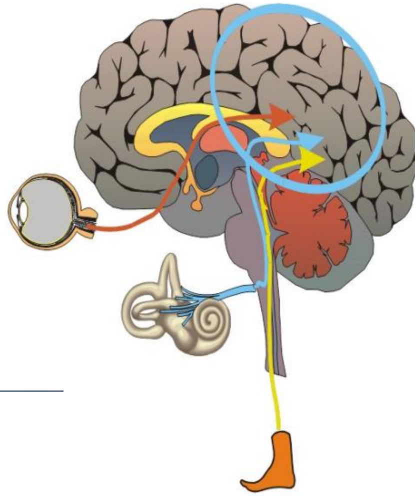
Enseignement National

DES de Médecine Physique et de Réadaptation – DIU de Rééducation

Module : Equilibre-Locomotion-Préhension

Toulouse dec 2025



Pathophysiology and semiology of postural and gait disorders

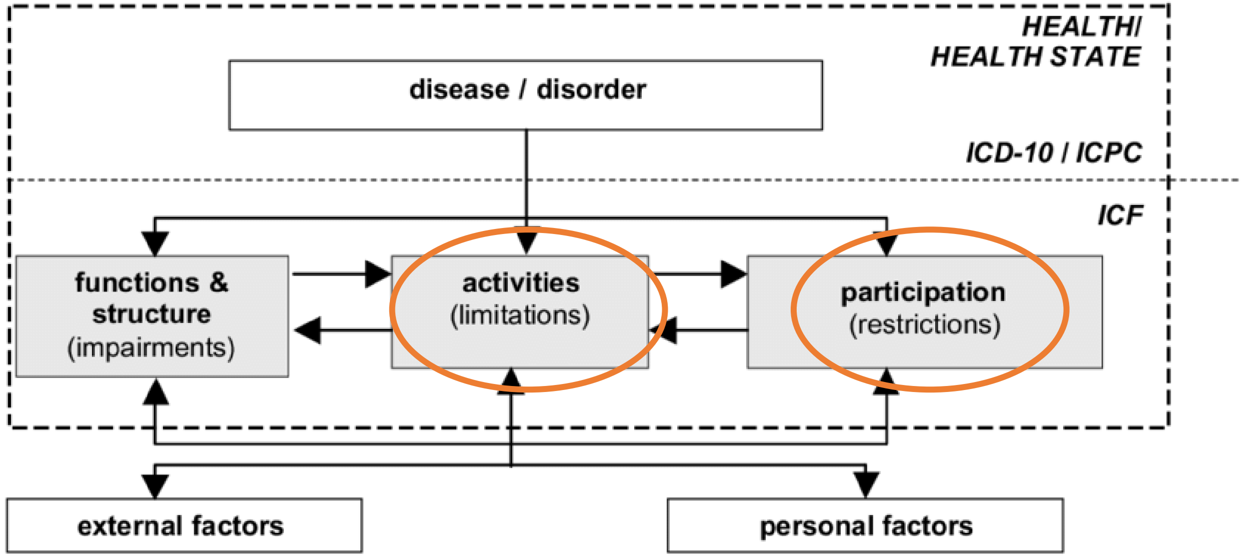
Prof Dominic Pérennou

Department of NeuroRehabilitation and Lab CNRS Neurocognition

Grenoble-Alpes University Hospital and University Grenoble-Alpes, France

International classification of functionning

- WHO -



d4 Mobility

- Changing and maintaining body position **d410-d429**
- Carrying, moving and handling objects **d430-d449**
- Walking and moving **d450-d469**
- Moving around using transportation **d470-d489**
- Mobility, other specified **d498**
- Mobility, unspecified **d499**

Interaction with
the environnement →

For a normal (appropriate) mobility, which functions are required ?

Which funtions must be relearned – trained ?

6 functions ensure mobility

- Verticalisation
- Orientation
- Stabilisation
- Propulsion
- Energy consomption
- Navigation

Postural control (Verticalisation, Orientation, Stabilisation)

Gait (Propulsion, Energy consomption, Navigation)

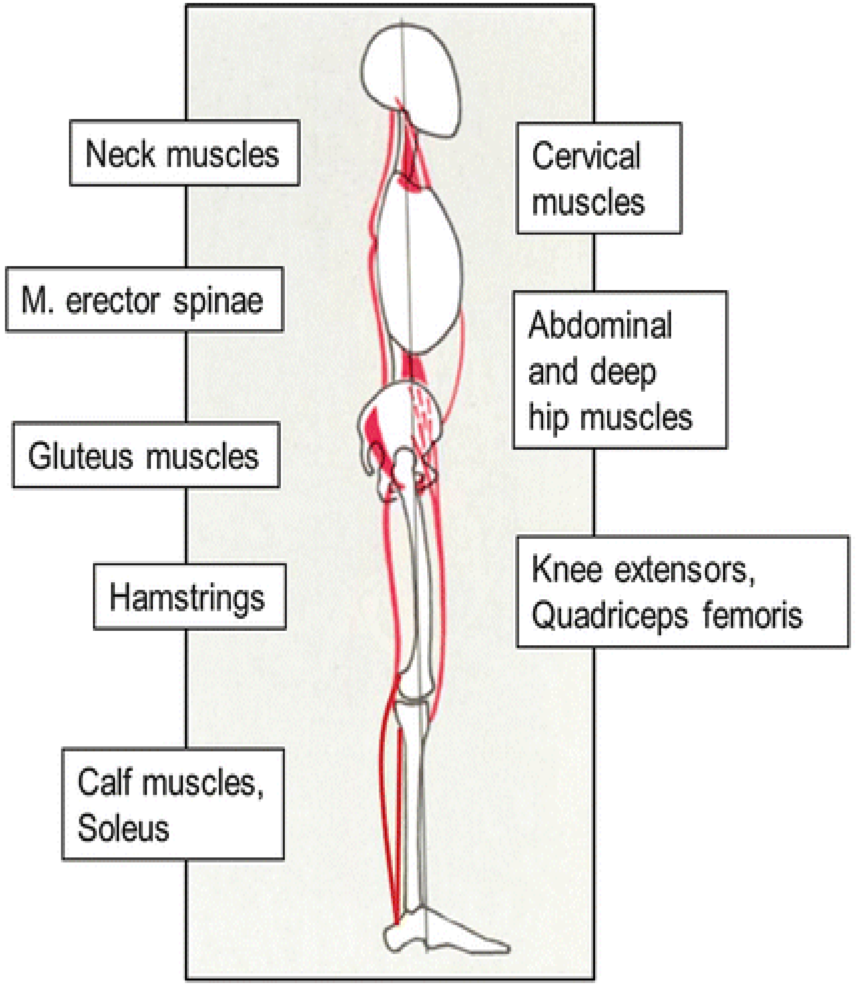
Verticalisation

Sufficient tone and strengh

Overall of posterior postural muscles

Verticalisation Pb if flacid paresis
Overall of posterior postural muscles

Anti-Gravity-Muscles of the Human Body (Postural Muscles)



Often difficult to identify per se vs orientation and stabilization in erect posture

Verticalisation may be impaired because

of a flacid paresis in central neurological conditions

problem on peripheral nervous system

In contrast verticalisation may be facilitated by spasticity (among other causes)

little evidence (no data?) on the positive influence of spasticity on the standing posture after stroke

May be trained

No evidence for early/very early verticalisation training on gait recovery after stroke

Efficacy and safety of very early mobilisation within 24 h of stroke onset (AVERT): a randomised controlled trial

*The AVERT Trial Collaboration group**

Lancet 2015

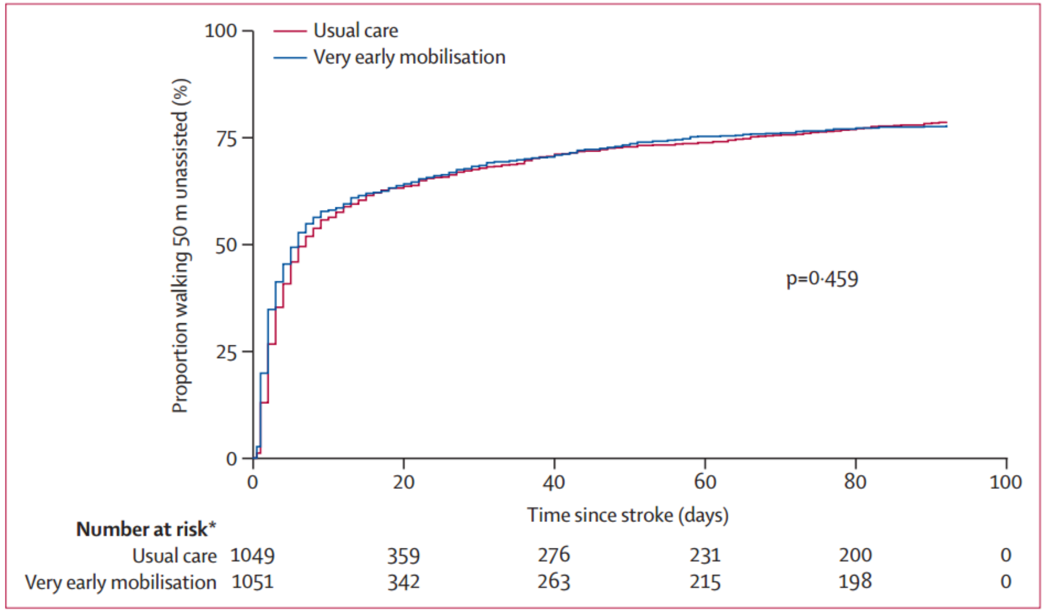


***Figure 3*: Time to walking unassisted 50 m by 3 months**
*Number of patients who had not achieved walking.

Negative result due to an inappropriate outcome ?

Do we need to change our practice regarding verticalisation ?

Do exoskeleton bring something ?

For a normal (appropriate) mobility, which functions are required ?

Which funtions must be relearned – trained ?

6 functions ensure mobility

- Verticalisation
- **Orientation**
- Stabilisation
- Propulsion
- Energy consomption
- Navigation in the environnent

Verticalisation, Orientation, Stabilisation: Postural control

Propulsion, Energy consomption, Navigation in the environnent: Gait

A theoretical frame
that might be better applied in clinical neurosciences ?

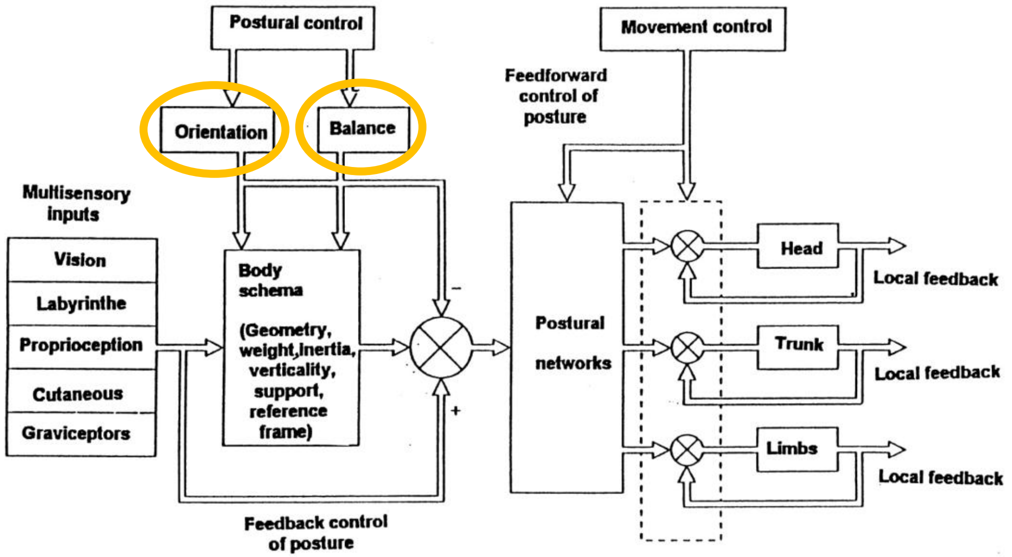


FIG. 1. Representation of the two levels of postural organisation, the body scheme and the postural networks.

Jean Massion – Marseille
Several conceptual articles from 1992 to 1998

Postural Orientation and Equilibrium

Supplement 29. Handbook of Physiology, Exercise: Regulation and Integration of Multiple Systems

Fay B. Horak, Jane M. Macpherson

Published online: **1 January 2011** | https://doi.org/10.1002/cphy.cp120107 | Citations: 82

Comprehensive Physiology
Browse other articles of this reference work:

BROWSE TABLE OF CONTENTS ›
BROWSE BY TOPIC ›
BROWSE A-Z ›

Modélisation des déficits d'orientation verticale

Atteinte unilatérale du tronc cérébral ou vestibulaire périphérique: Pb d'orientation lié à une asymétrie de tonus. Ipsilésionnel

Atteinte hémisphérique unilatérale (cortex parietal, temporal ou insulaire, thalamus; D > G): Pb d'orientation latérale lié à un biais dans la verticale biologique. Contralesionnel

Atteinte centrale bilatérale sur les voies de la graviception somesthésique ou vestibulaire : **Pb d'orientation sagittale lié à un biais dans la verticale biologique + tonus extenseurs?**

Atteinte bilatérale sur les voies de la graviception somesthésique ou vestibulaire périphérique (centrale ou périphérique): incertitude sur la direction de la verticale.

Orientation with respect to verticality

lateropulsion

retropulsion

Dissociation posture mouvement neuronal support in animals

nature communications

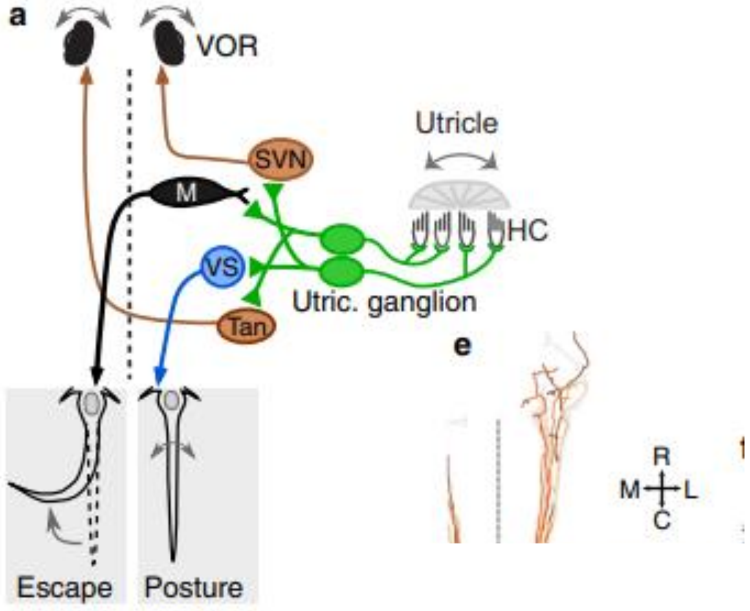
Article
https://doi.org/10.1038/s41467-022-32824-w

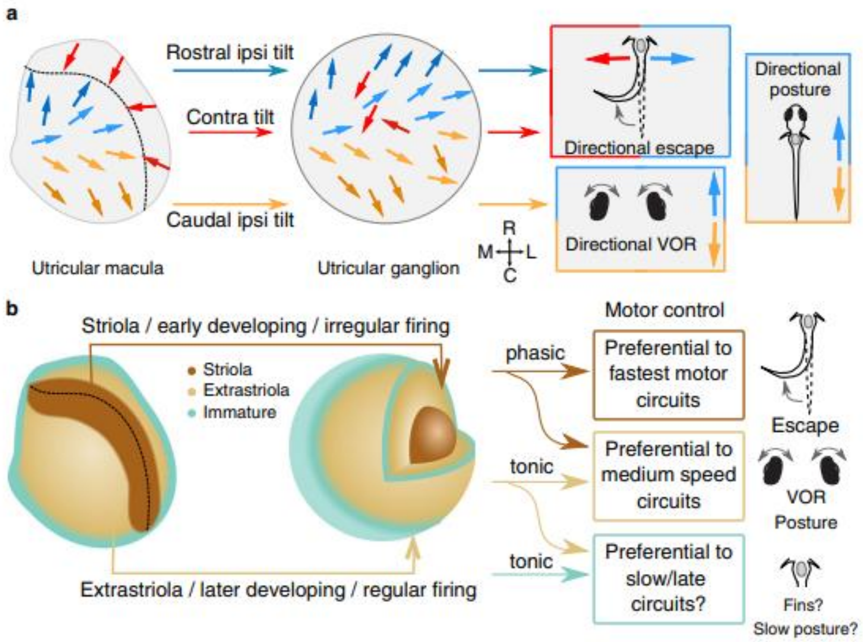
Organization of the gravity-sensing system in zebrafish

