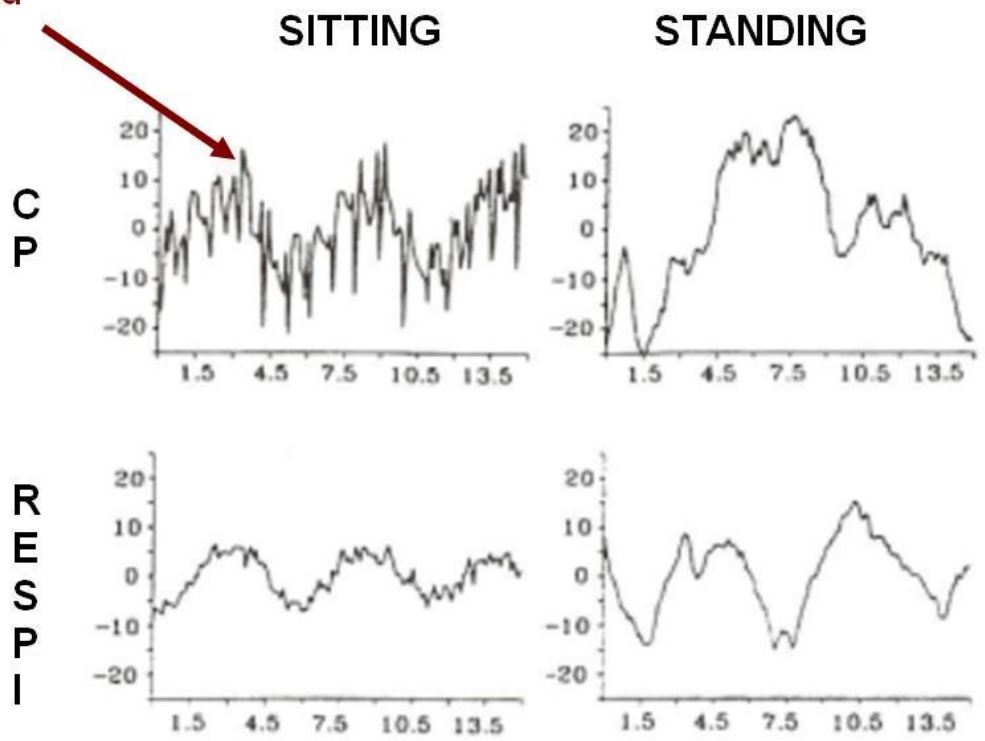
Gurfinkel (1971): the disturbance is directed **backwards** during inspiration and **completely compensated for** by counter-disturbing movements occuring at the hip and neck level : *"respiratory synergy"*.



Interaction between posture and respiration

Watanabé et al. (1976), Hunter et Kearney (1981), Bouisset et Duchêne (1994): the disturbance is **not completely compensated for** and seems directed **forward**.

CP directed forward during inspiration



Bouisset et Duchêne, 1994

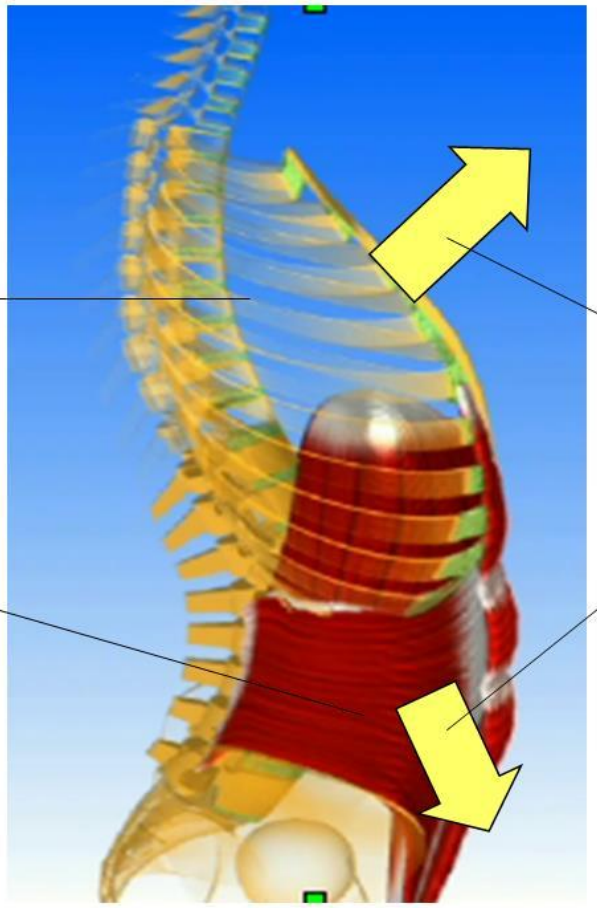
Interaction between posture and respiration

Rib cage and abdomen have different structures and kinematics:

=> their effect on posture could be different as well

rib cage = bony cartilaginous structure

abdomen = full fluid container

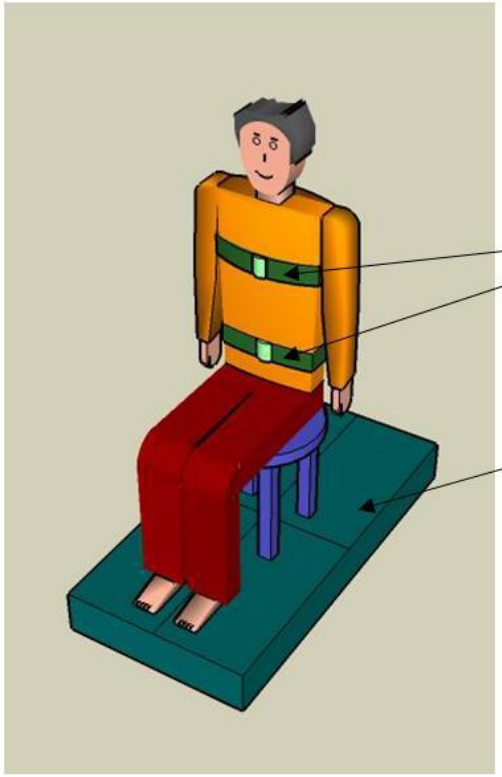


different kinematics

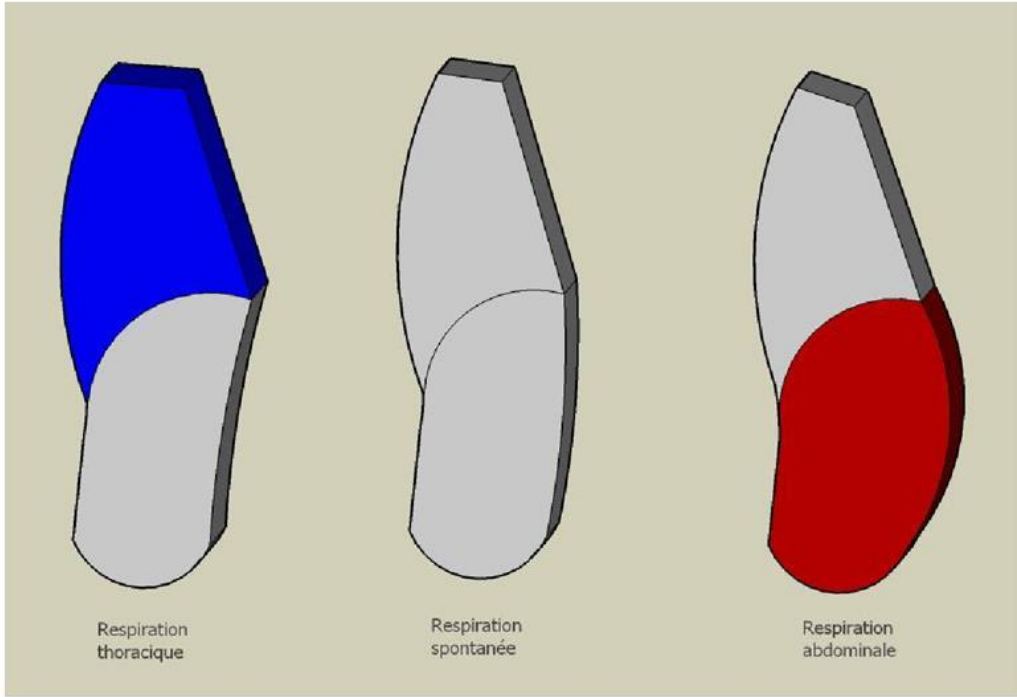
Hypothesis: variation in respiratory disturbance to posture could be related to different respiratory modes

Interaction between posture and respiration

Method: posturographic examination associated with respiratory kinematics recording in 10 healthy male subjects



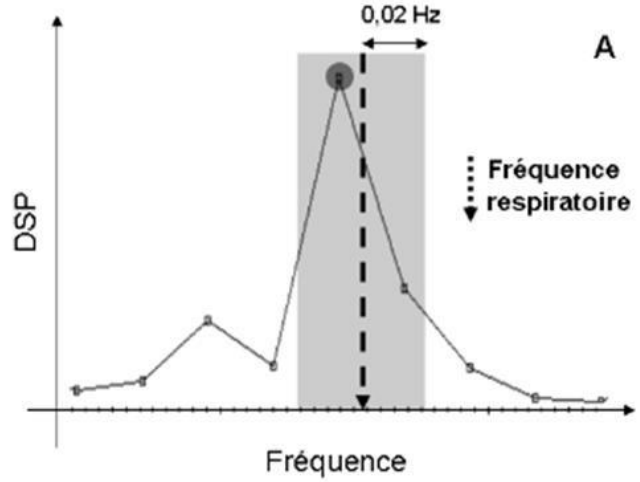
Experimental conditions: **respiratory mode (T, A)**, posture (sitting, standing).
4 trials of 30 sec per condition



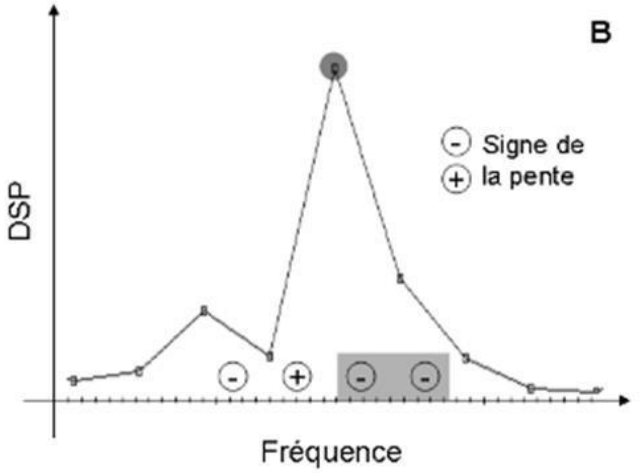
Interaction between posture and respiration

Data analysis:

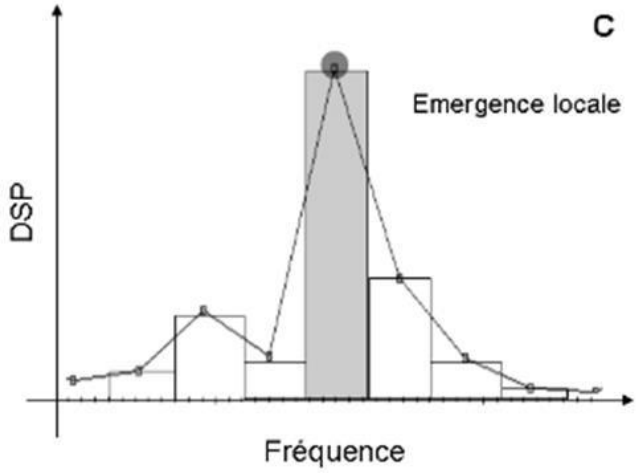
- 6 stabilometric parameters calculated in the time domain in the anterior-posterior (X) and medial-lateral (Y) axes: mean position **(X0, Y0)**, mean deviation (**Xm, Ym**), mean velocity (**VmX, VmY**) du CP.
- 4 original parameters calculated in the frequency domain to assess the respiratory component of the CP: peak detection parameters (**RPX, RPY**), respiratory emergence parameters (**REmX, REmY**)