Received: 11 October 2021

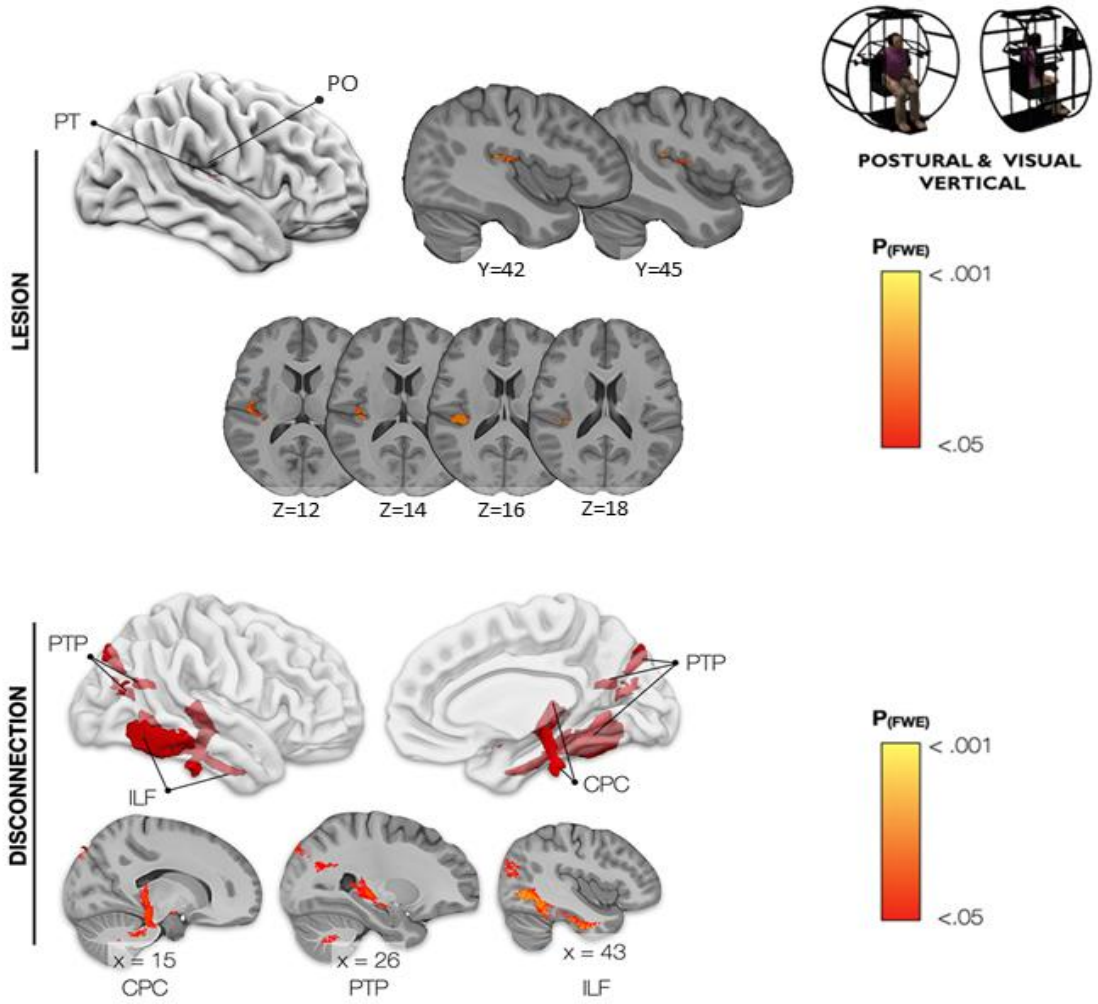
Accepted: 18 August 2022

Zhikai Liu[1], David G. C. Hildebrand[2], Joshua L. Morgan[3], Yizhen Jia[1], Nicholas Slimmon[1] & Martha W. Bagnall[1]



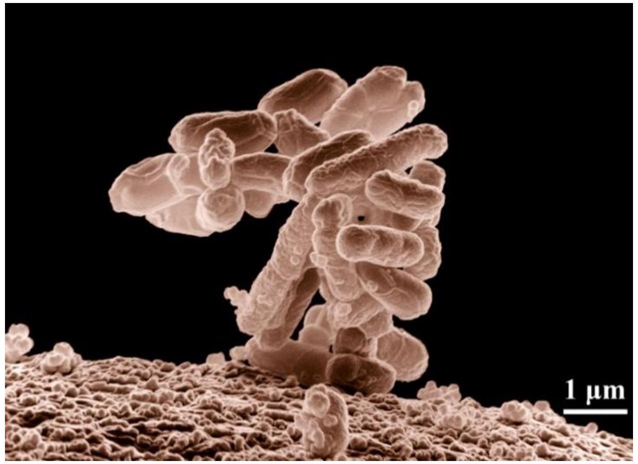


Core of the sense of upright in Human



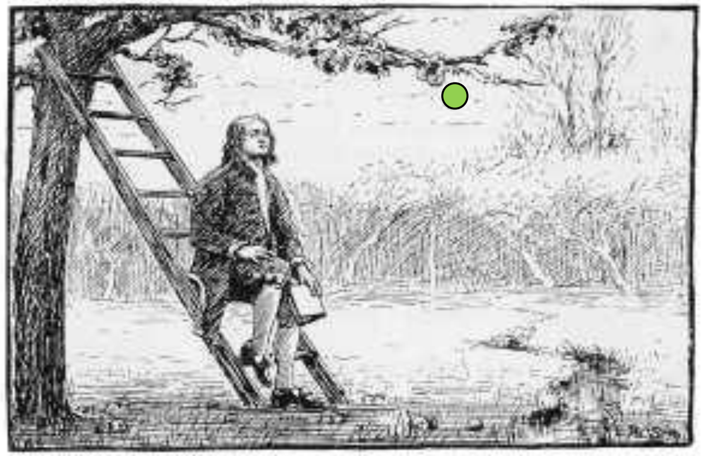
Piscicelli et al in preparation

Gravity sensing is universal on Earth



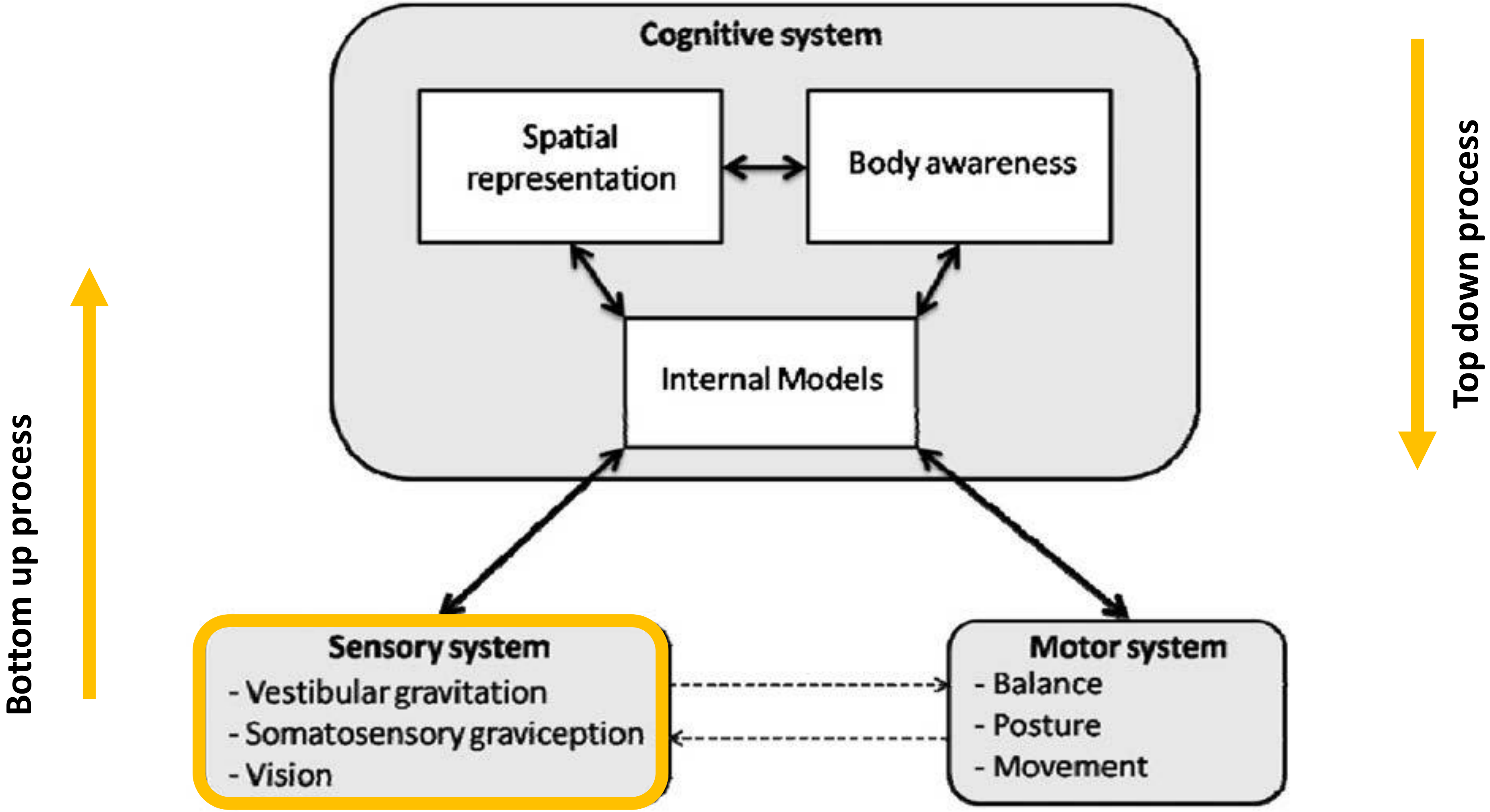
Unicellular organs
Vestibular like gravity sensing

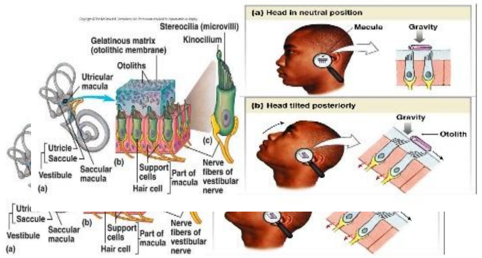
Plants
Proprioception like gravity sensing



Animals and Humans
Polymodal sense of upright
Internal models

Integrated model of the sense of upright



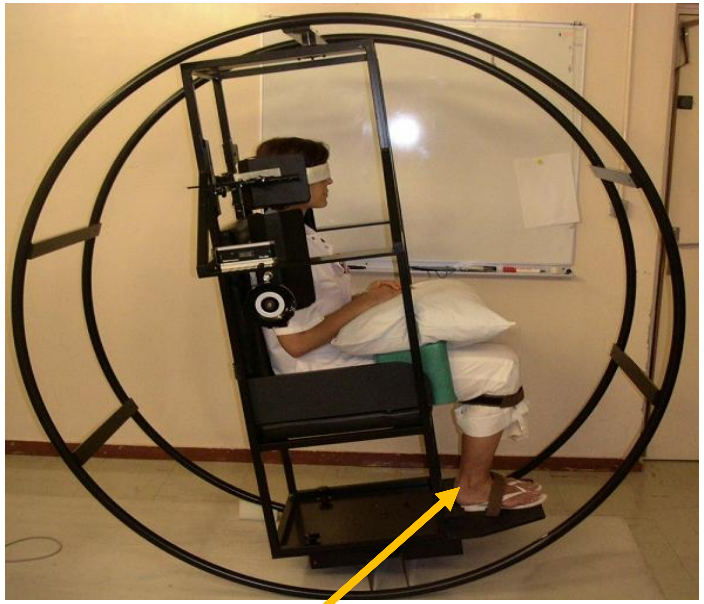


+ prehension, writing horizontal

Barra, Pérennou et al, Neuropsychologia 2012

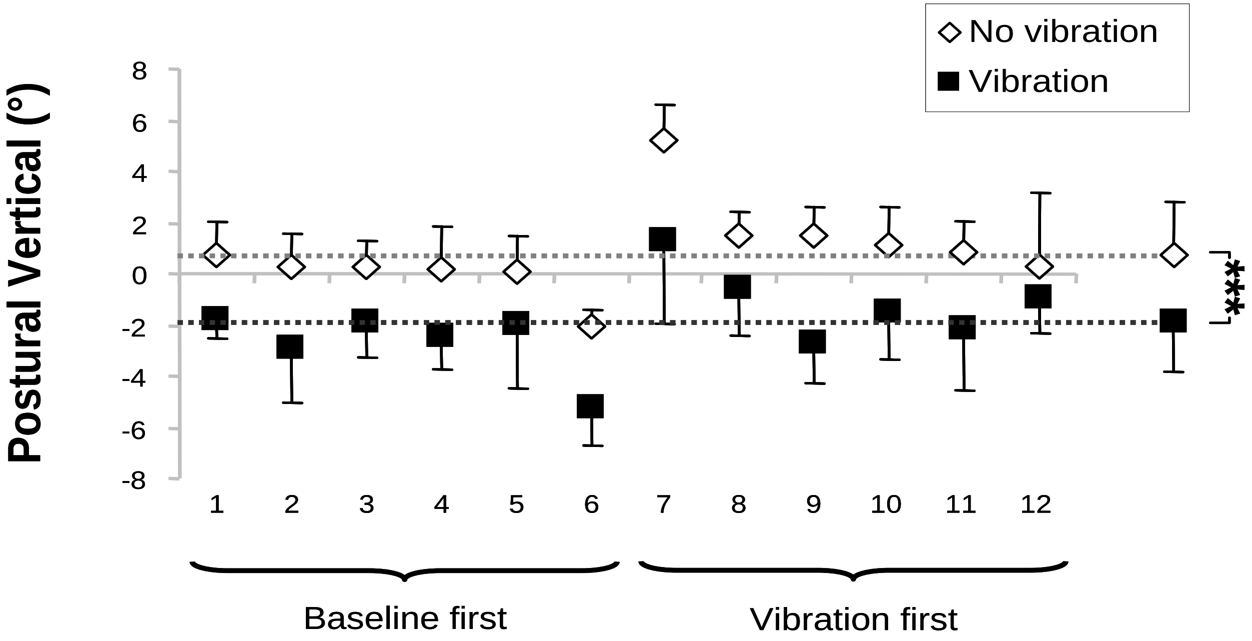
Proprioception contributes to gravity sensing

Tendino-muscular vibration in normal indivuals



Vibration

Individual data

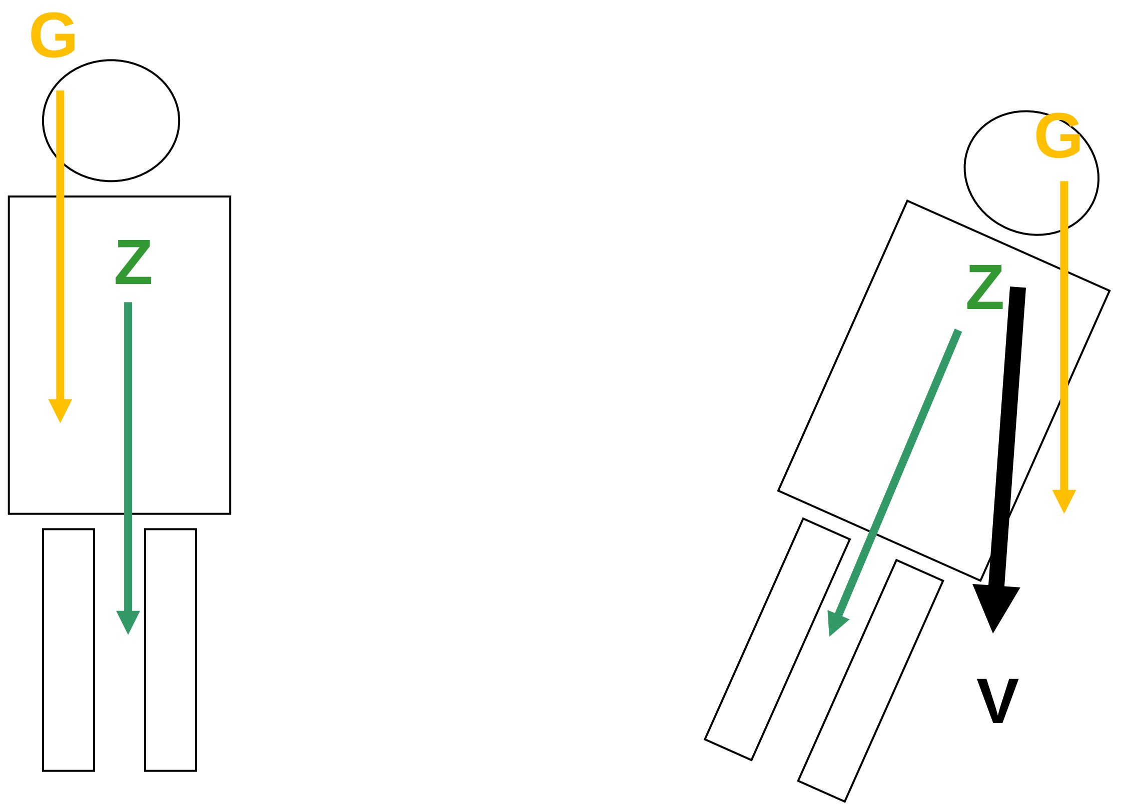


Subjects

Barbieri et al EBR 2008

The sens of verticality is supported by internal models

The Aubert effect : allows analysing the interplay between somaesthetic and vestibular information in the internal model of verticality



G : otolithic graviception

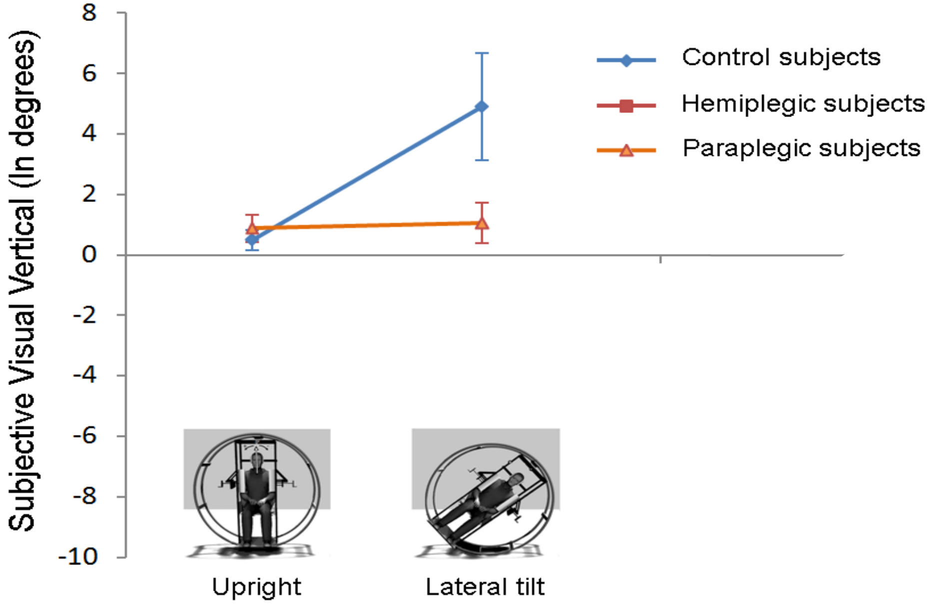
Z : somaesthetic graviception

V : verticality representation

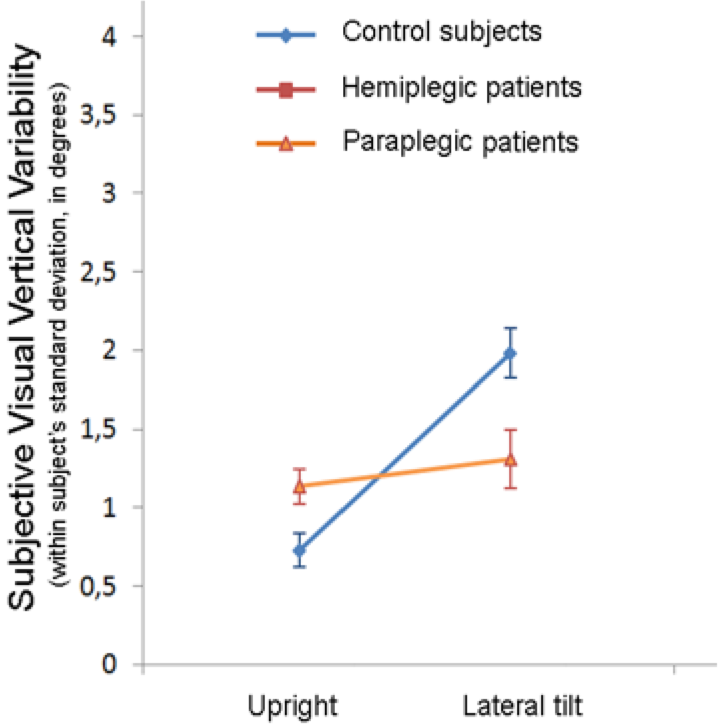
Brain Advance Access published November 19, 2010
doi:10.1093/brain/awq311 Brain 2010: Page 1 of 12 | 1
BRAIN
A JOURNAL OF NEUROLOGY

Humans use internal models to construct and update a sense of verticality

Julien Barra,[1,2] Adélaïde Marquer,[2] Roxane Joassin,[3] Céline Reymond,[2] Liliane Metge,[4] Valérie Chauvineau[5] and Dominic Pérennou[2,3,5]



Paraplegics: VV orientation



Paraplegics: VV uncertainty

Brain Advance Access published November 19, 2010
doi:10.1093/brain/awq311 Brain 2010: Page 1 of 12 | 1
BRAIN
A JOURNAL OF NEUROLOGY

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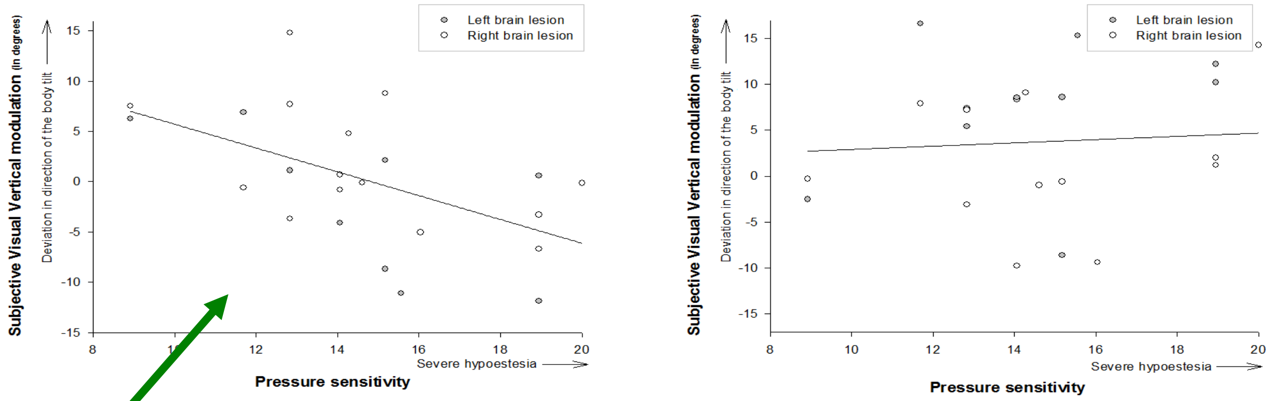
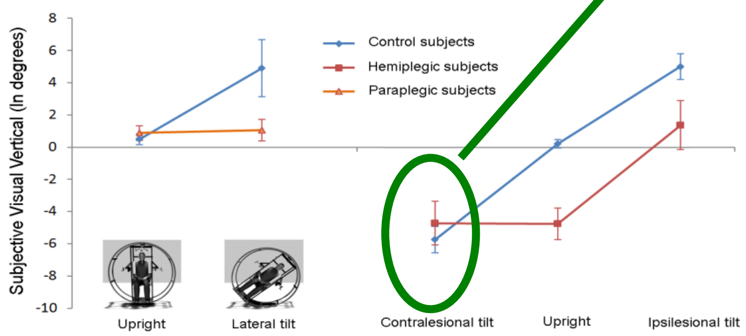


a) SVV Modulation after contralesional body tilt

b) SVV Modulation after Ipsilesional tilt

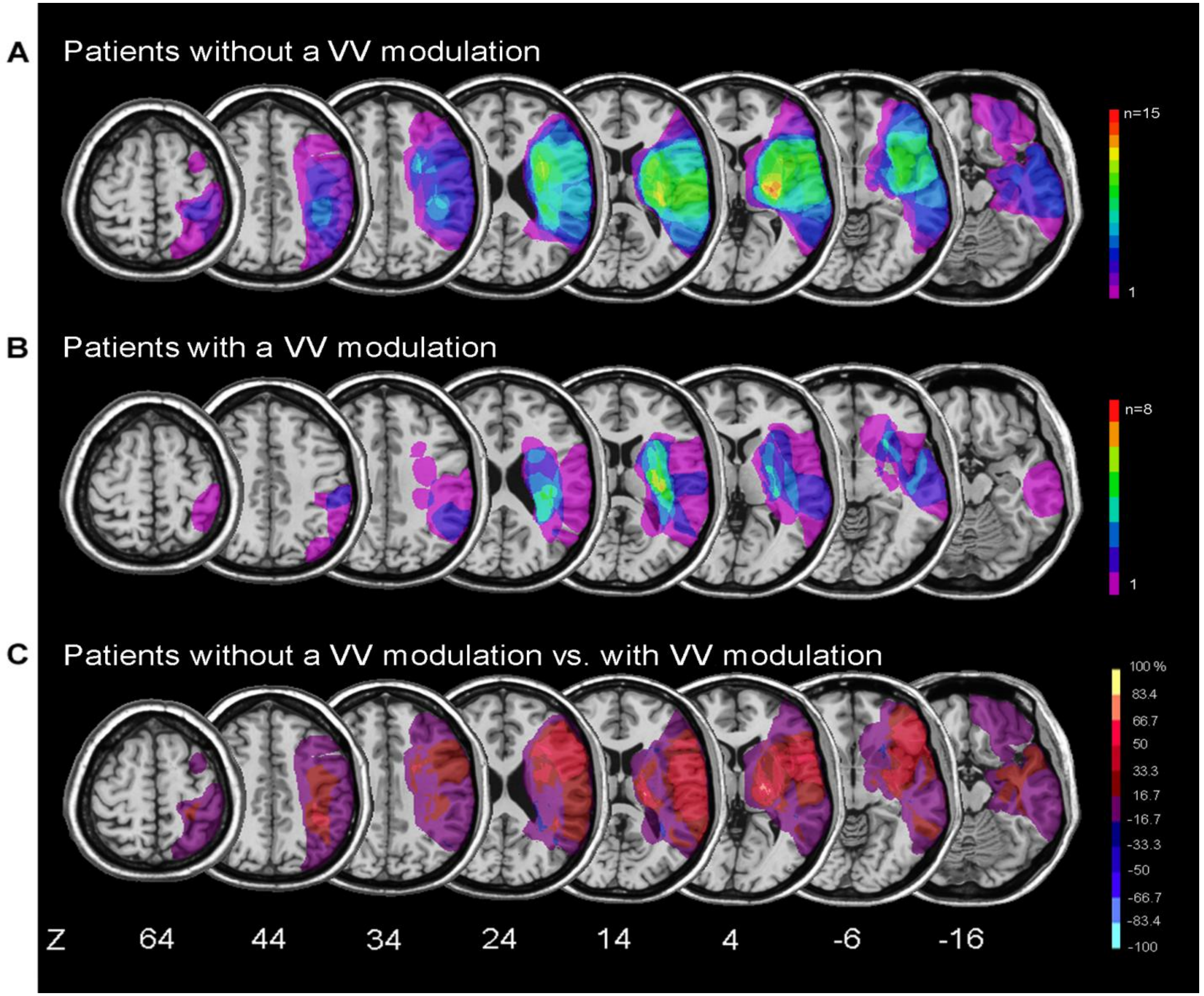


a) Paraplegic subjects

b) Hemiplegic subjects

Hemiplegics: VV orientation

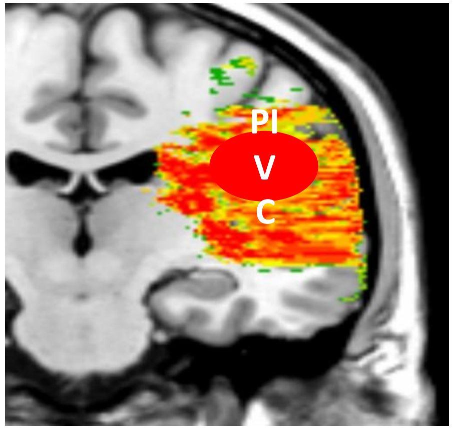
Rôle crucial du thalamus postéro-latéral dans la synthèse des graviceptions vestibulaires et somesthésiques : modèle interne de verticalité



Barra et al Brain 2010

Two types of lateropulsion

Parieto-Insular
Vestibular Cortex



Posterolateral
thalamus

Brandt and Dieterich 2019

Hemisphere (PI cortex, thalamus)

The person aligns her/his body
onto an abnormal reference of
verticality, tilted the side opposite the lesion

Contralesional lateropulsion

Patient frequently unaware of the lateropulsion

Pushing : the most dramatic clinical manifestation

Two types of lateropulsion

Brain stem (Wallenberg)

Likely caused by trouble on vestibulo-spinal pathways (tonic asymmetry)

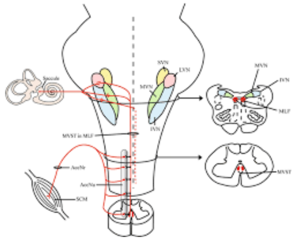
Ipsilesional lateropulsion

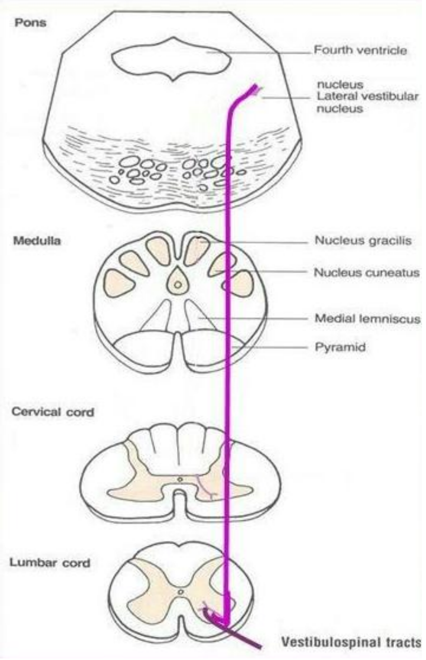
Non causal association with symptoms of vestibulo-ocular pathways : ipsilesional ocular torsion, skew deviation, head tilt, VV tilt

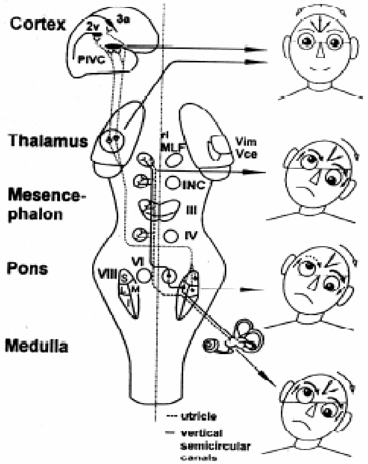
Verticality representation (quasi)normal

Patient aware of the lateropulsion

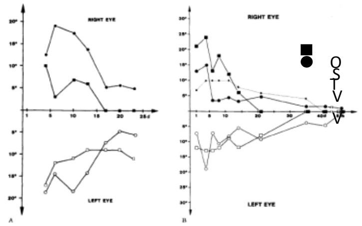
Prevalence about 80% acute phase,
not known other phases







Brandt & Dieterich



From Brandt & Dieterich 1994

Some words about terminology

History

Babinski & Nageotte 1902 : first occurrence of the word lateropusion in the literature

André Thomas 1940: Description of the association of 3 signs : body tilt, active pushing, resistance

Patricia Davies 1980: pusher syndrome

2000-2020 disputes

Consensus (almost)

Dai & Pérennou 2021

Nolan et al 2022

Lateropulsion definition

One of the three components

Lateral Body tilt / active pushing / resistance to passive correction

Terminology « pusher syndrome » less and less used

→ **Ne plus considérer uniquement les formes sévères, spectaculaires**

Body tilt
well revealed by the STS

Resistance to directionnal
passive correction

Obvious active pushing
Resistance to correction

Lateropulsion prevalence after stroke

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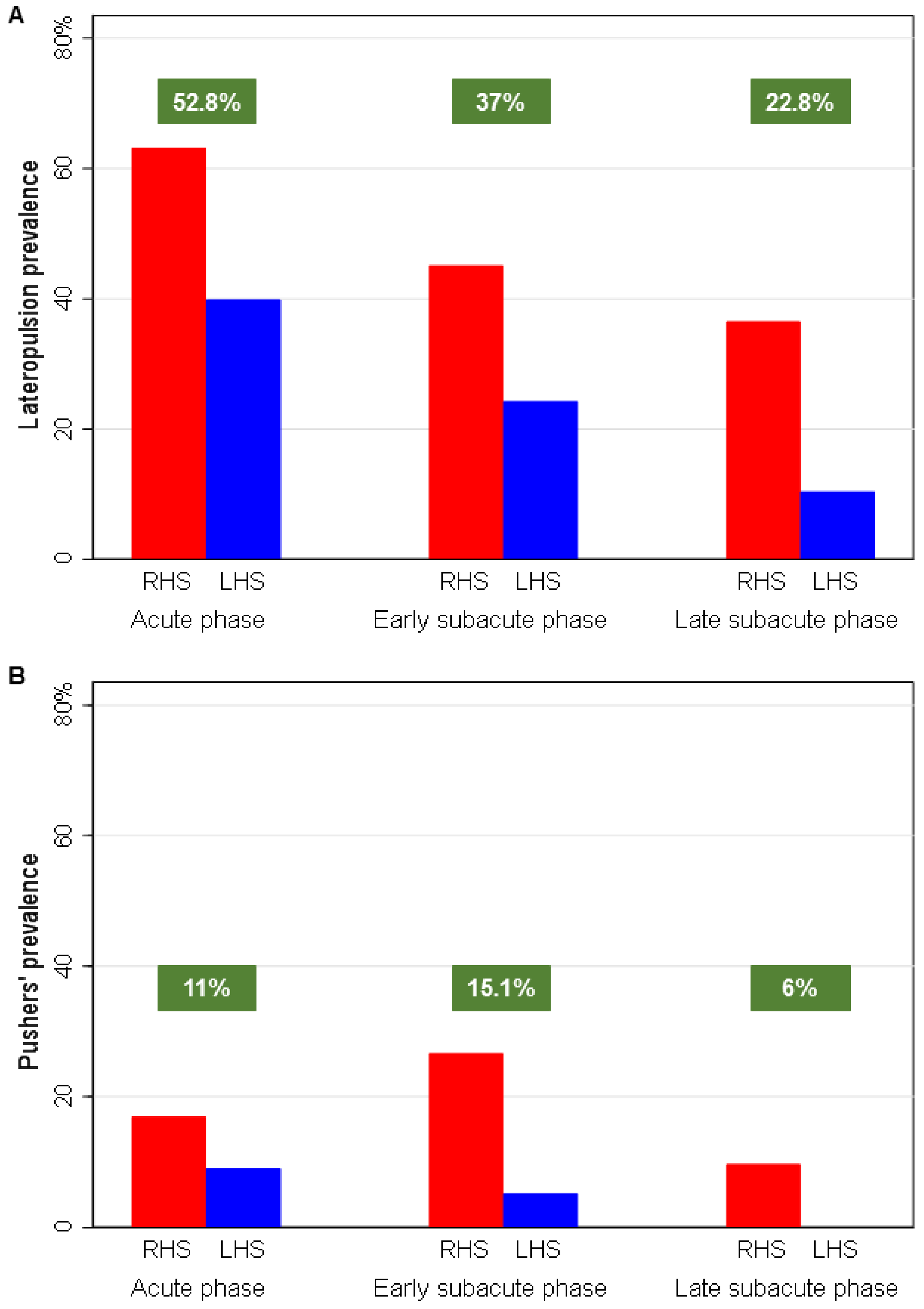
AMERICAN ACADEMY OF NEUROLOGY.