Local maximum at the respiratory frequency ± 0,02 Hz



Local maximum surrounded by at least two slopes of the same sign

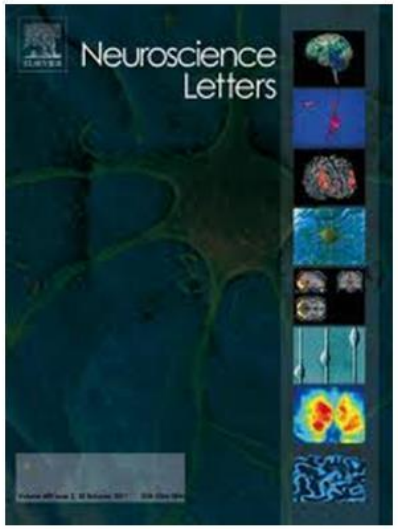


Ratio between the max bands and the 6 adjacent bands > 1,5

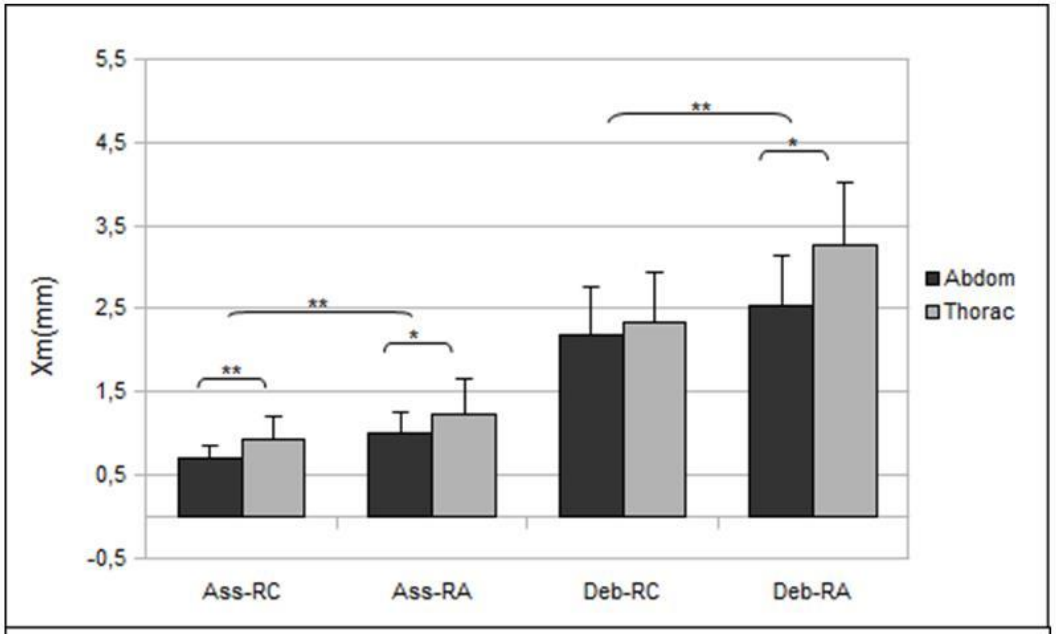
Multicriteria respiratory pic detection algorithm

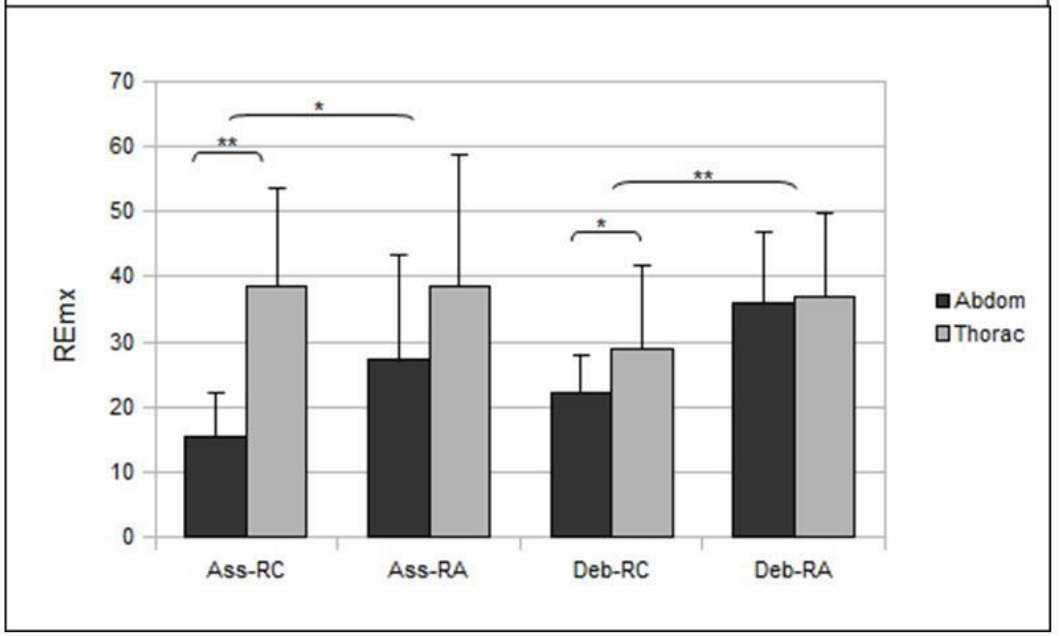
Interaction between posture and respiration

Results: Xm et REmX are higher in thoracic breathing ($p<0,05$)



Hamaoui et al., 2010

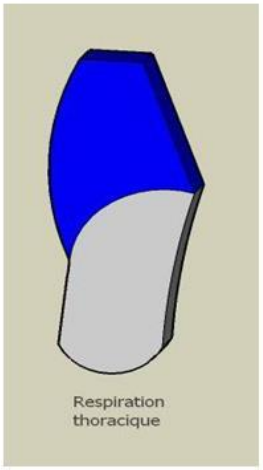


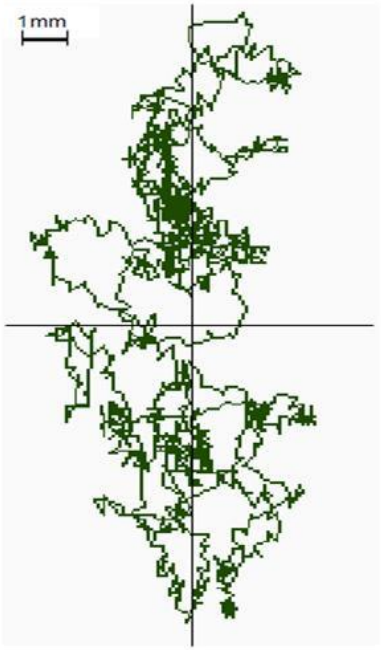


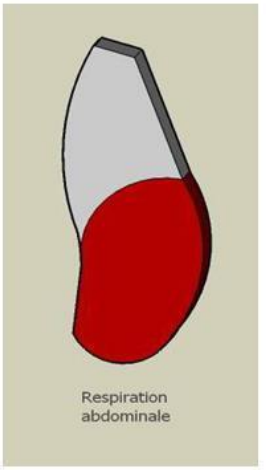
…no specific direction of the respiratory disturbance to posture

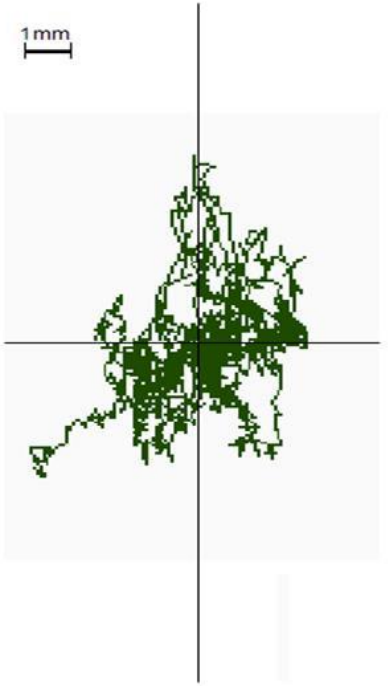
Interaction between posture and respiration

Results: stabilograms (XY graph of CP) are larger in thoracic breathing









Discussion: respiration disturbs postural equilibrium more when it is mainly thoracic. This could be due to a higher position of the rib cage (higher lever arm). However a specific direction of the respiratory disturbance was not found in raw data.

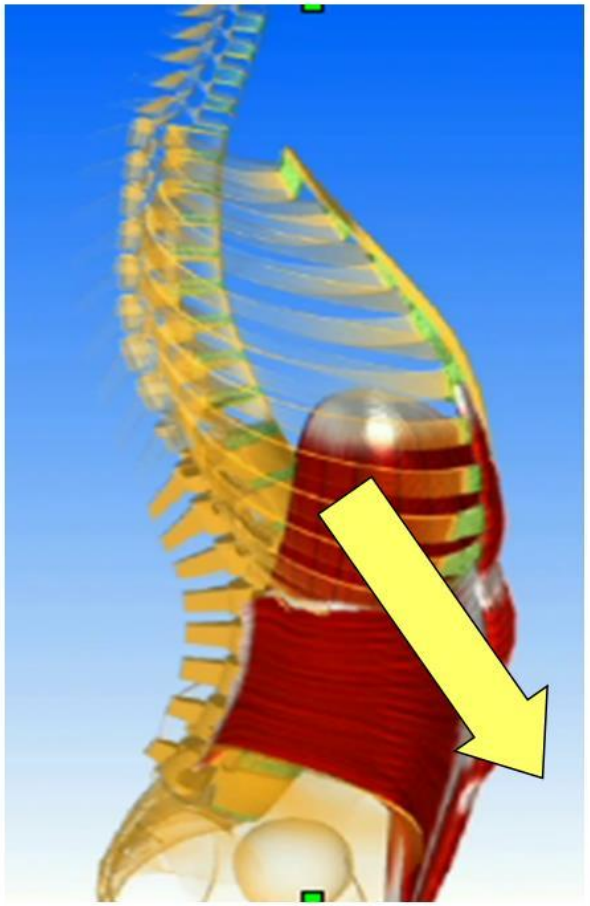
Problem: CP is the net result of disturbances + compensation

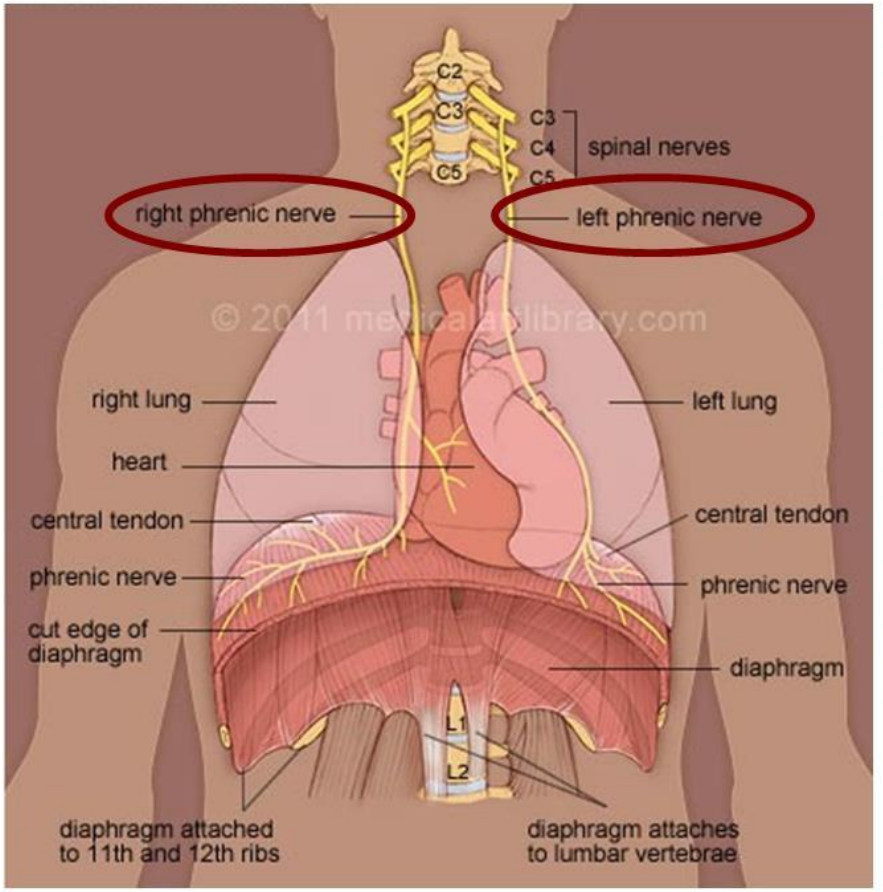
PoM Lab

Interaction between posture and respiration

Hypothesis: exploring the effect of a specific contraction of the diaphragm could partly reveal the direction of the respiratory disturbance

- The diaphragm is the main respiratory muscle in quiet breathing
  => is the disturbance oriented forward (abominal mass displacement) ?
- The right and left hemi-diaphragm have a separate innervation
  => what is the effect of a unilateral contraction ?



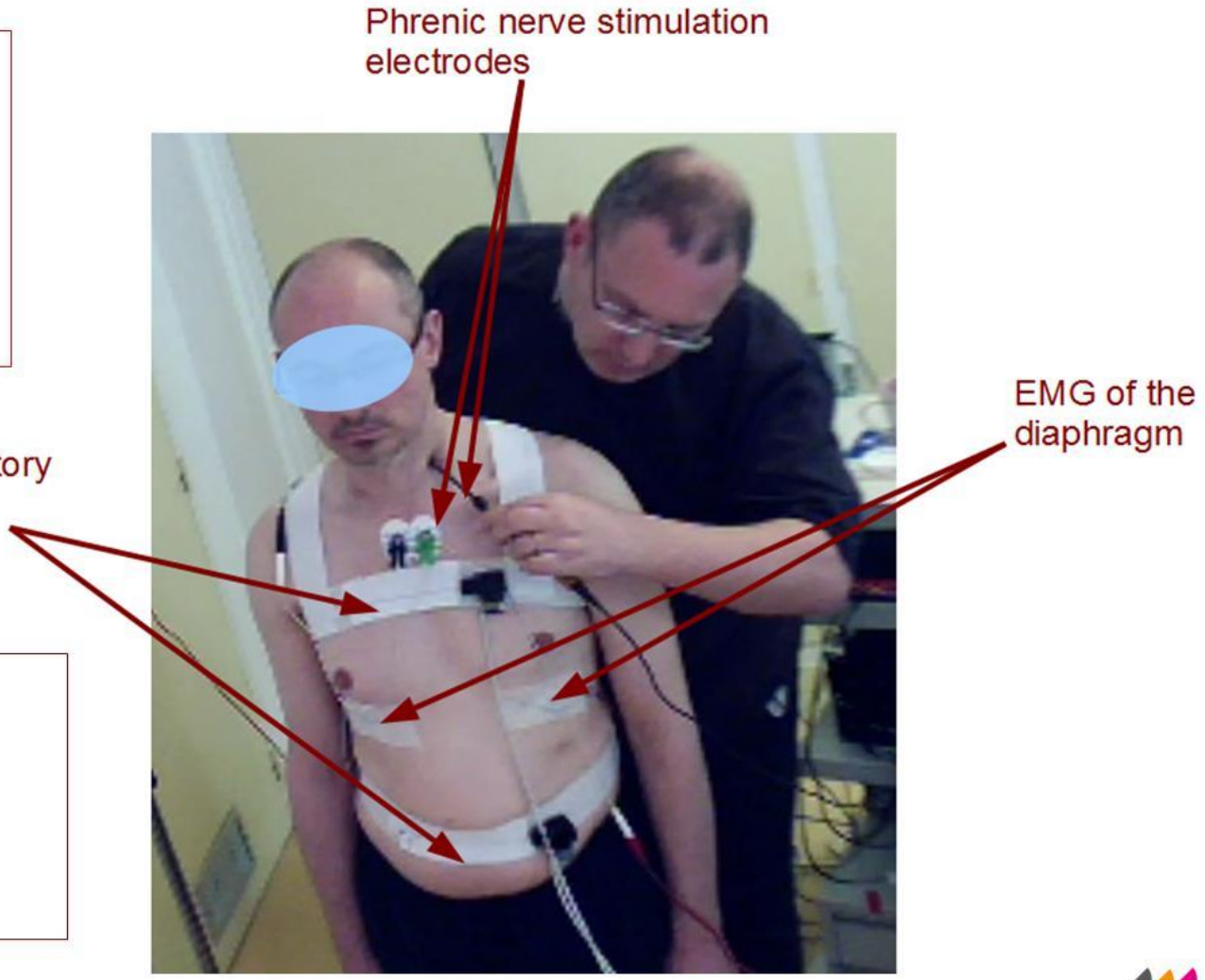


Interaction between posture and respiration

Method: force plate measurements associated with **phrenic nerve stimulations** and **abdominal sniff maneuvers** in 12 healthy subjects.

Experimental conditions for **stimulations**:
- posture (sitting, standing)
- stim side (left, right, bilateral)
=> 2 trials of 1 mn for each condition

Experimental conditions for abdominal **sniff** :
- posture (sitting, standing)
=> 2 trials of de 1mn for each condition



experimental setup

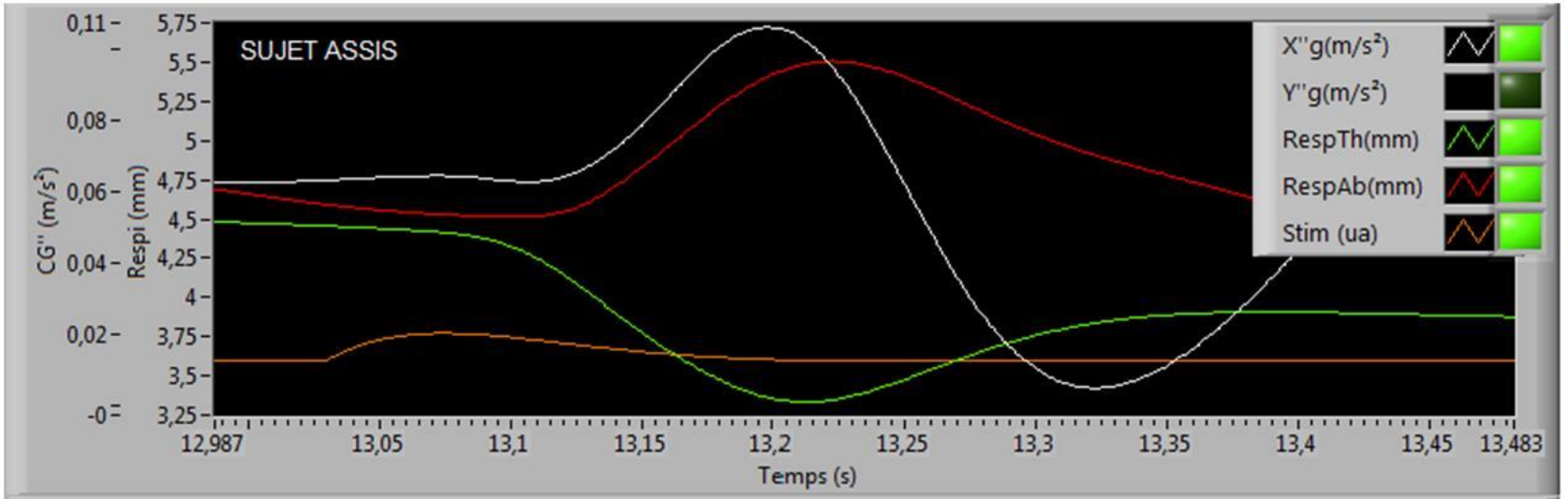
Interaction between posture and respiration

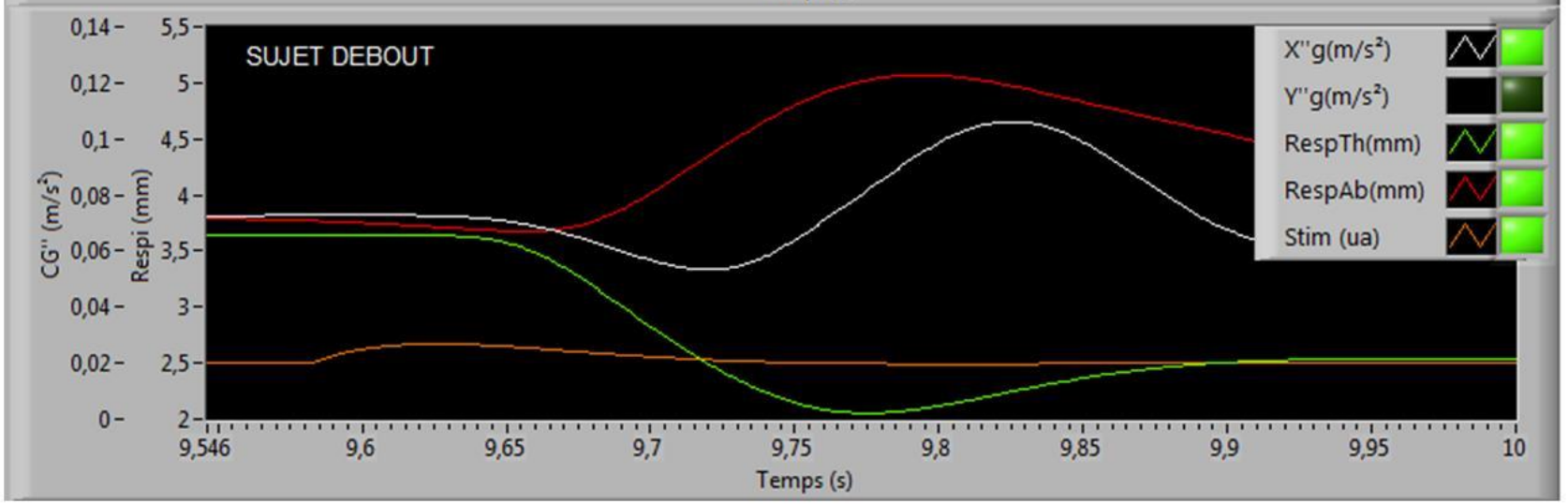
Results: analysis of respiratory peaks and of CG acceleration (X''g)