February 21, 2022 RESEARCH ARTICLE

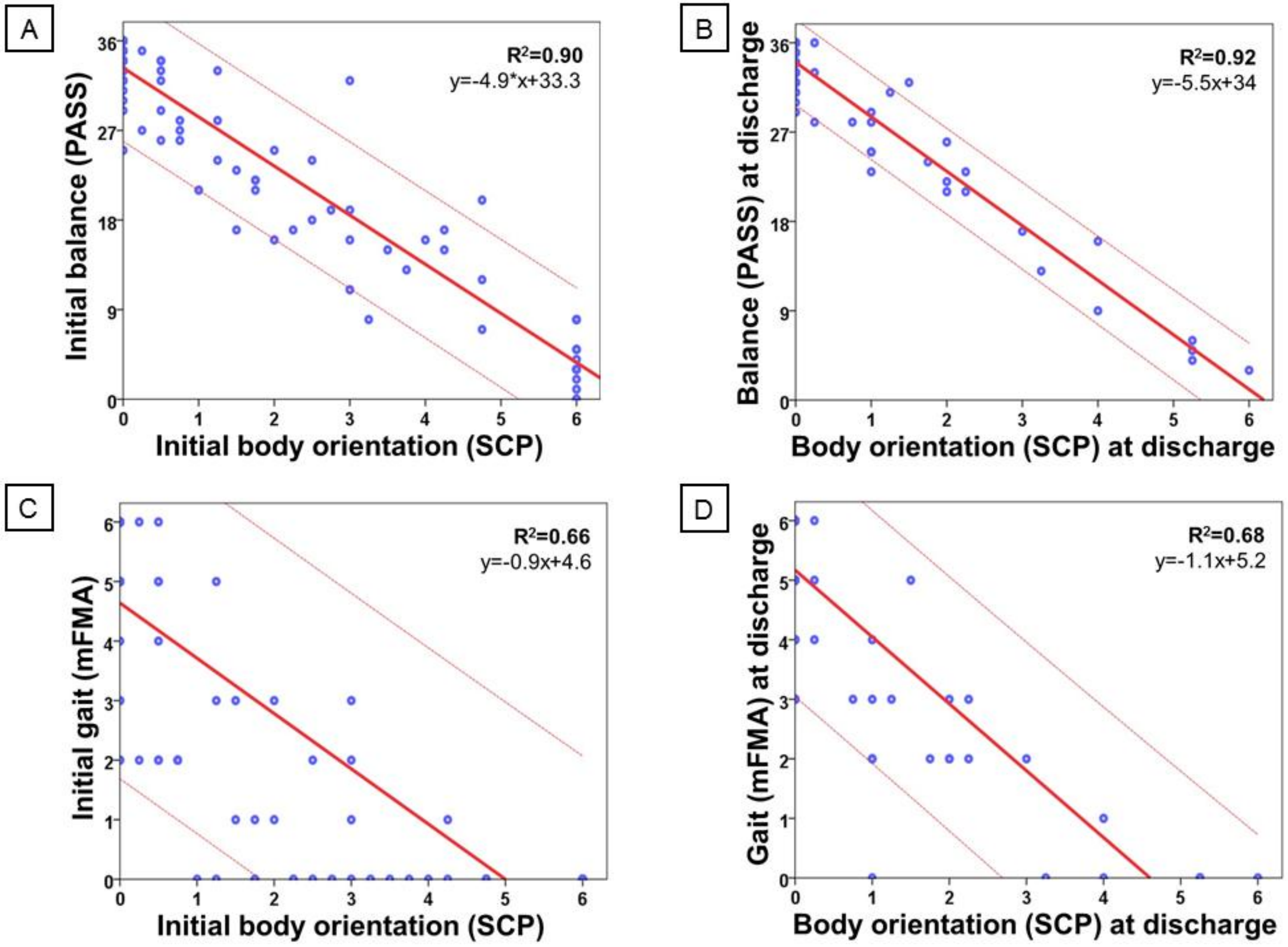
Lateropulsion Prevalence after Stroke: A Systematic Review and Meta-analysis

Shenhao Dai, Camille Lemaire, Celine Piscicelli, Dominic Pérennou

First published February 21, 2022, DOI: https://doi.org/10.1212/WNL.0000000000200010



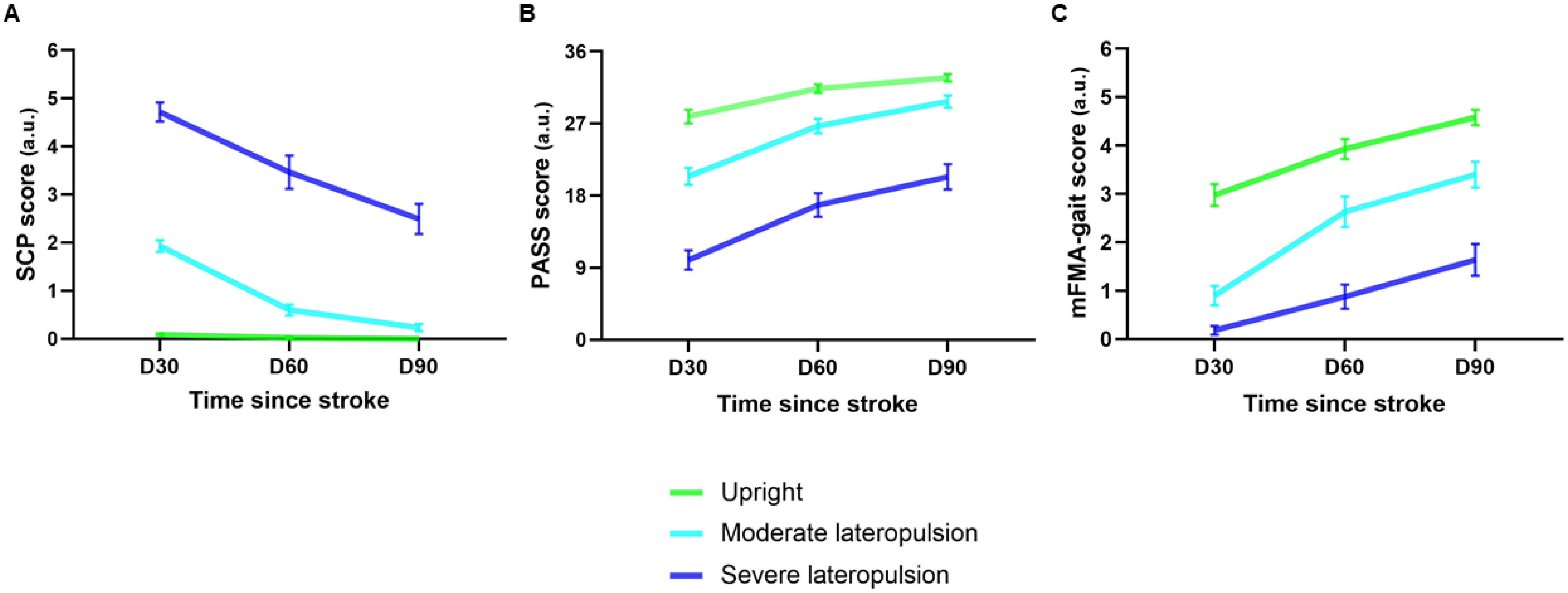
Balance and gait disorders after hemisphere stroke mainly due to lateropulsion at the subacute phase



Dai et al Neurology 2021

And we know that gait disorders mainly due to balance disorders (abondant literature)

Series >100 patients

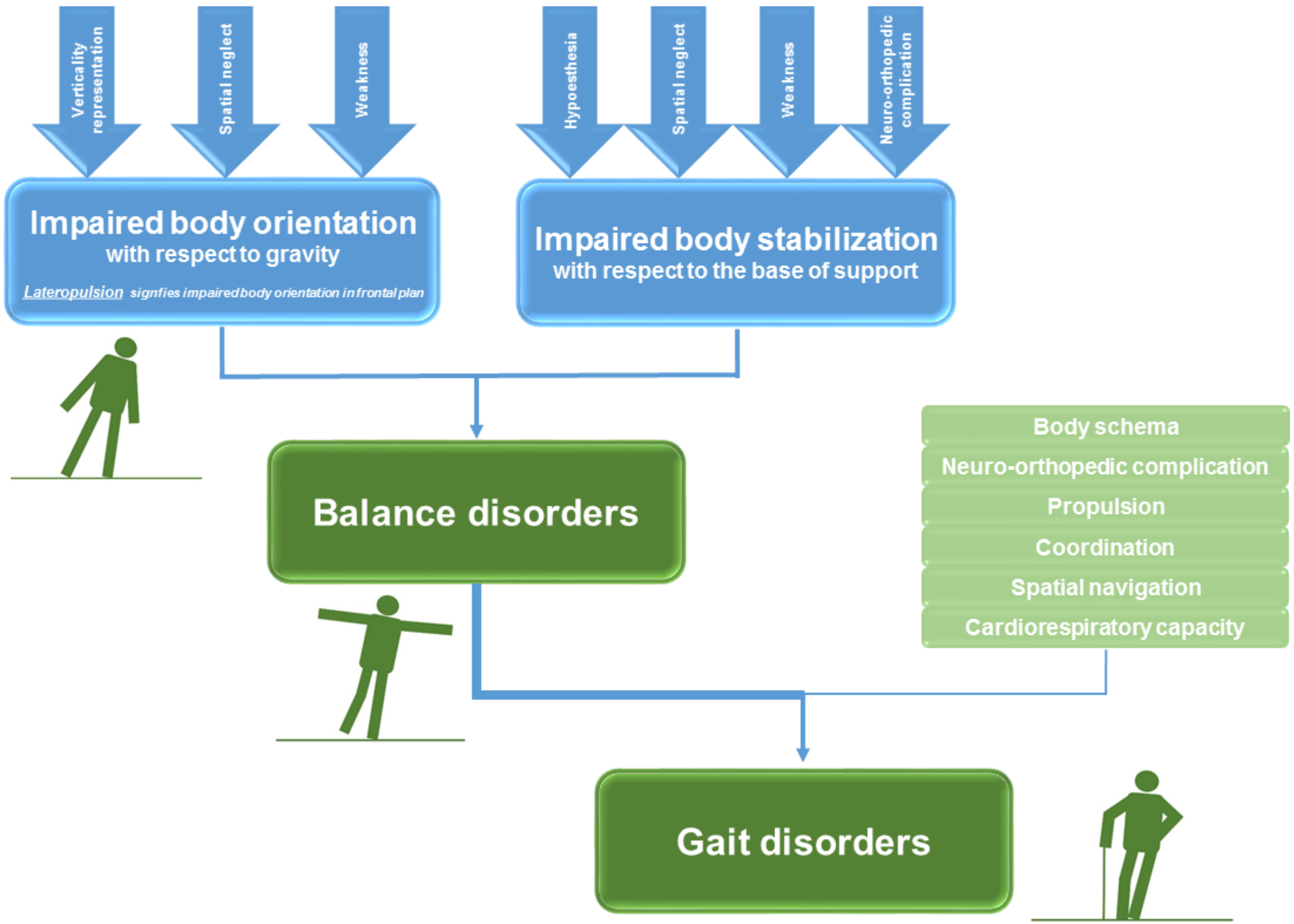


Balance and gait recover without lateropulsion alleviation, due to a better postural stabilisation

40% of lateropulsion recovery explain balance recovery, before D60 ++

Dai et al Annals PRM 2023

Gait disorders after stroke



Dai et al Neurology 2021

Stabilisation vs orientation after stroke
According to balance difficulty

Sitting Posture

Effet délétère latéropulsion +++

Effet délétère weakness +

Pas d’effet autres déficit

Pas d’effet âge

Hugues et al in preparation

Standing posture

		β_0	β	SE	z value	p value
Unable to stand alone	Intercept	-3.41	-19.86	5.30	-3.75	$<10^{-3}$
	Motor weakness	6.38	0.51	0.08	6.00	**$<10^{-6}$**
	Lateropulsion	4.44	2.61	0.87	3.00	**0.003**
	Hypoesthesia (moderate/severe)	3.33	3.33	1.26	2.64	**0.009**
	Age	*1.41*	*0.11*	*0.06*	*1.82*	*0.07*
	Limb apraxia	1.20	0.39	0.20	1.99	**0.048**
	Executive function deficits (moderate/severe)	*-1.20*	-1.20	1.36	-0.88	*0.38*
	Lateral homonymous hemianopia (yes)	0.59	0.59	1.53	0.38	0.70
	Spatial neglect	0.02	0.00	0.05	0.02	0.98
Stood alone with difficulty	Intercept	1.38	-7.02	1.73	-4.05	$<10^{-4}$
	Motor weakness	3.65	0.29	0.06	5.19	**10^{-6}**
	Lateropulsion	2.08	1.22	0.76	1.60	0.11
	Hypoesthesia (moderate/severe)	1.29	1.29	0.49	2.64	**0.009**
	Lateral homonymous hemianopia (yes)	*1.14*	*1.14*	*0.61*	*1.88*	*0.06*
	Age	0.71	0.06	0.02	2.41	**0.02**
	Limb apraxia	0.50	0.16	0.12	1.42	0.16
	Spatial neglect	-0.21	-0.01	0.03	-0.39	0.70
	Executive function deficits (moderate/severe)	-0.06	-0.06	0.53	-0.11	0.91

Hugues et al - Annals PRM - revision

Lateropulsion, a major determinant of fall risk after a right hemisphere stroke

Patients assessed at D30 post-stroke

Followed 2 years

Logistic regression to predict fallers for right hemisphere strokes

Lateropulsion : OR=8.1; 95% IC [2.2-29.8]; p=0.002

Incontinence: OR=5.7; 95% IC [1.3-24.3];p=0.019

→ **Fall prevention +++**

Gimat et al., in preparation

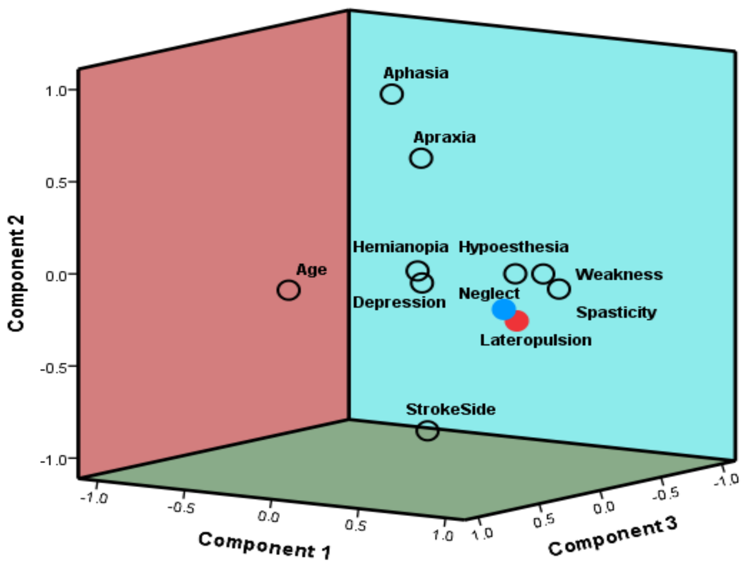
SHARE April 27, 2021; 96 (17) ARTICLE

Lateropulsion After Hemispheric Stroke

A Form of Spatial Neglect Involving Graviception

Shenhao Dai, Céline Piscicelli, Emmanuelle Clarac, Monica Baciu, Marc Hommel, Dominic Pérennou

First published March 15, 2021, DOI: https://doi.org/10.1212/WNL.0000000000011826



A factorial analysis revealed a strong proximity between lateropulsion and spatial neglect in the 3 dimension structure determining the data set

Score for Contraversive Pushing (SCP), Karnath et al Neurology 2000

***Table 1** Clinical assessment scale for contraversive pushing**

		Sitting	Standing
(A) Posture (symmetry of spontaneous posture)			
Score 1 = severe contraversive tilt with falling to the contralesional side		☐	☐
Score 0.75 = severe contraversive tilt without falling		☐	☐
Score 0.25 = mild contraversive tilt without falling		☐	☐
Score 0 = no tilt / upright body orientation		☐	☐
	Total (max = 2):		
(B) Extension (use of the arm/leg to extend the area of physical contact to the ground)			
Score 1 = performed already in rest		☐	☐
Score 0.5 = performed not until position is changed		☐	☐
Score 0 = no extension		☐	☐
	Total (max = 2):		
(C) Resistance (resistance to passive correction of posture to an upright position)			
Score 1 = resistance is shown		☐	☐
Score 0 = resistance is not shown		☐	☐
	Total (max = 2):		

* Translated from Karnath H-O, Brötz D, Götz A. Clinical symptoms, origin, and therapy of the "pusher syndrome." Nervenarzt: In press.