bilateral phrenic nerve stimulation

X''g directed forward in sitting posture, but backward in standing posture

Similar results were found in abdominal sniff conditions





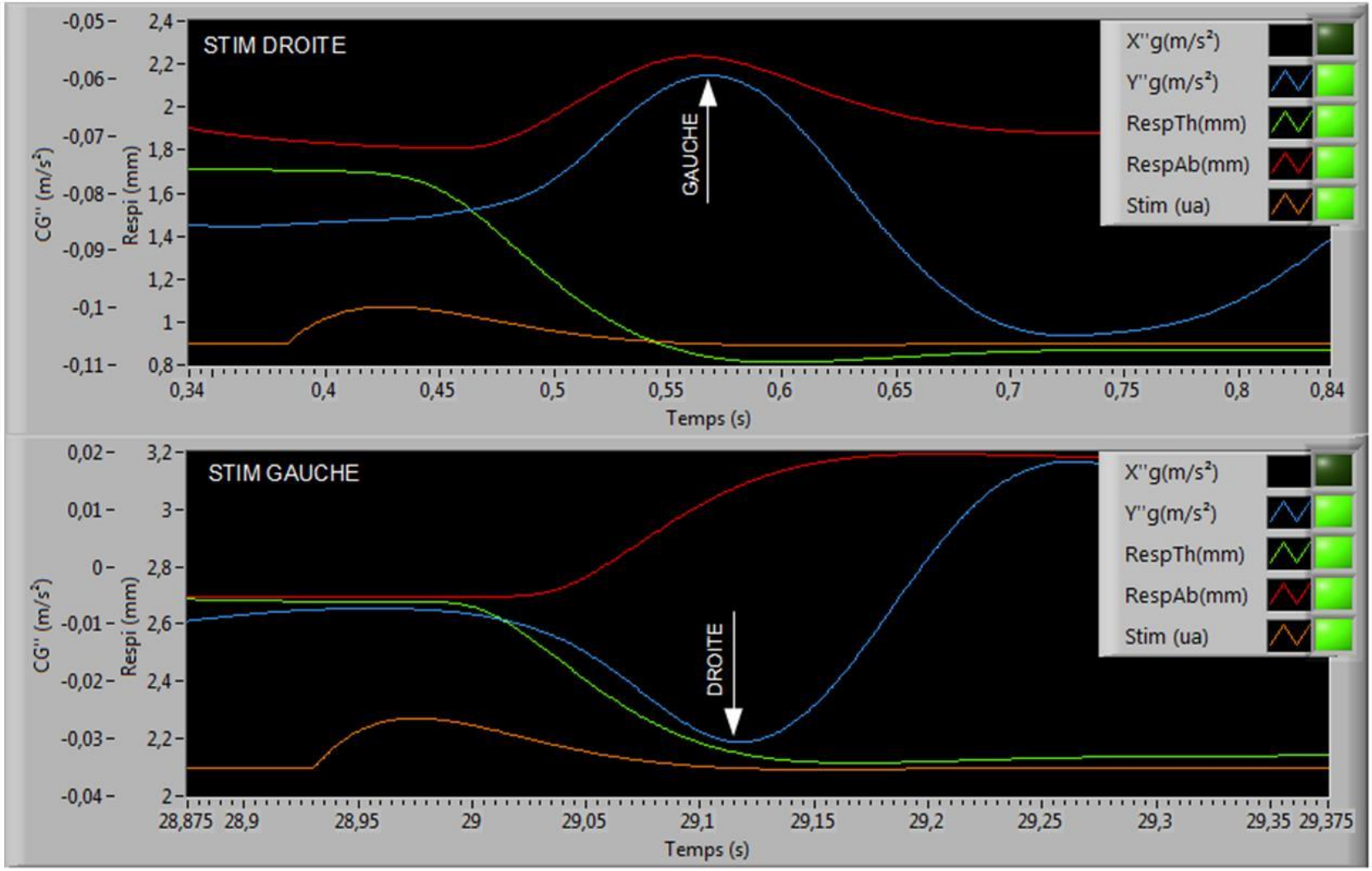
Interaction between posture and respiration

Results: analysis of respiratory peaks and of CG acceleration (Y''g)

unilateral phrenic nerve stimulation in sitting posture

Y''g peak directed at the left side in right stim

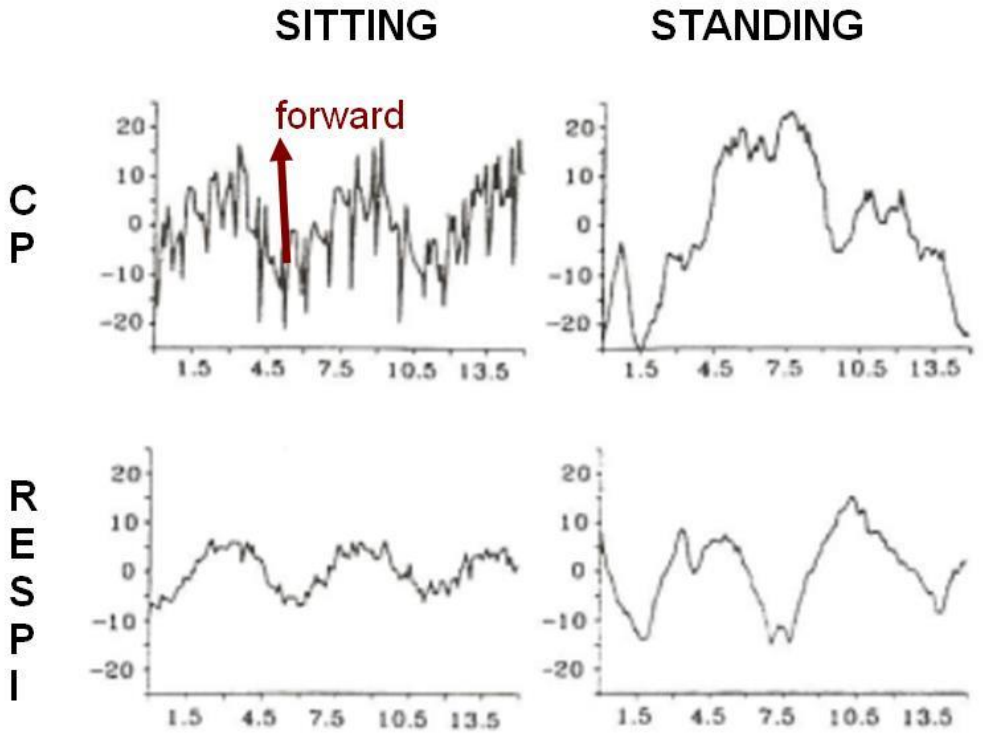
Y''g peak directed at the right side in left stim



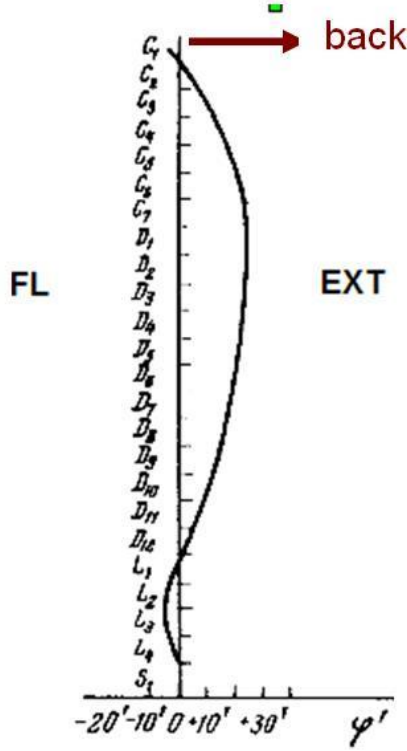
=> The peak direction is inverted in standing posture in 66% of the subjects

Interaction between posture and respiration

Discussion: a specific contraction of the diaphragm induces a postural disturbance oriented forward in sitting posture but backward while standing.



Bouisset et Duchêne, 1994



Gurfinkel, 1971

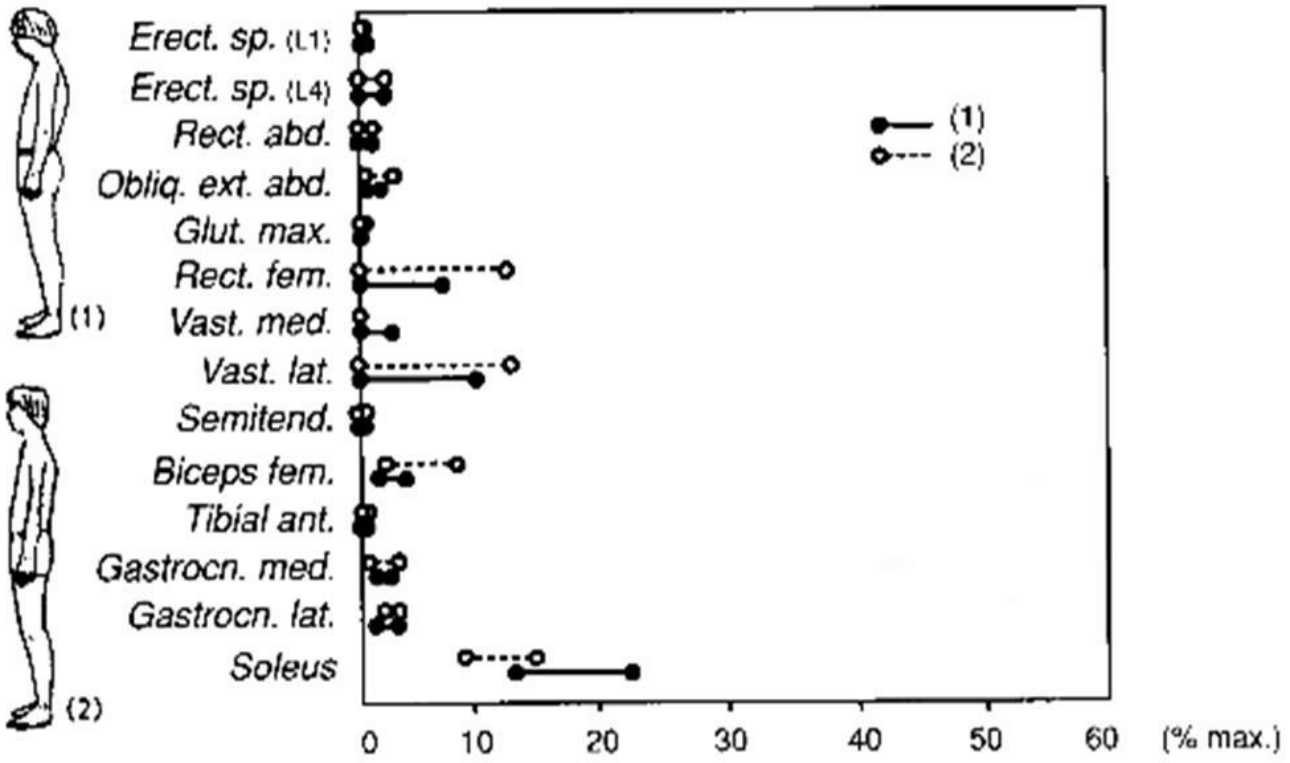
Effect of higher degrees of freedom in standing posture ?

Hamaoui et al., 2014

Muscular tension and postural equilibrium

Muscular tension supports postural equilibrium:

Activity of postural muscles is necessary to stabilize the bony segments against the effect of gravity (Carlsöö, 1961) and to provide a stable geometric configuration of the body .

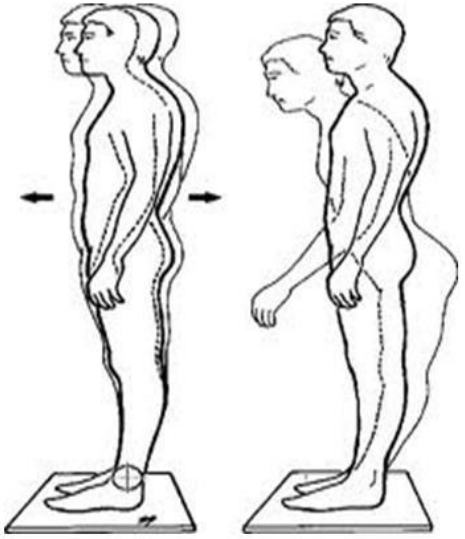


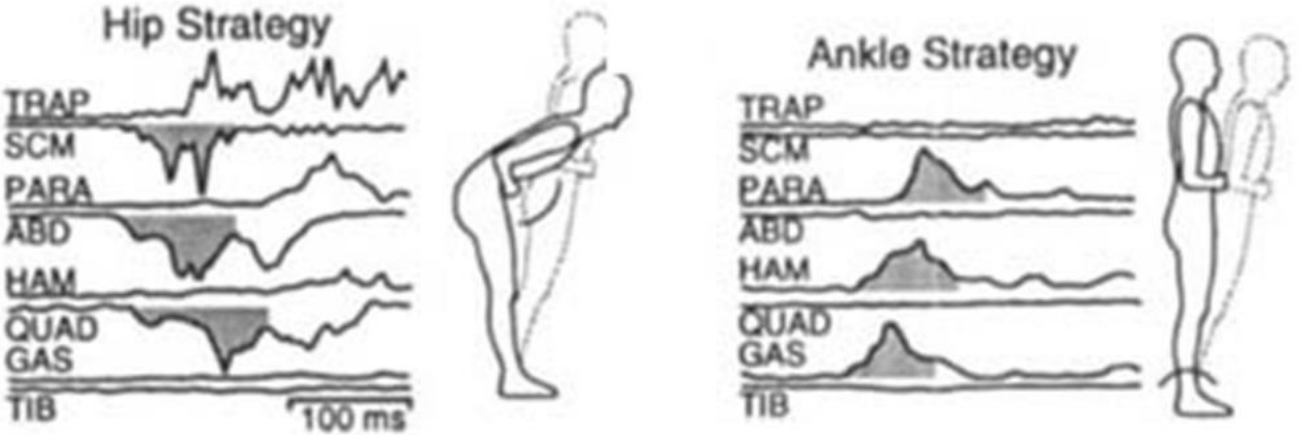
Okada, 1972

Muscular tension and postural equilibrium

Muscular tension is likely to impair postural equilibrium:

it could limit the mobility of the articulated chain necessary to compensate for the disturbing forces applied on the body; e.g. hip and ankle strategies (Horak et al., 1986)