Insufficient clinical properties of existing lateropulsion scales → a new one in preparation

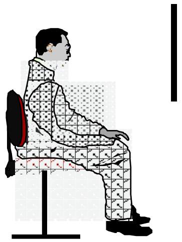
4 domains

- Lateral body tilt
- Unawareness of the body tilt
- Active pushing
- Resistance

Postural tasks to detect light forms of lateropulsion

- Standing feet together
- Dynamic tasks: STS, gait
- With and without vision

Two main modalities for measuring verticality perception

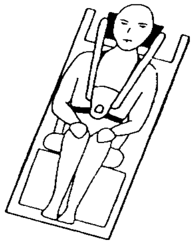


Visual vertical (VV)

Witkin et Asch , 1948

Normality from -2.5° to + 2.5°

Vision and otolithic graviception



Postural vertical (PV)

Clark and Graybiel, 1963

Normality from -2.5° to + 2.5°

Somaesthetic graviception

Visceral graviceptors
Proprioception
Cutaneous pressure

Mesurer la verticale posturale
- Wheel paradigm -

Noir complet

Tête, tronc, membres tenus

Suject aléatoirement incliné (15-45°), puis ramené dans la direction opposée jusqu'à se percevoir vertical.

Vitesse lente (1.5°/s) et constante pour réduire stimulation canaux semicirculair es

Inclinaison mesurée avec inclinomètre

VP teste graviception somaesthesique

Gravicepteurs viscéraux,Proprioception, Pression cutanée

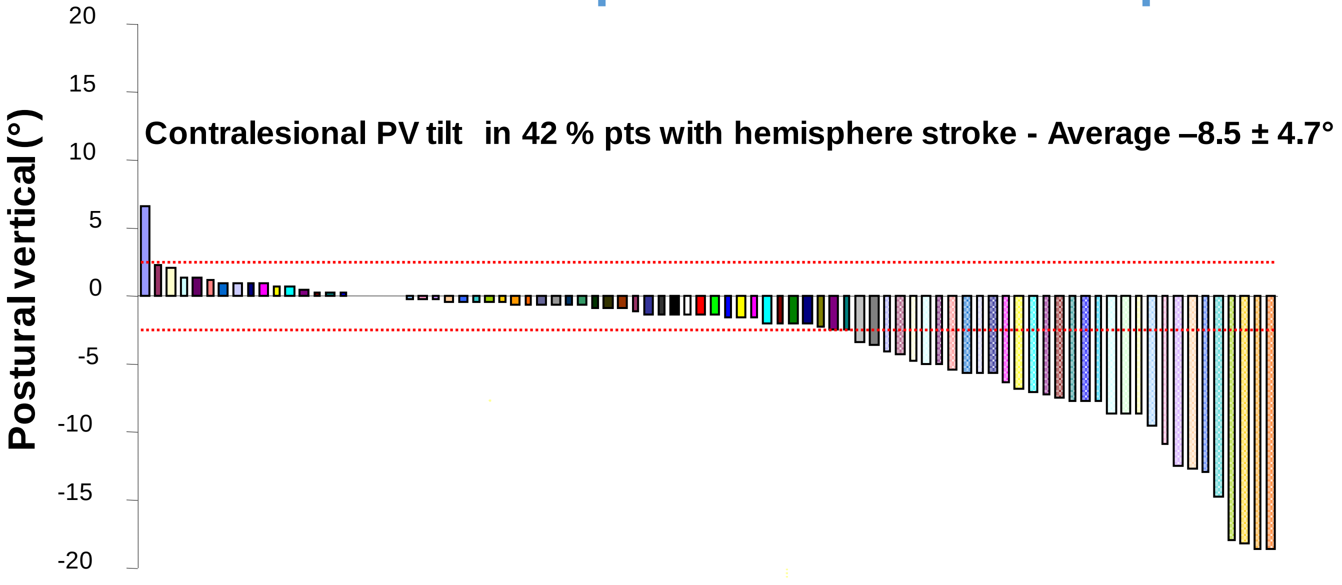
Dites "stop" lorsque vous êtes vertical

Sujets normaux réalisent cette tâche très précisément, limites de normalité -2.5° à +2.5°
Valeurs positives pour inclinaisons droites (normaux) or ipsilesionelles (patients)

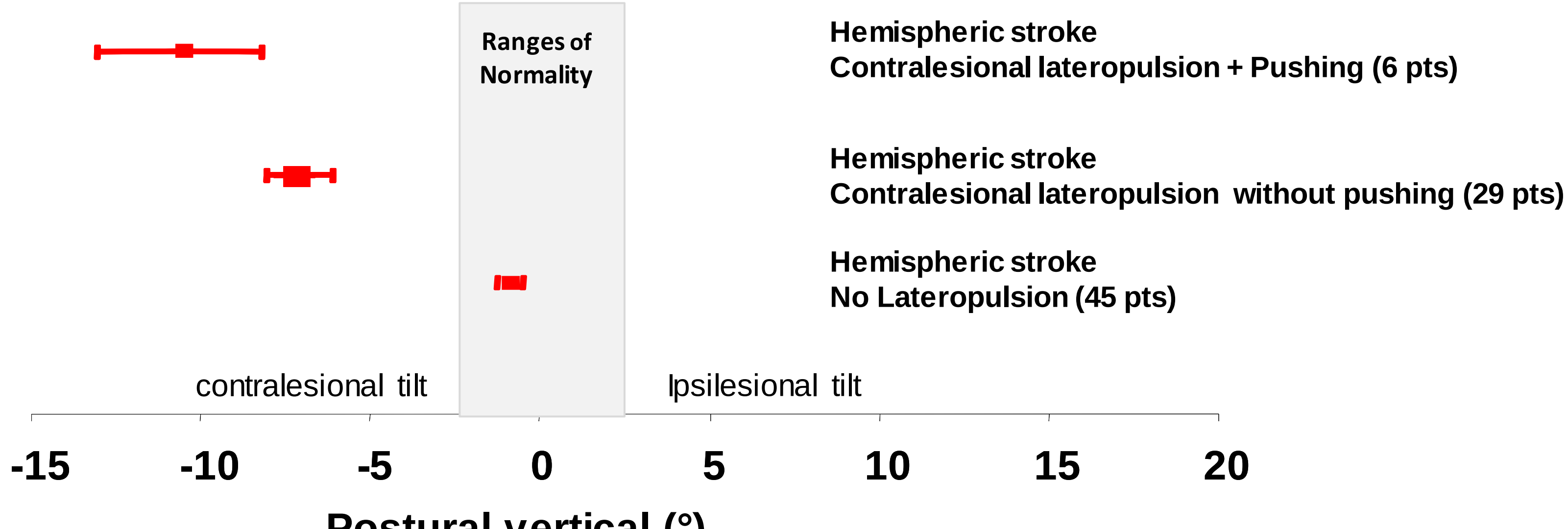
Pérennou et al Brain 2008

Serie of 80 consecutive patients with a hemispheric stroke

A) Individual data: continuum



B) Close relationship PV and lateropulsion (SCP) r = -0.71 $p<10^{-6}$



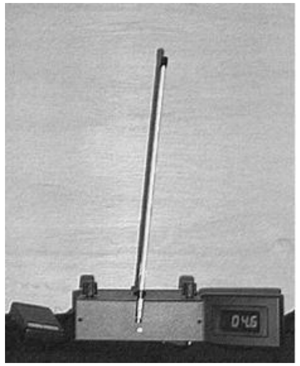
From Pérennou et al Brain 2008

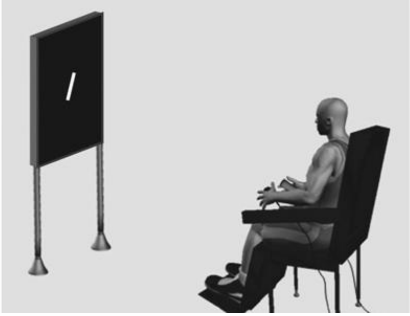
Mesuring the visual vertical: myriad of protocols

Hemispheric dome
Dieterich and Brandt 1993

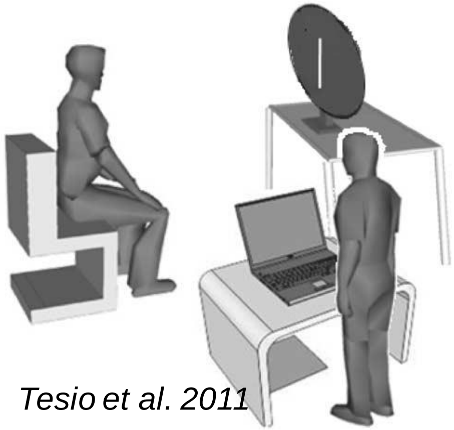
Bucket test
wergal et al. 2009

C-RFT line
Bagust 2005



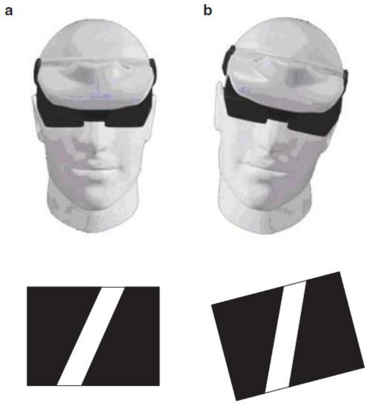


Lopez et al. 2008

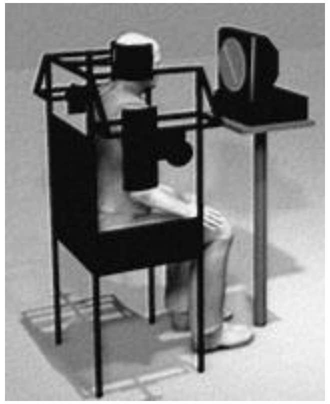


Tesio et al. 2011

C-RFT dots
Gosselin et al. 2014



Suarez et al. 2012

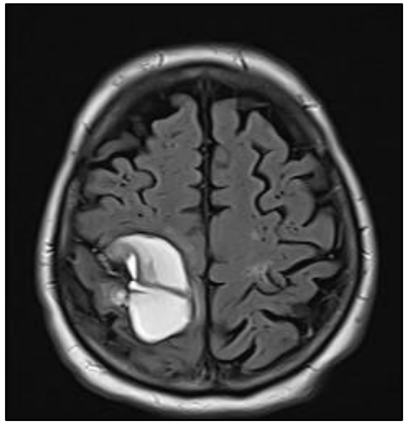


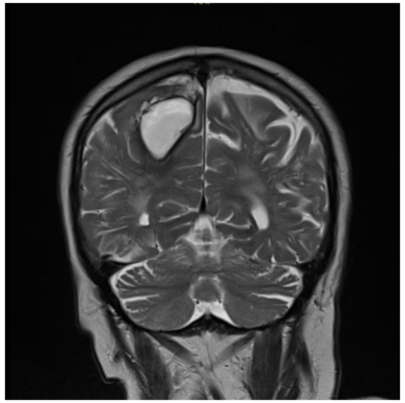
Pérennou et al. 2008

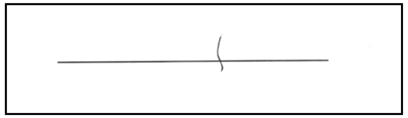
Saj et al. 2005
Rousseaux et al. 2013

Tilted verticality representation

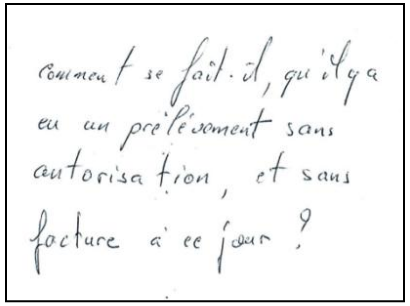
Also tilted drawing and writing



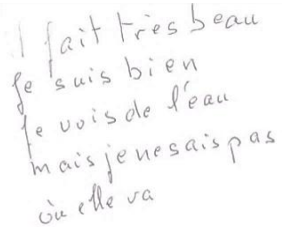


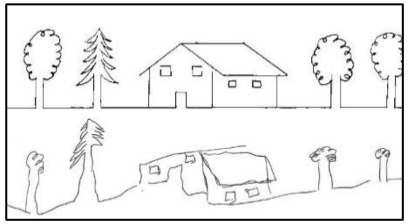


avant AVC



après AVC





Joly et al 2020
Lafitte et al 2025

Toward a specific rehabilitation of the sense of upright to attenuate lateropulsion

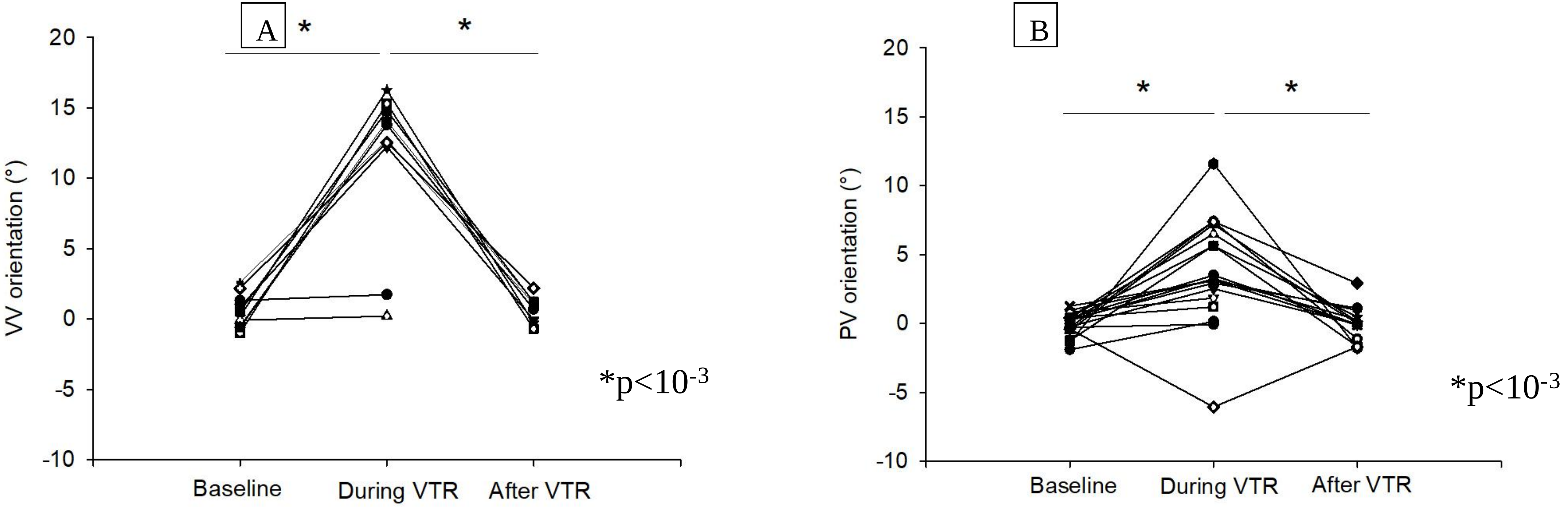
especially in patients with a right hemisphere stroke

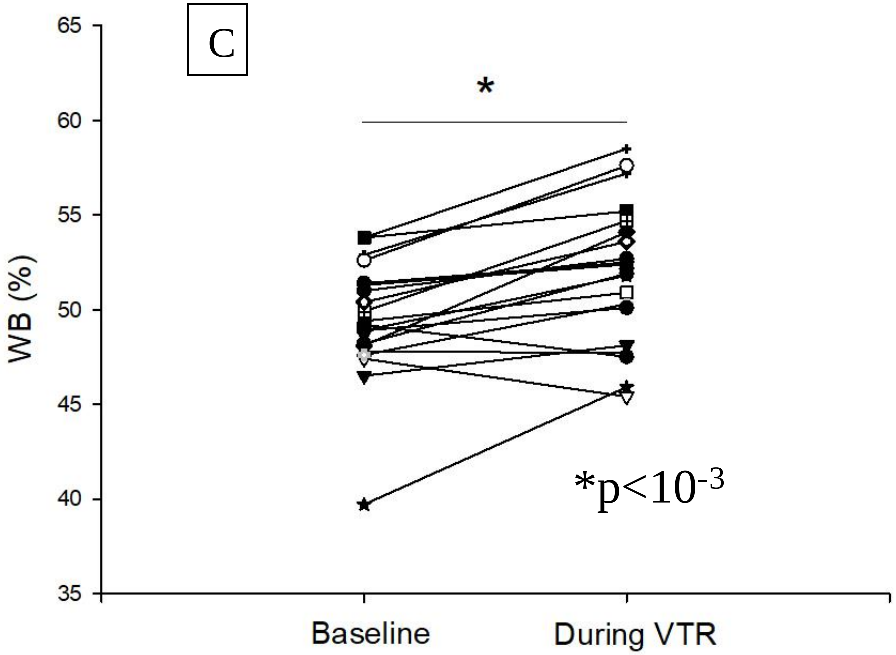


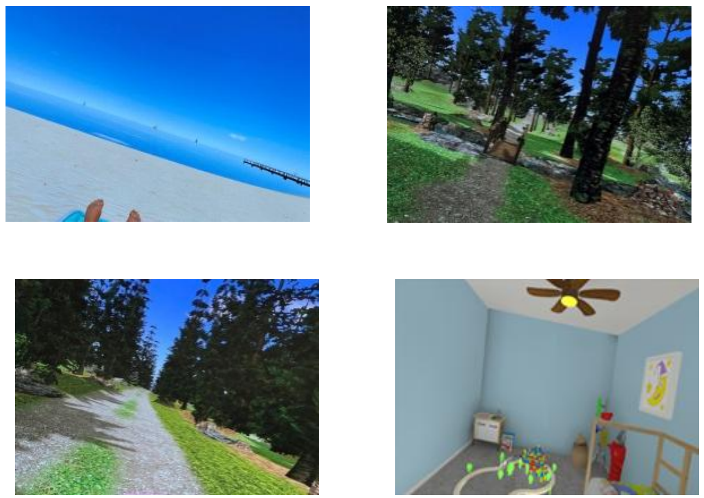


External cues of verticality

Neuromodulation / recalibration coordinate system referred to the vertical



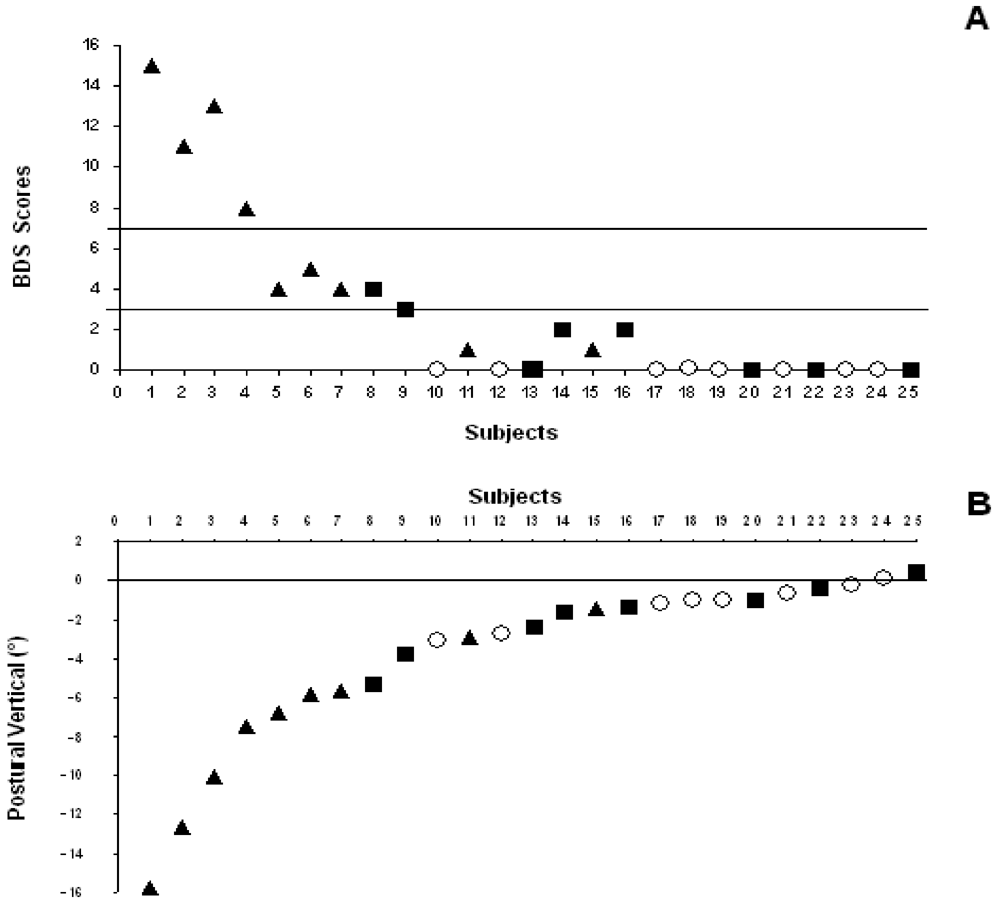




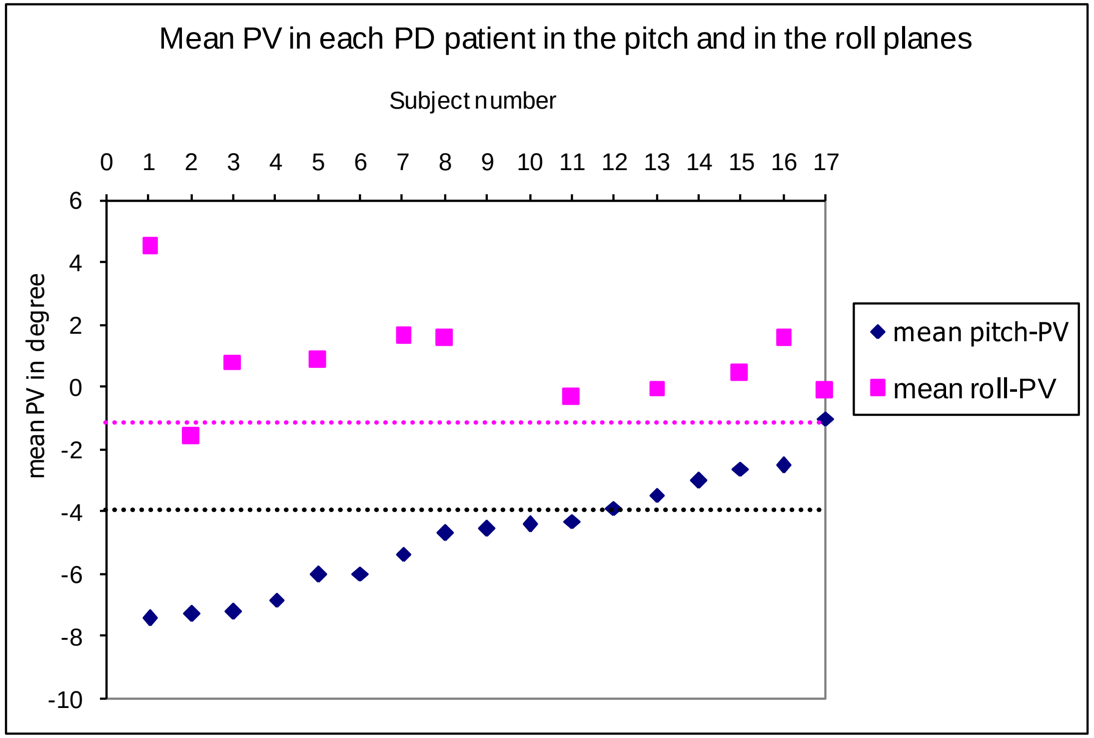
Dehem et al - J Eng Rehabil 2025

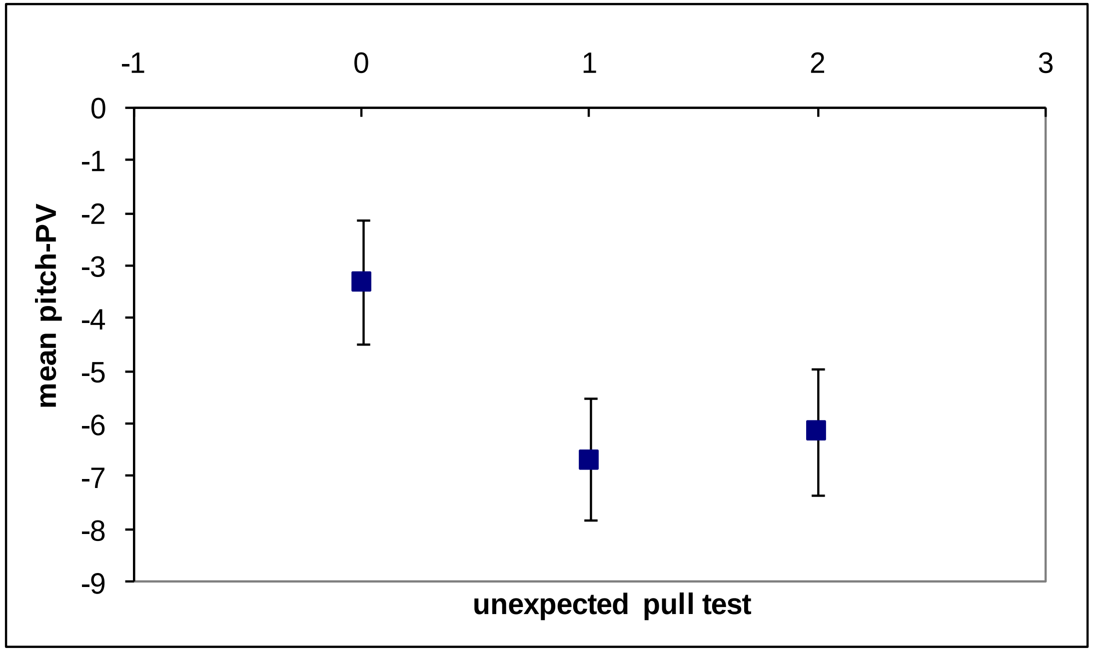
What about the sagittal plane ?

Retropulsion in elderly



Manckoundia et al 2007



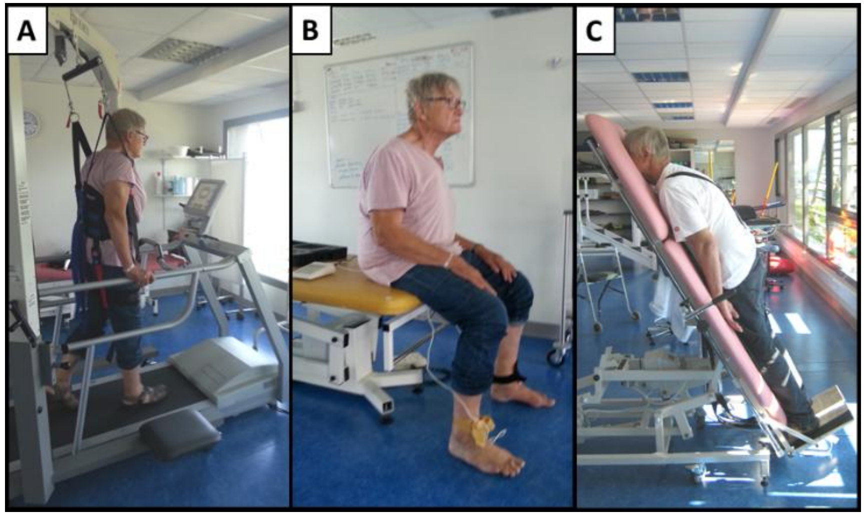


Retropulsion et PV chez des patients ayant une maladie de Parkinson

Pérennou et al in preparation

Proposal for retropulsion rehabilitation (program 2 weeks; 3-4 h per day)

1. PV modulation to be shifted forward (normalised): 3 techniques



PV modulation checked at the first session

2. Active upright orientation: awareness and exercises of trunk positioning, challenging the stabilization (backward disequilibrium) in the sagittal plane, task specific retraining (sit-to-stand…)

3. General muscular, balance and effort training adapted to PD, as proposed by:

Smania et al NNR 2010; Silva-Batista et al Gait & Posture 2018; Visieux et al 2020

From Pérennou et al Annals PRM 2023

	1st sequence of intensive rehabilitation 10 days in June 2015		2nd sequence of Intensive rehabilitation 10 days in April 2016	
	Before	After	Before	After
Walking parameters				
Cadence (step/min)	103	97		
…speed (m/s)	0.78	0.74		
Posture in sagittal plane				
Retropulsion				
Unexpected Pull Test (0-4 a.u.)	**3**	**2**		
Backward Disequilibrium Scale (0-15) (a.u.)	**4**	**3**	**3**	**3**
Five times Sit to Stand Test (sec)	**57**	**43**	**22**	**22**
Postural vertical (°)	**-9**	**0.1**	**-7.6**	**-0.4**
Camptocormia				
Sagittal C7 arrow (mm)	**265**	**230**	**380**	**290**
Trunk anterior flexion (°)	**45**			
Shift of the center of pressure (mm)	**-8**	**-4**	**-18**	**-14**
Posture in frontal plane				
Left trunk tilt (mm [°])	**- 85 [8]**	**- 45 [4]**		
Postural vertical (°)	**0.5 (1.5)**			
Balance tests				
Berg Balance Scale (0-56 a.u.)	**50**	**53**	**51**	**52**
Timed up and go test (sec)	**13**	**12**	**10**	**9**

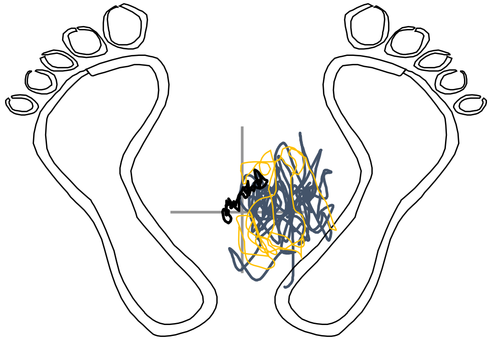
Number of falls divided by 10 several months after the first intervention

⟹ Results sufficiently interesting to poursuie this track

From Pérennou et al 2023

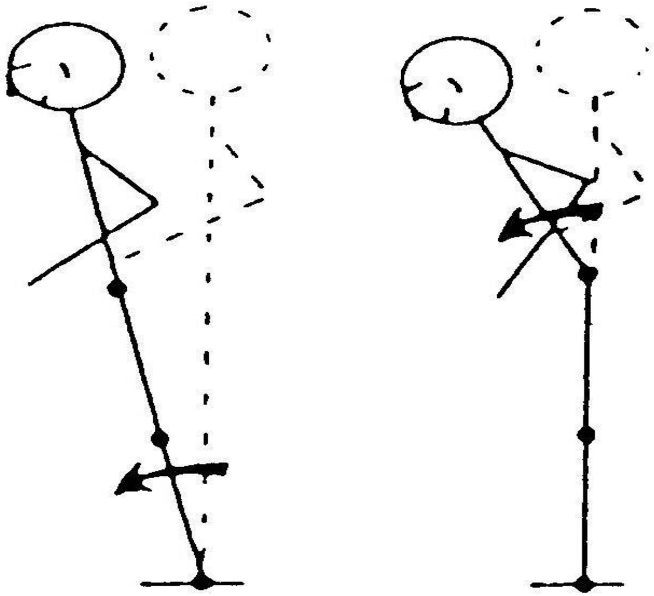
Postural stabilization

To control mouvements of the center of mass, and ensure that is projection on the ground is within the base of support

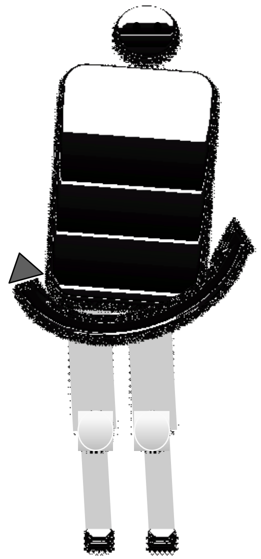


Frontal and Rolando cortex (motor cortex)
Temporo-Parietal cortex (body schema)
Corticospinal tract
Cerebellum (postural coordination)
Basal Ganglia