Horak et Macpherson, 2007

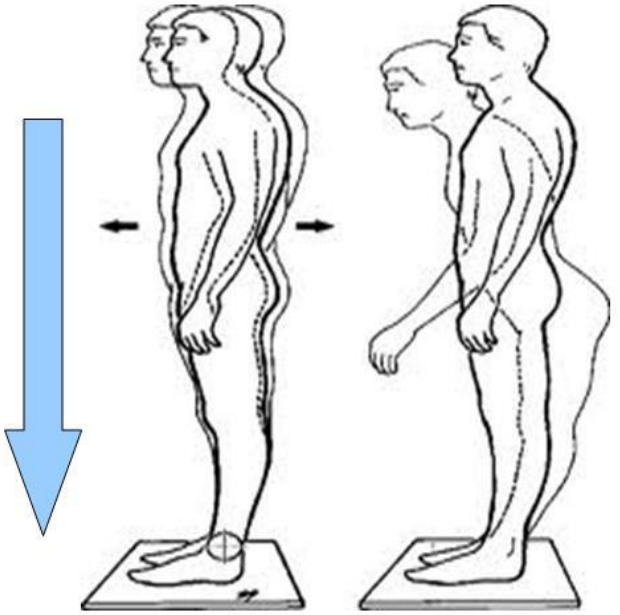
PoM Lab

Muscular tension and postural equilibrium

Question : does increase muscular tension along the torso increase or impair postural equilibrium ?

STABILIY

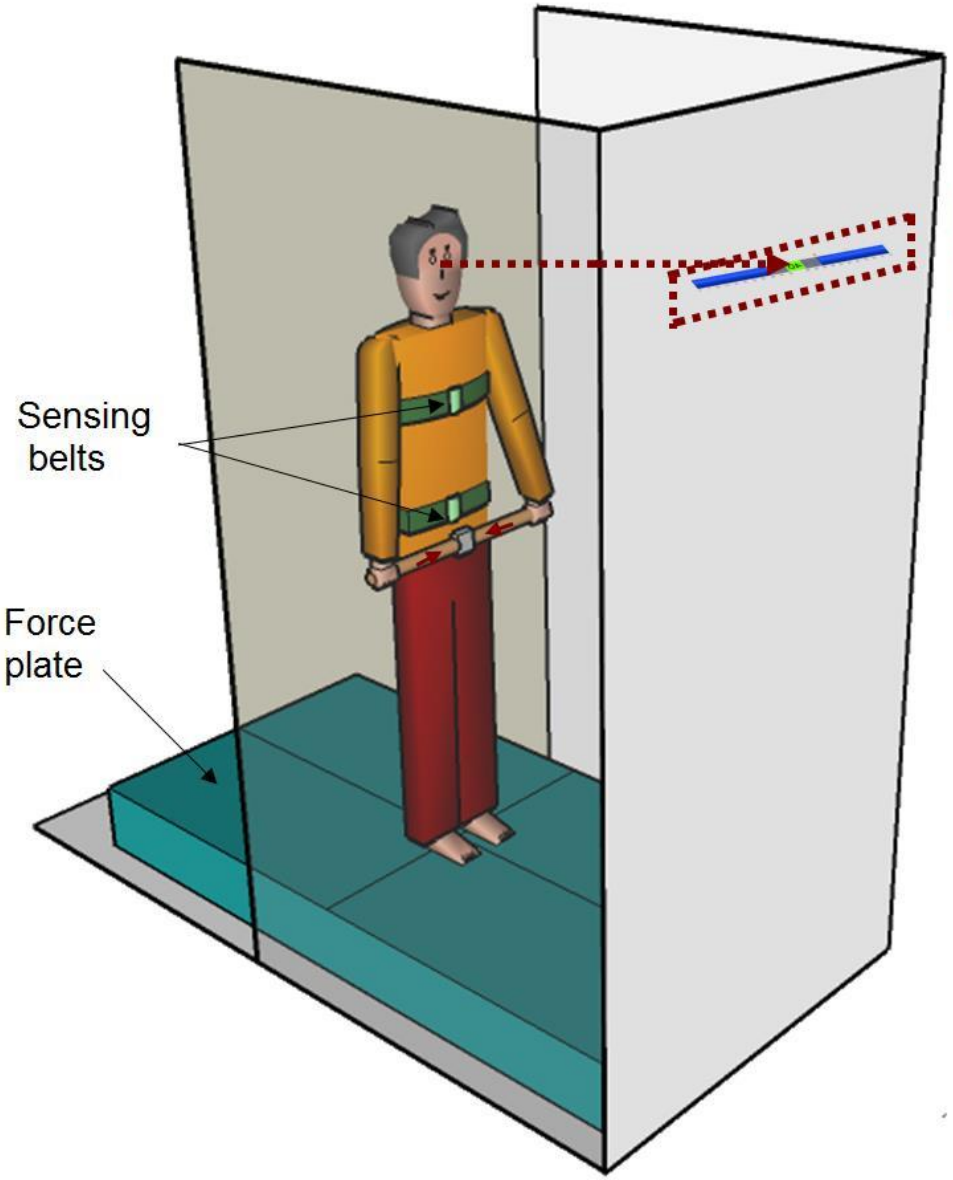
?

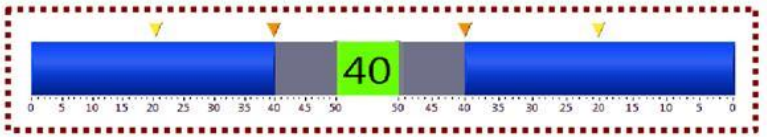


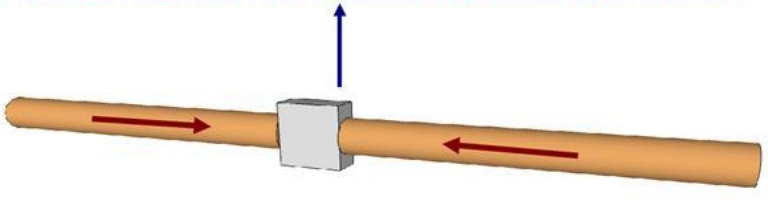
MOBILITY

Muscular tension and postural equilibrium

Method: posturographic examination associated with an original compressive load paradigm used to set the back muscular tension at different controlled levels, in 11 healthy subjects







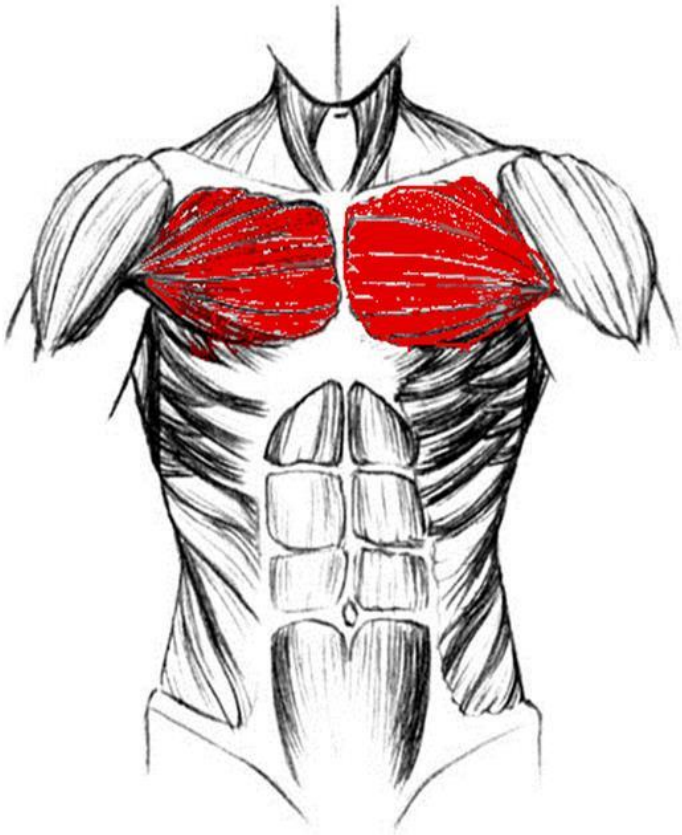
Experimental conditions: **compressive load** (0%, 20% and 40% of the MVC), breathing amplitude (QB, DB).

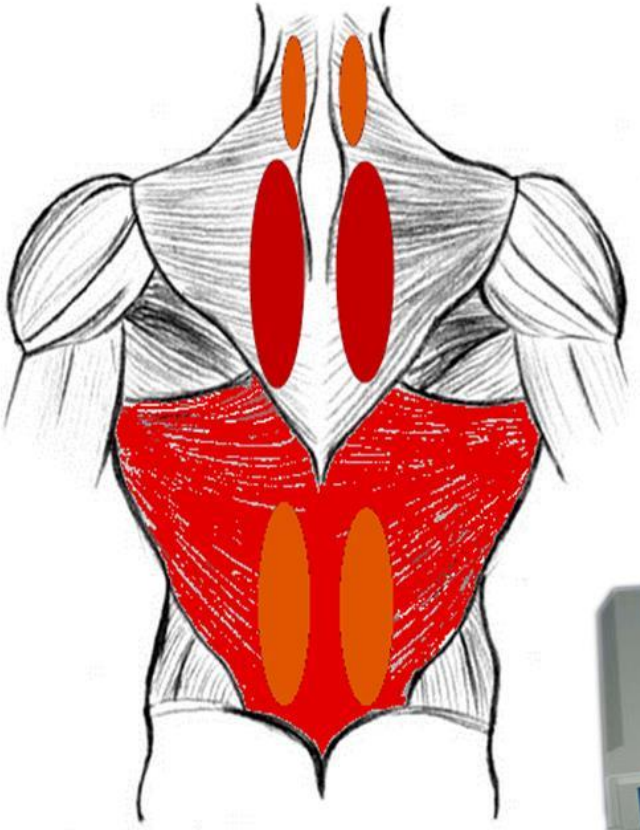
4 trials of 30-s per condition.

Data analysis: parameters calculated in time-domain and frequency domain

Muscular tension and postural equilibrium

Method: EMG pre-test (16 muscles) intended to map out the main muscles of the compressive load and to ensure that their activity varied according to the load applied on the sensor.





Wireless EMG device

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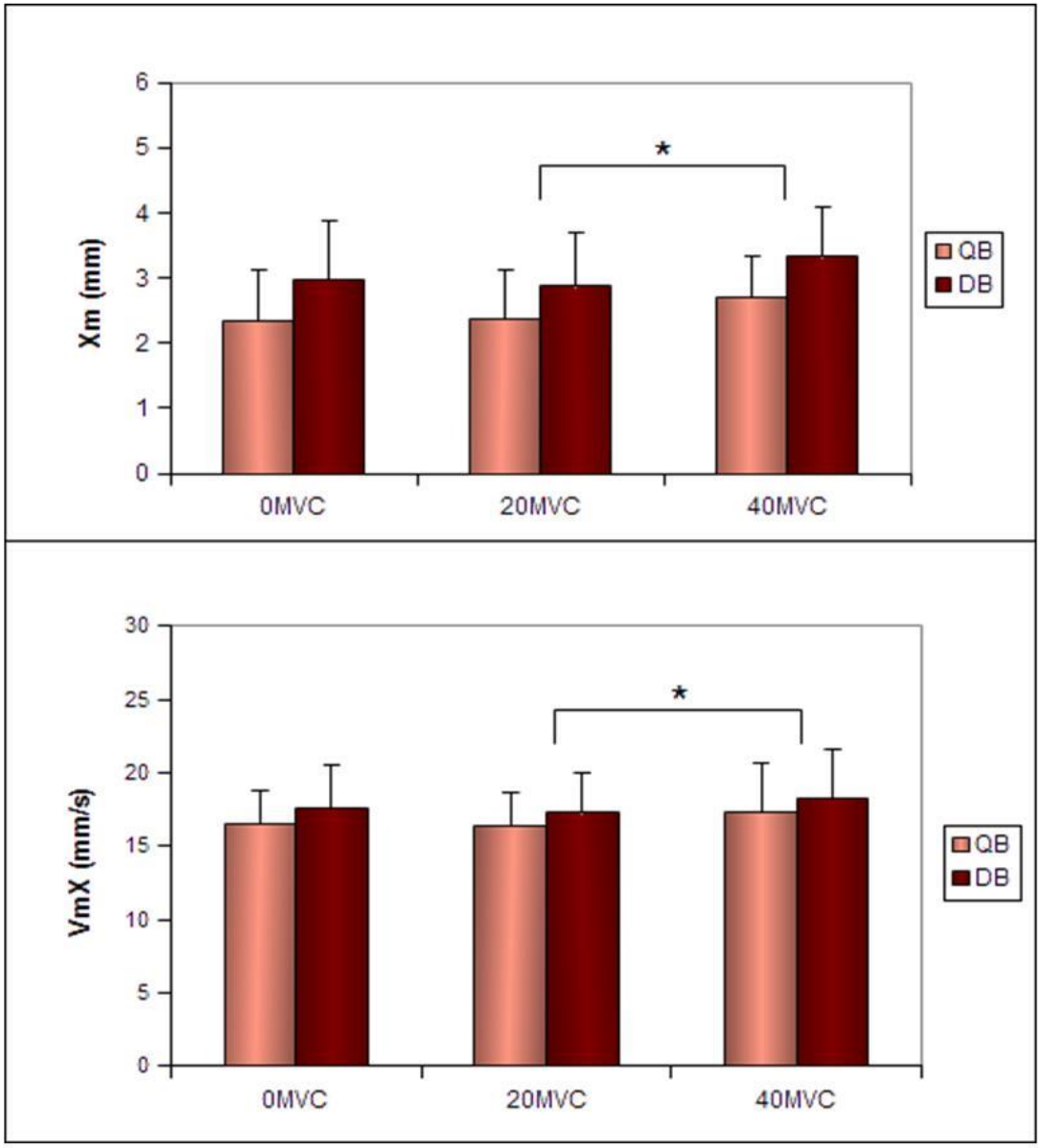
Muscular tension and postural equilibrium

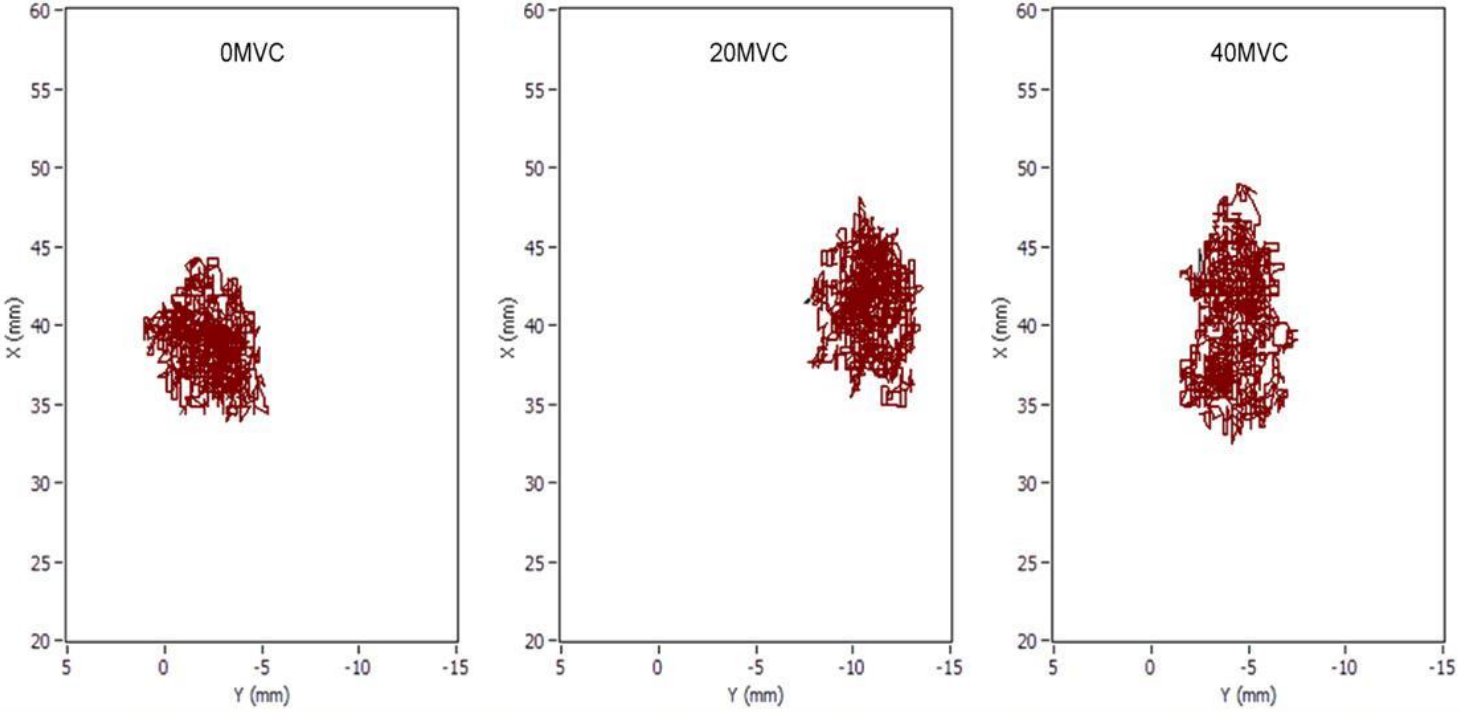
Results: mean deviation and mean velocity of CP along the anterior-posterior axes significantly increased between 20MVC and 40MVC conditions, but not between 0MVC et 20MVC.

Hamaoui et al., 2011



Muscular tension and postural equilibrium

Results: visual inspection of raw data showed larger stabilograms in 40 MVC



Discussion: increased muscular along the torso is likely to impair postural equilibrium when it exceeds a given level.
This phenomenon could be related to the loss of mobility, which reduces the capacity to compensate for and to dampen the disturbing forces

PoM Lab

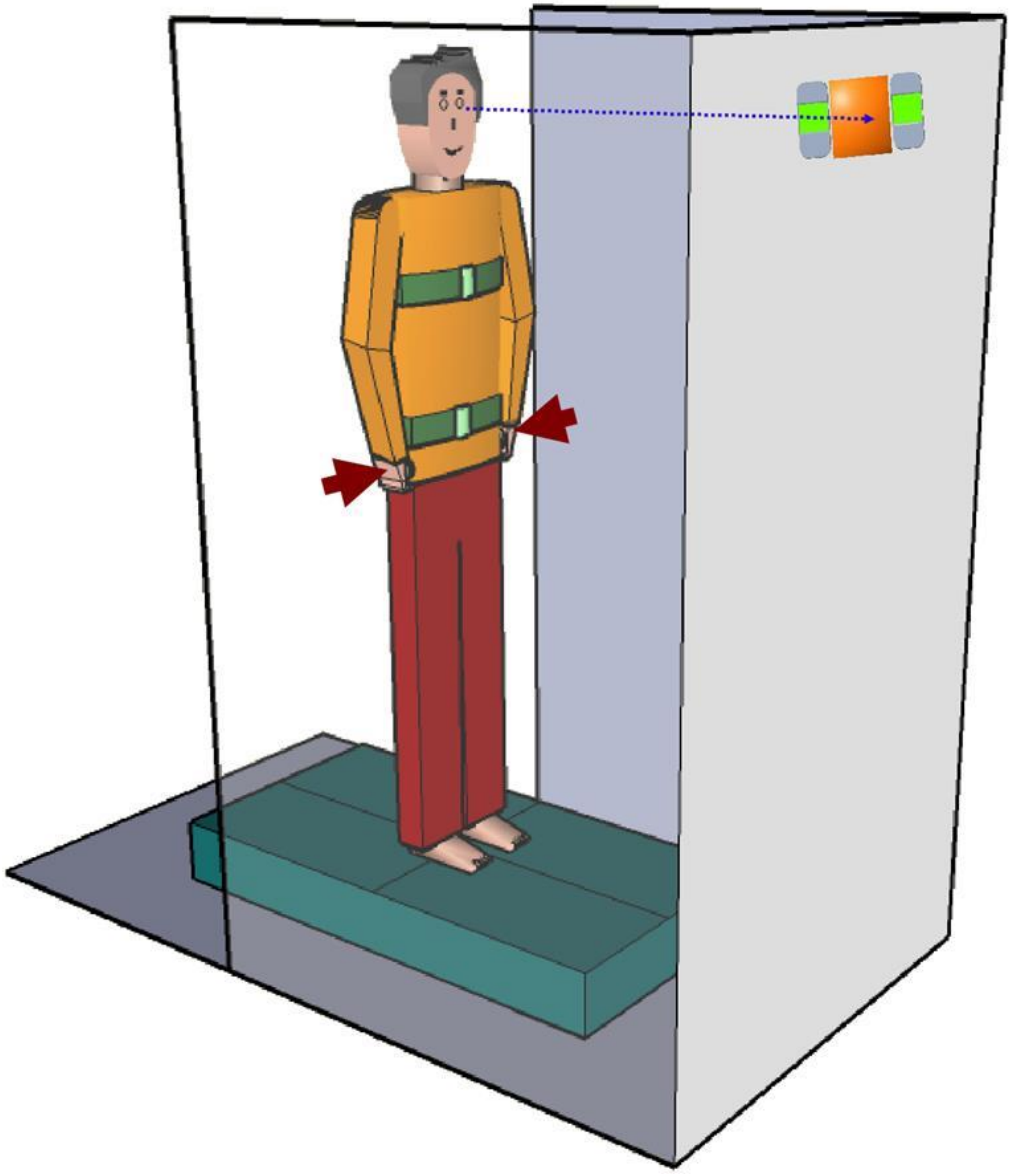
Muscular tension and postural equilibrium

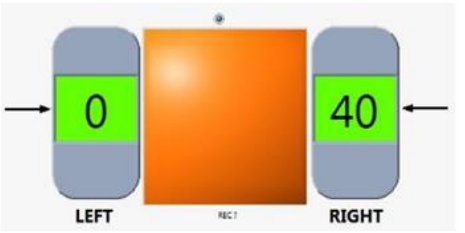
In a pathological context, increased muscular tension is frequently asymmetrical (one-sided back pain, hemiplegia...)

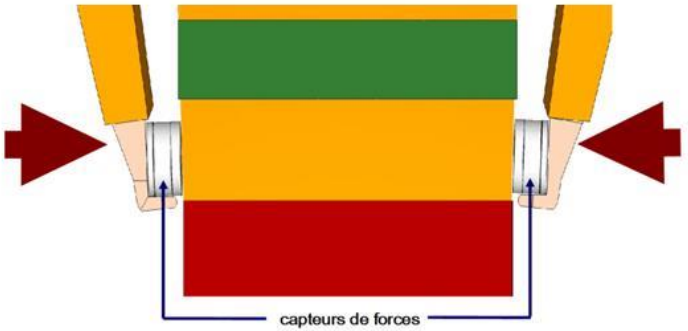
Question: does increased muscular tension disturb postural equilbrium more when it is asymmetrical ?