Main stabilisation mechanisms in standing



Pitch: ankle or hip



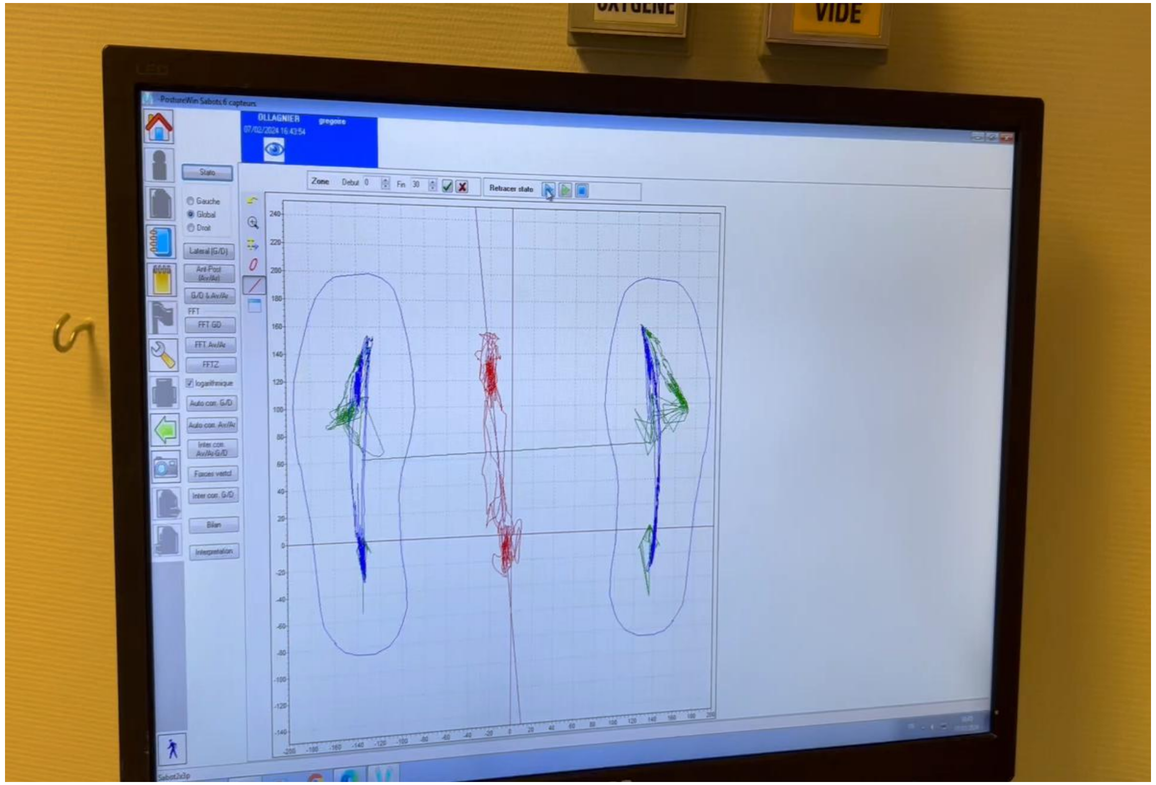
Roll : loading - unloading

Individuals with hemiparesia
Pilot their stabilisation in standing
from the strong leg

Contrôle de la posture debout statique par mise en tension d'un groupe musculaire

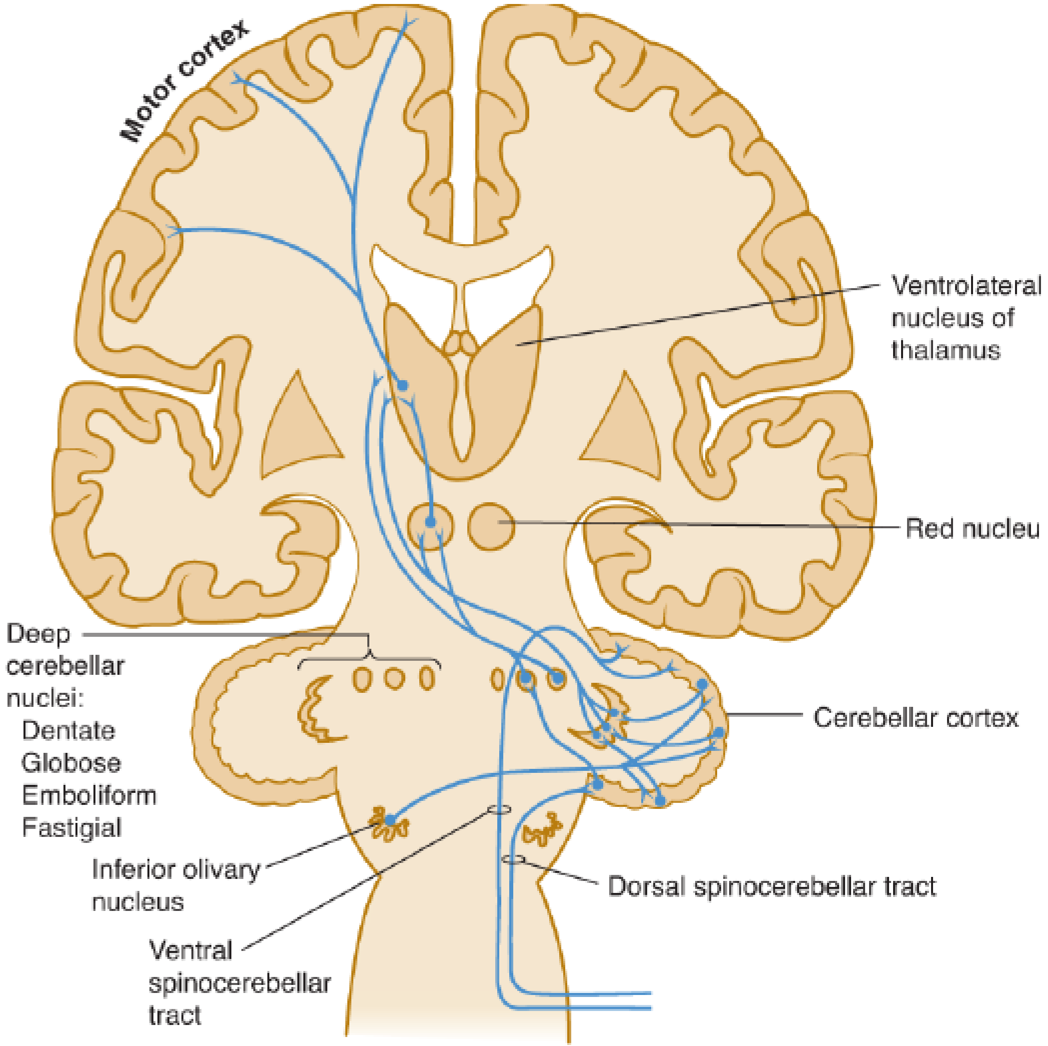
Tonus des muscles extenseurs,

artisan principal de la posture érigée


VIDE

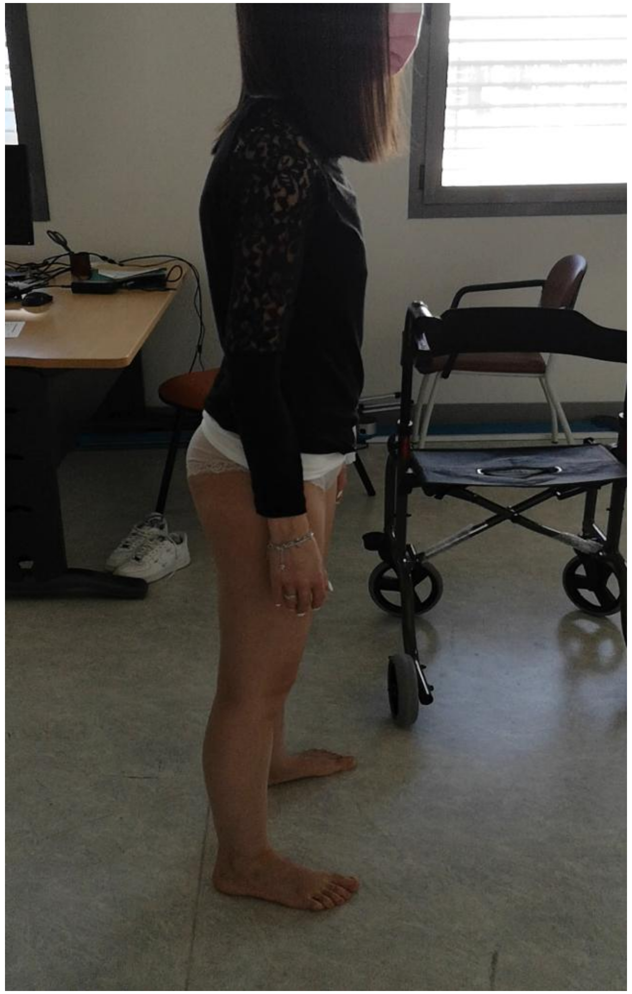
Votre interprétation ?

Modèle humain de trouble de la stabilisation posturale: pathologie cérébelleuse



Impaired corrections of postural oscillations

Impaired intersegmental coordination



Feet apart

Feet together

Without vision
Value of the Romberg sign?

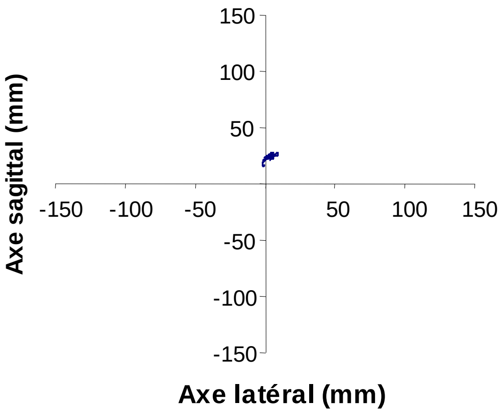
Female 36 yrs, SCA type 7, Starting 2007-2008, diagnosis in 2015, several falls / yr
Video this week


MILANO POLO CLUB

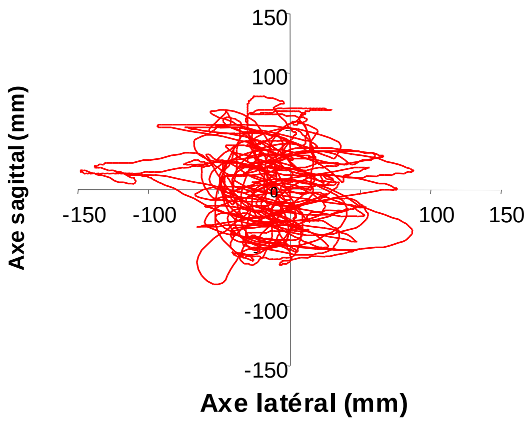
Individu normal

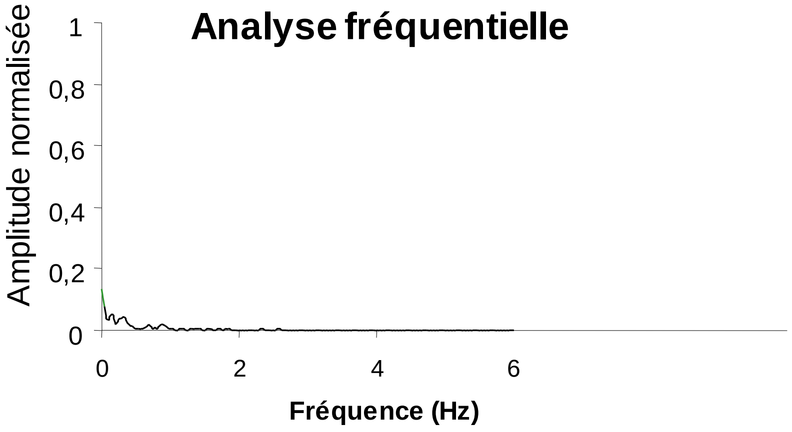
Individu avec une atrophie cérébelleuse évoluée

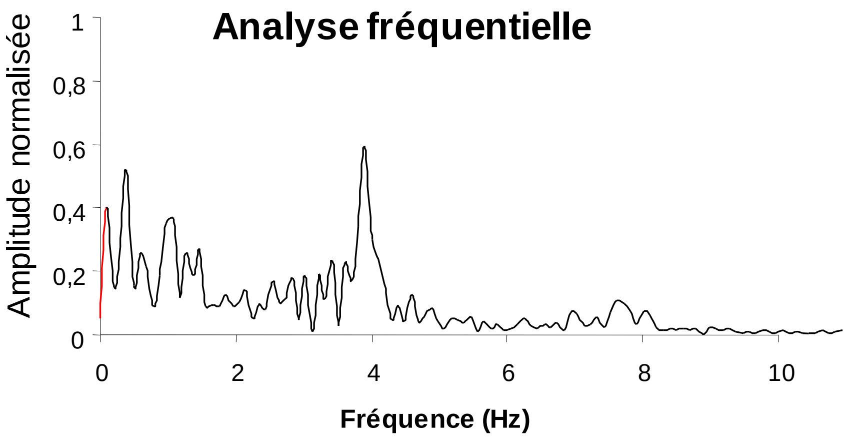
Trajectoires du centre de pression plantaire



Trajectoires du centre de pression plantaire







Valeur du signe de Romberg ?

Rôle crucial du cervelet dans la coordination posturale

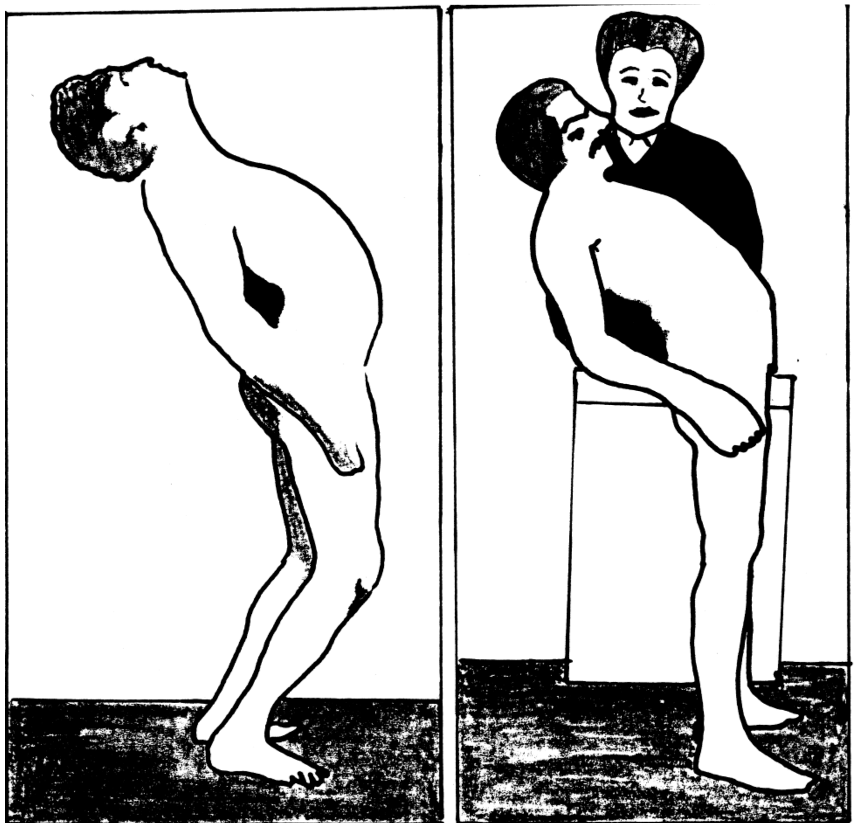


Illustration de l'asynergie cérébeleuse
D'après Babinski, Rev Neurol 1899

Long-Term Effects of Coordinative Training in Degenerative Cerebellar Disease

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ARTICLES

Intensive coordinative training improves motor performance in degenerative cerebellar disease

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ABSTRACT

Objectives: The cerebellum is known to play a strong functional role in both motor control and motor learning. Hence, the benefit of physiotherapeutic training remains controversial for patients with cerebellar degeneration. In this study, we examined the effectiveness of a 4-week intensive coordinative training for 16 patients with progressive ataxia due to cerebellar degeneration (n = 10) or degeneration of afferent pathways (n = 6).

Methods: Effects were assessed by clinical ataxia rating scales, individual goal attainment scores, and quantitative movement analysis. Four assessments were performed: 8 weeks before, immediately before, directly after, and 8 weeks after training. To control for variability in disease progression, we used an intraindividual control design, where performance changes with and without training were compared.

Results: Significant improvements in motor performance and reduction of ataxia symptoms were observed in clinical scores after training and were sustained at follow-up assessment. Patients with predominant cerebellar ataxia revealed more distinct improvement than patients with afferent ataxia in several aspects of gait like velocity, lateral sway, and intralimb coordination. Consistently, in patients with cerebellar but without afferent ataxia, the regulation of balance in static and dynamic balance tasks improved significantly.