Muscular tension and postural equilibrium

Method: posturographic examination associated with a bimanual compressive load paradigm in 10 healthy male subjects







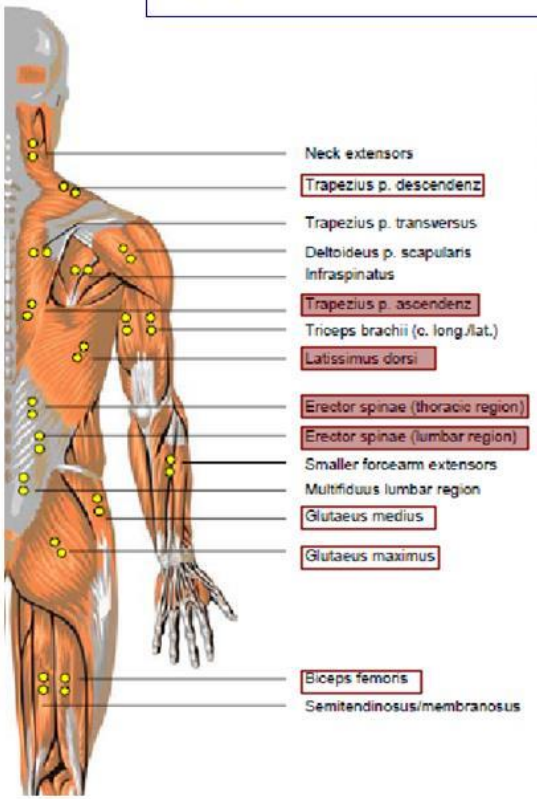
Experimental conditions: load level (0%, 20%, 40% MVC) and laterality (BI, L, R), respiratory amplitude (QB, DB).

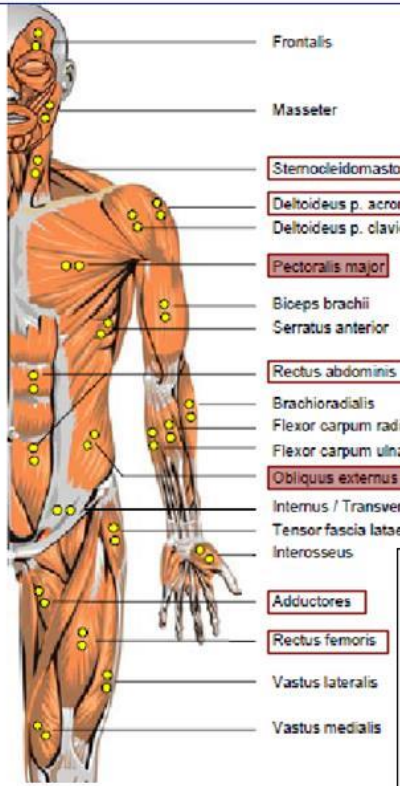
4 trials of 30-sec per condition

Data analysis: parameters calculated in time-domain and in frequency-domain

Muscular tension and postural equilibrium

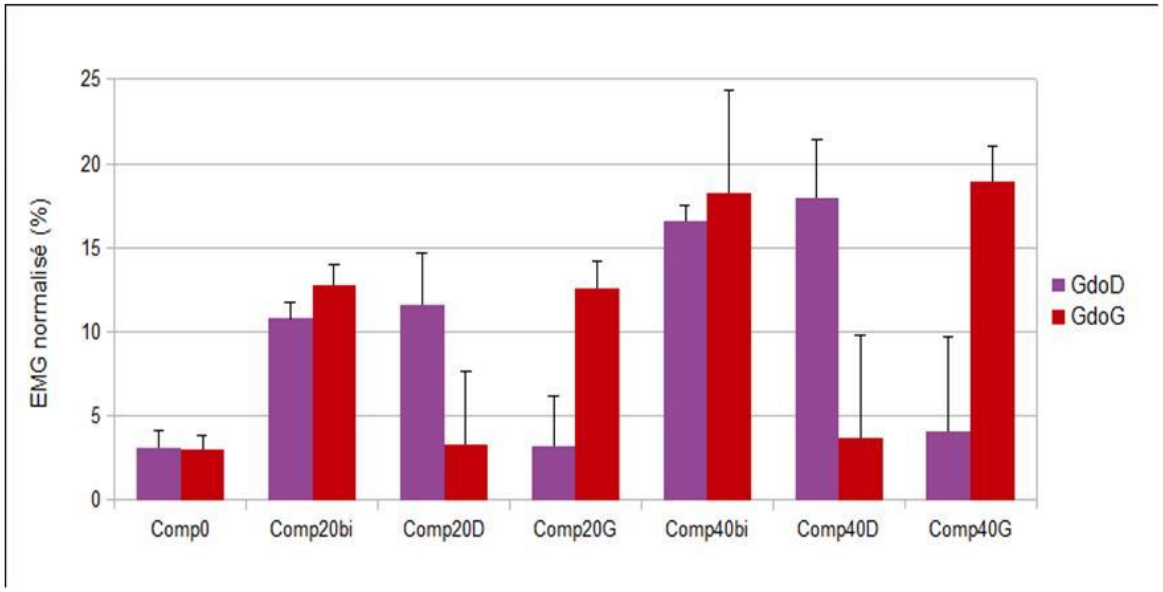
Method: 2 EMG pre-tests (15 muscles) intended to map out the main motor muscles of the task, and to ensure that their activity varied according to load applied on each side of pelvis





Results: the EMG activity of the main motor muscles was related to the compressive load level and side

=> reliability of the model



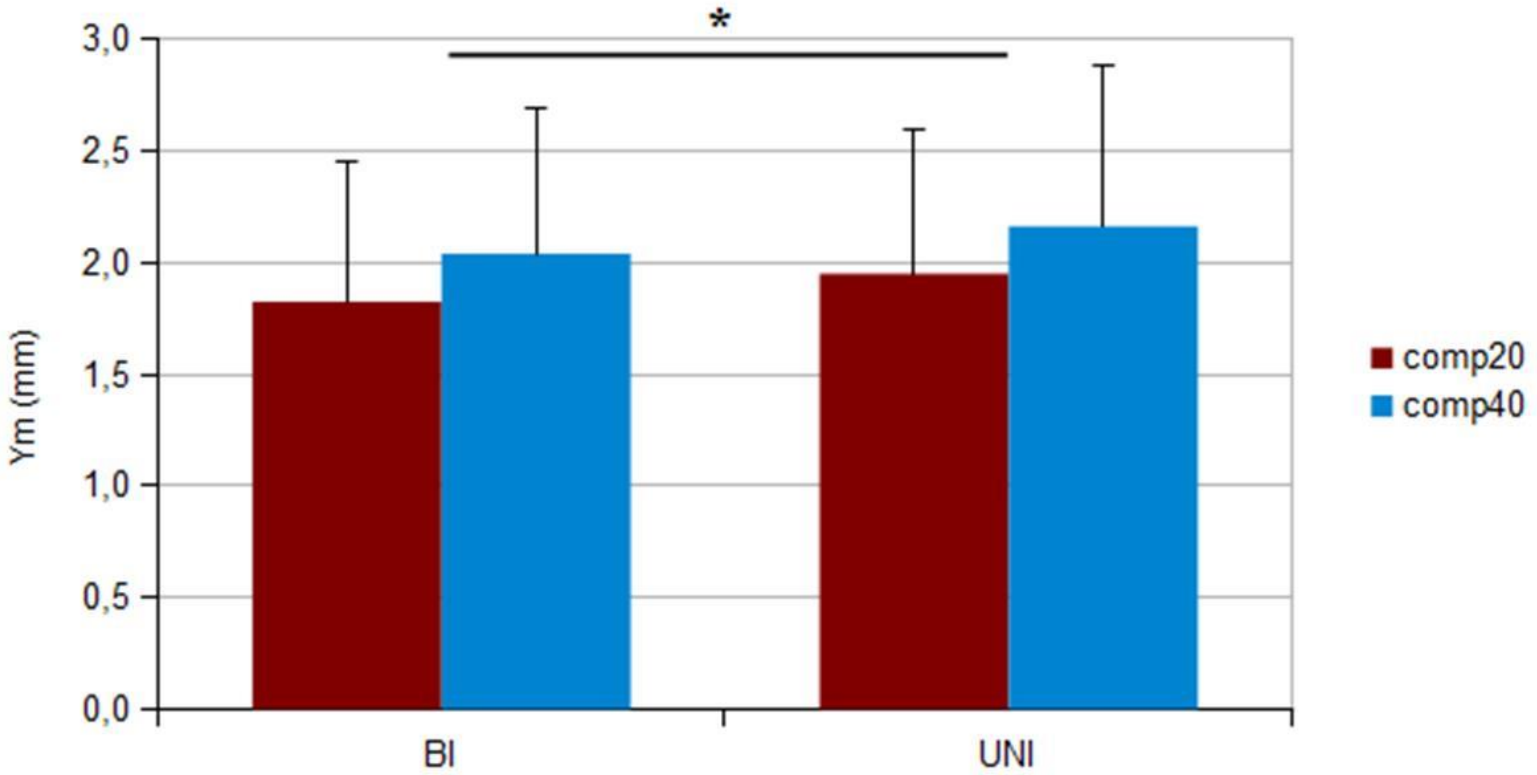
PoM Lab

Muscular tension and postural equilibrium

Results: in unilateral loads compared to bilateral loads

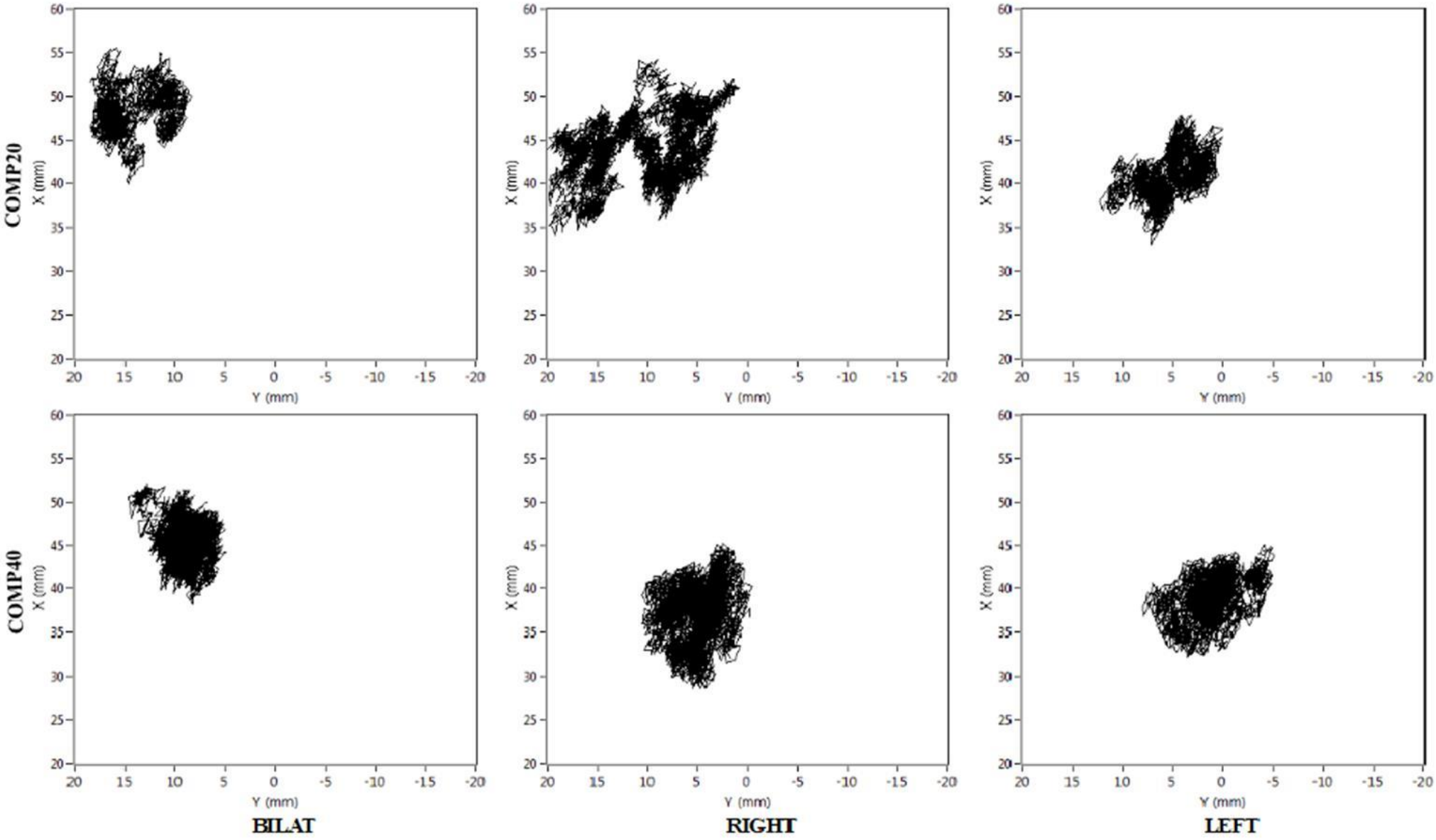
=> CP mean deviation along the ML axis (Ym) is higher ($p<0.05$)

=> CP mean position is located backwards (X0) ($p<0.05$)



Muscular tension and postural equilibrium

Results: stabilograms are larger and more backward in UNI than in BI



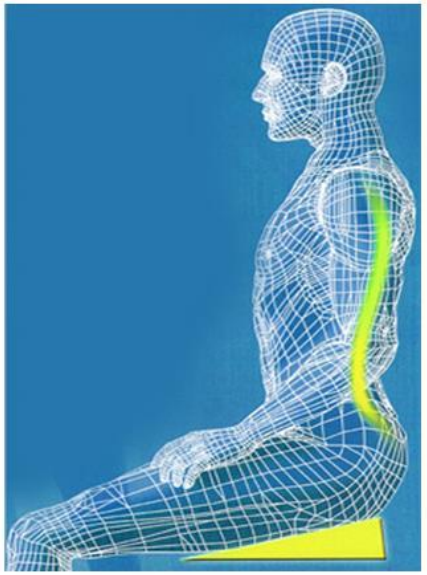
Muscular tension and postural equilibrium

Discussion:

=> Increase muscular tension is likely to disturb postural equilbrium more when it is asymmetrical:

- biomechanical hypothesis: asymmetry of the counter-disturbing and dampening mechanims => less efficient.
- neurophysiological hypothesis: asymmetry in the propriocetive flow between between the right and left muscles => more difficult to interpret by the CNS.

Hamaoui et Le Bozec, 2014



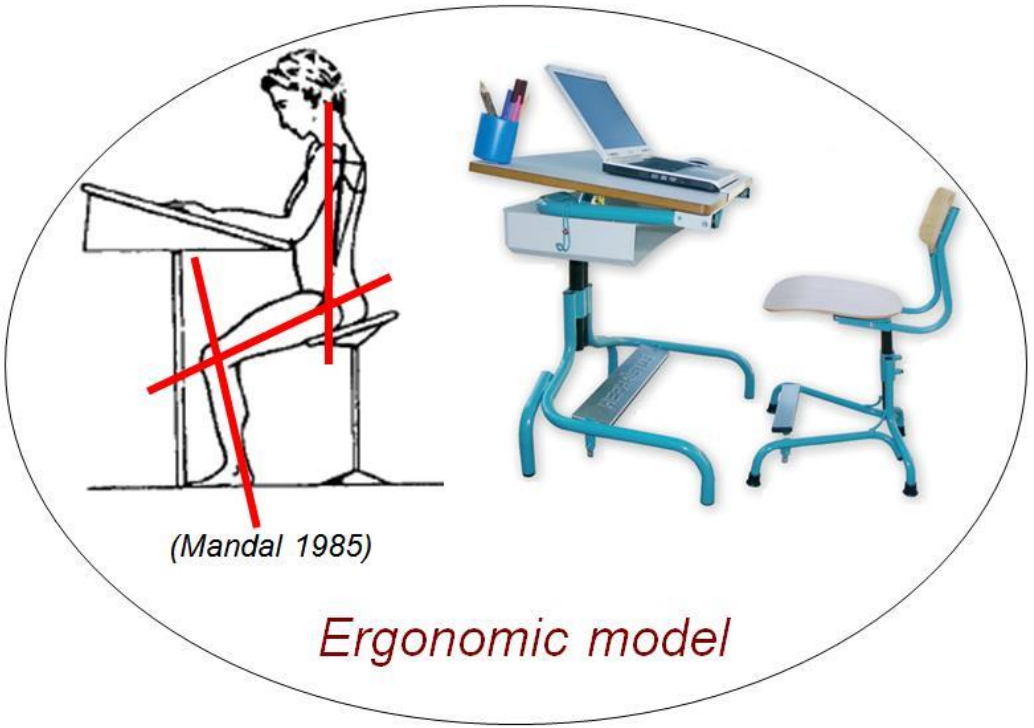
PoM Lab

Ergonomics of the seated posture

Aims of the project

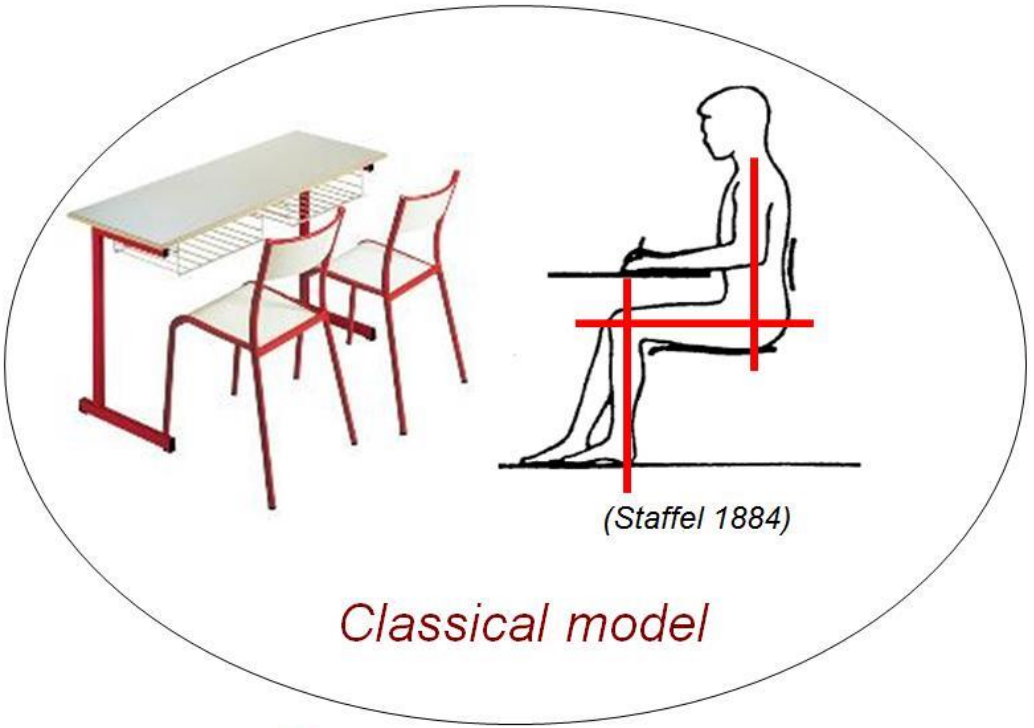
-Determine what are the best settings of the seat and table to reduce the biomechanical load applied on the musculo-skeletal system.

-Design of a plane seat.



(Mandal 1985)

Ergonomic model



(Staffel 1884)

Classical model

OR ?

PoM Lab

Ergonomics of the seated posture

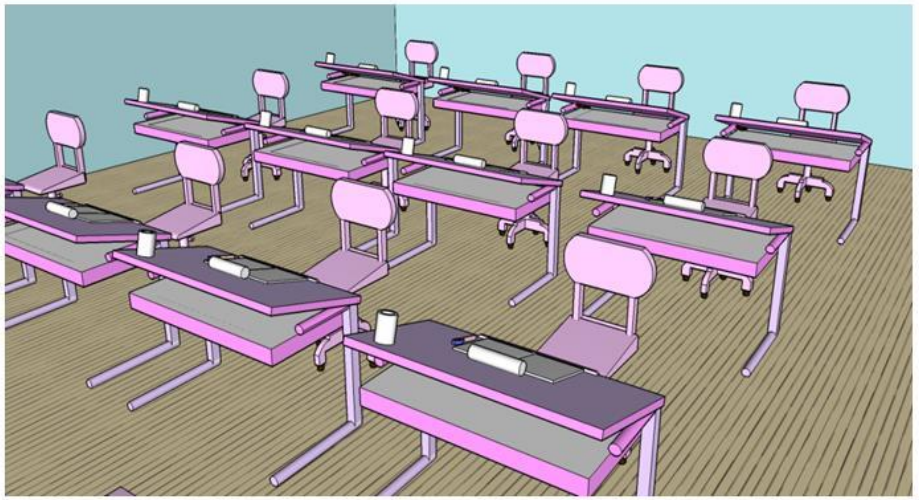
Partnerships

- Héphaïstos company (France)
- Midi-Pyrénées region
- ARTEC Aerospace

Hassaïne et al., 2014

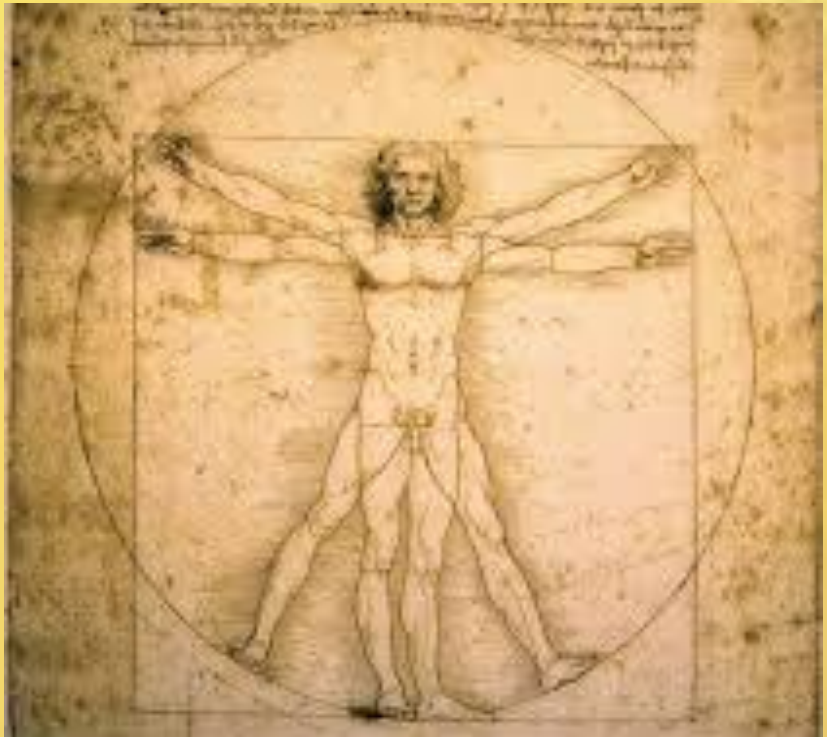
Fundings

- 2009-11: technology transfer: 100k€
- 2009-10: post-doc grant: 44k€
- 2011-14: doctoral grant: 90k€
- 2013-14: technology transfer: 10k€



Journal of Ergonomics Related Journals

- Occupational Medicine & Health
- Forensic Biomechanics
- Rheumatology: Current Research



Journal of Ergonomics Related Conferences

- 4th Dental health Congress Bangalore, India
- 5th International Conference and Exhibition on Occupational Health & Safety

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