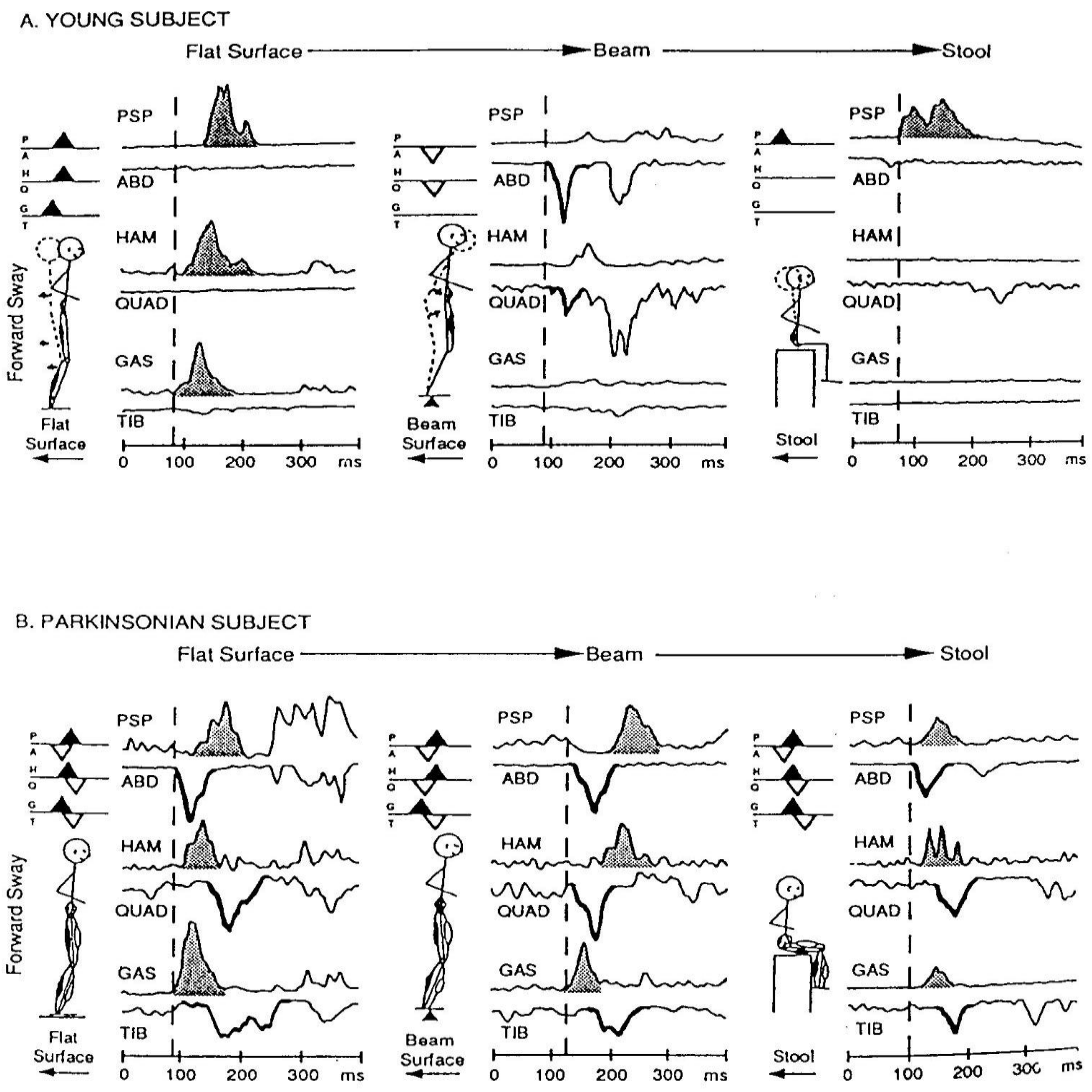
Conclusion: In patients with cerebellar ataxia, coordinative training improves motor performance and reduces ataxia symptoms, enabling them to achieve personally meaningful goals in everyday life. Training effects were more distinct for patients whose afferent pathways were not affected. For both groups, continuous training seems crucial for stabilizing improvements and should become standard of care.

Level of evidence: This study provides Class III evidence that coordinative training improves motor performance and reduces ataxia symptoms in patients with progressive cerebellar ataxia.

Neurology® 2009;73:1823–1830

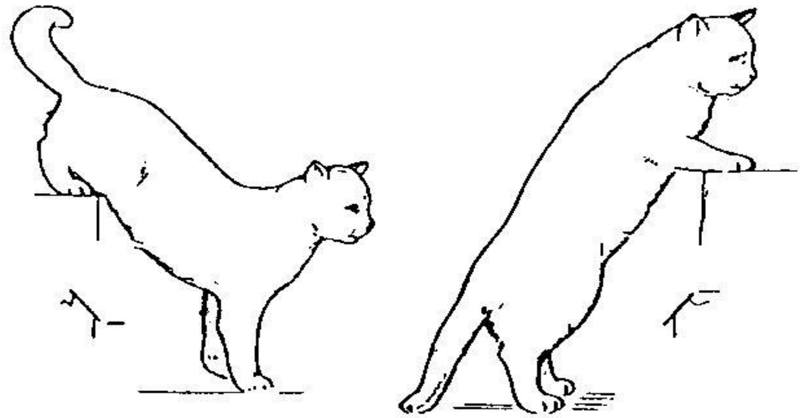
Rôle crucial des ganglions de la base

dans la flexibilité du répertoire de stratégies posturales

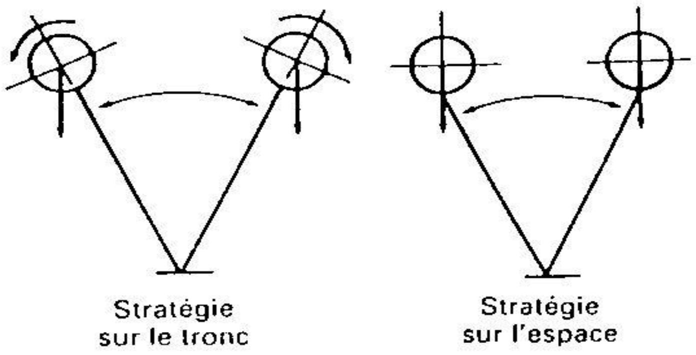


D’après Horak et al
J Neurol Sci 1992

Sélection d’un référentiel stabilisé



a



b

Stratégies de stabilisation de la tête. A) stabilisation de la tête en tangage chez le chat (reflexes du cou).B) deux stratégies de stabilisation de la tête en roulis décrites chez l`homme. D’après Massion, 1997.

Rôle des informations sensorielles pour la stabilisation posturale

Sélection de la stratégie de stabilisation

Stabilisation de la Tête: **vision et vestibulaire +++**

Stabilisation du tronc: proprioception ++

Stabilisation du centre de masse: modèle interne ++

Stratégie de cheville: somesthésie ++

Stratégie de hanche: vestibulaire ++

Réduire amplitudes oscillations posturales

Vision périphérique
Proprioception
Vestibulaire : canaux semi-circulaires

Elaboration modèles internes (centre de masse)

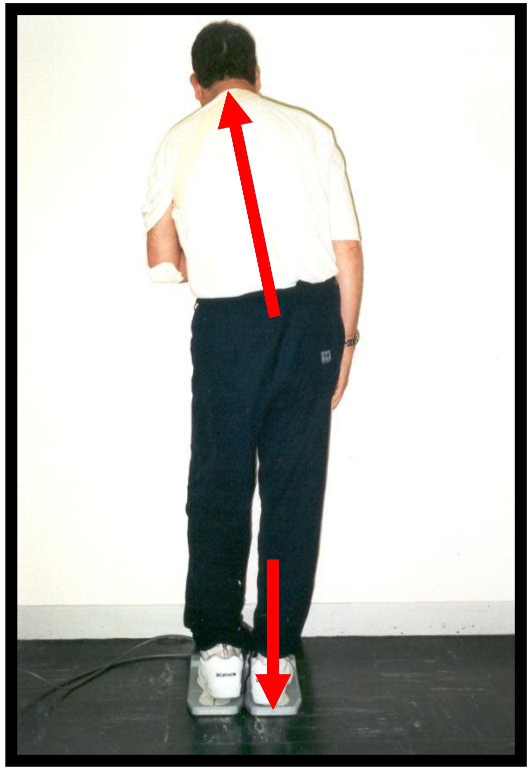
Compromise to be found between

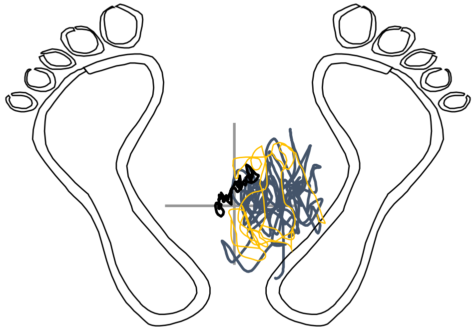
body orientation

→ **contralesional body tilt should mechanically load the contralesional leg**

and body stabilisation and BW symmetry

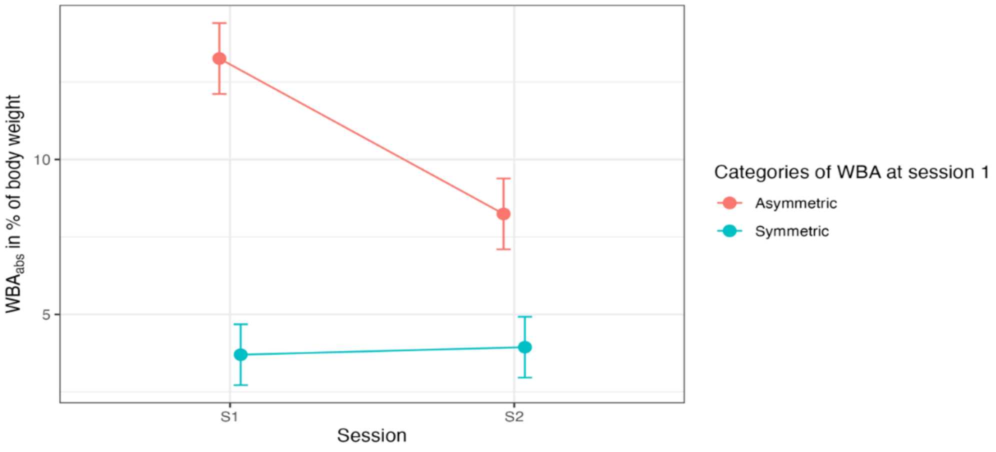
Disappointing RCT
Leplaideur et Annals PRM 2024
Hugues et al 2019

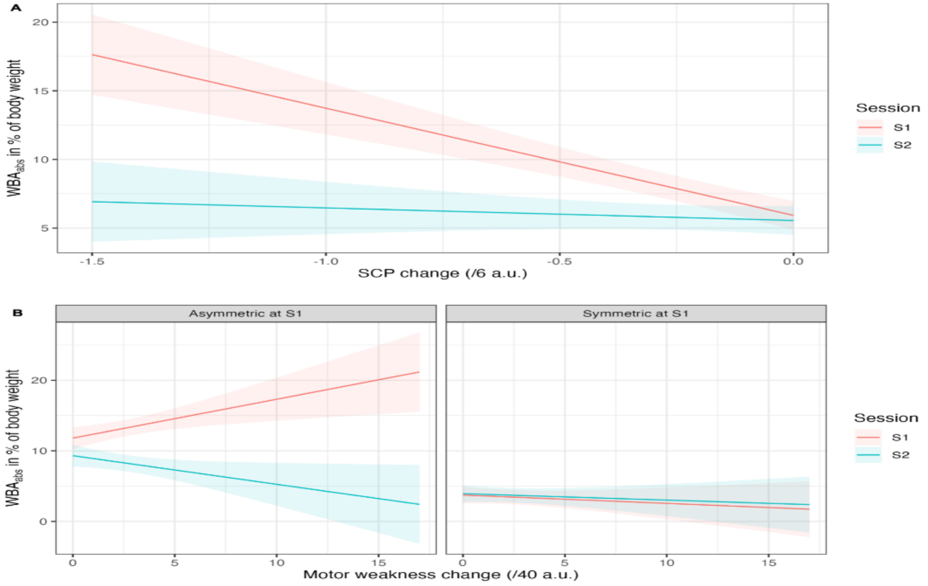




Ipsilesional shift of the CP is partly a compensatory strategy, which is the only way to stand for some patients (Barra et al Neurology 2009)

We need to better understand post-stroke WBA and WBA recovery





A linear mixed model showed that PASS scores (balance capacity) increased from S1 to S2 for only individuals who were initially asymmetric (MD = 2.8, 95%CI [1.5; 4.0], P<0.001, vs MD = 0.6, 95%CI [-0.4; 1.7], P=0.6).

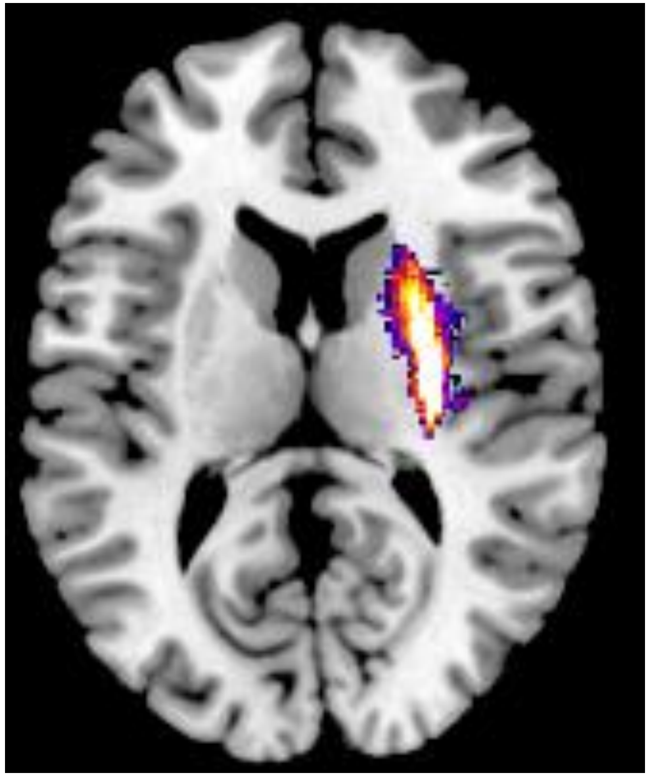
In this group, the gain in balance ability was strongly correlated with the WBA alleviation (Spearman correlation: r_s = -0.7, P=0.007).

Hugues et al submitted

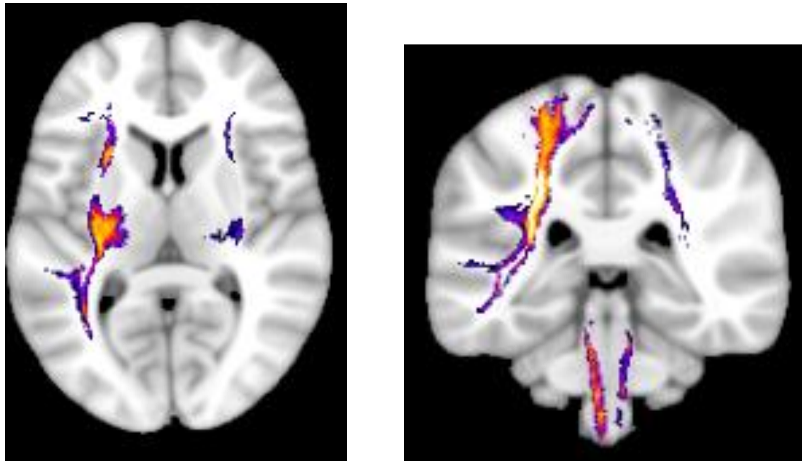
Neural bases of balance control in the right hemisphere

Balance in daily life (PASS): verticalisation + vertical orientation + stabilisation

DOBRAS STUDY



Grey matter



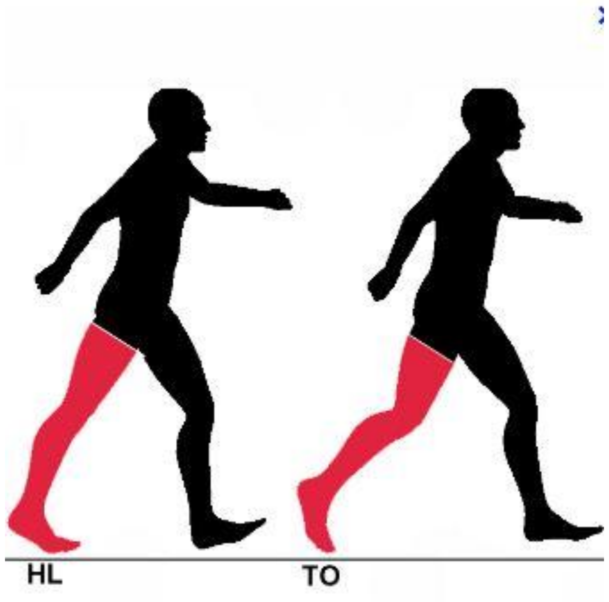
White matter

Karam et al in preparation

Mobility requires

Mobility

- Verticalisation
- Orientation
- Stabilisation
- **Propulsion**
- Energy consomption
- Navigation

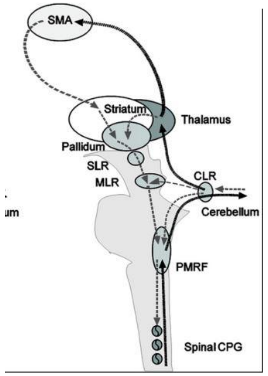


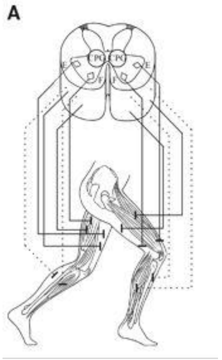
Appropriate propulsion requires

Arms swing
Hip extension
Knee extension
Ankle extension
Toe off

→

Force generation
Force coordination (gait schema)





Wide neural bases involving hemispheres, cerebellum, brain stem, spinal cord

Frontal cortex (motor cortex)
Parietal cortex
Cerebellum (coordination)
Basal Ganglia (automaticity)
Other ganglia of the Brain stem
And even the spinal cord which elicits rythmic movements

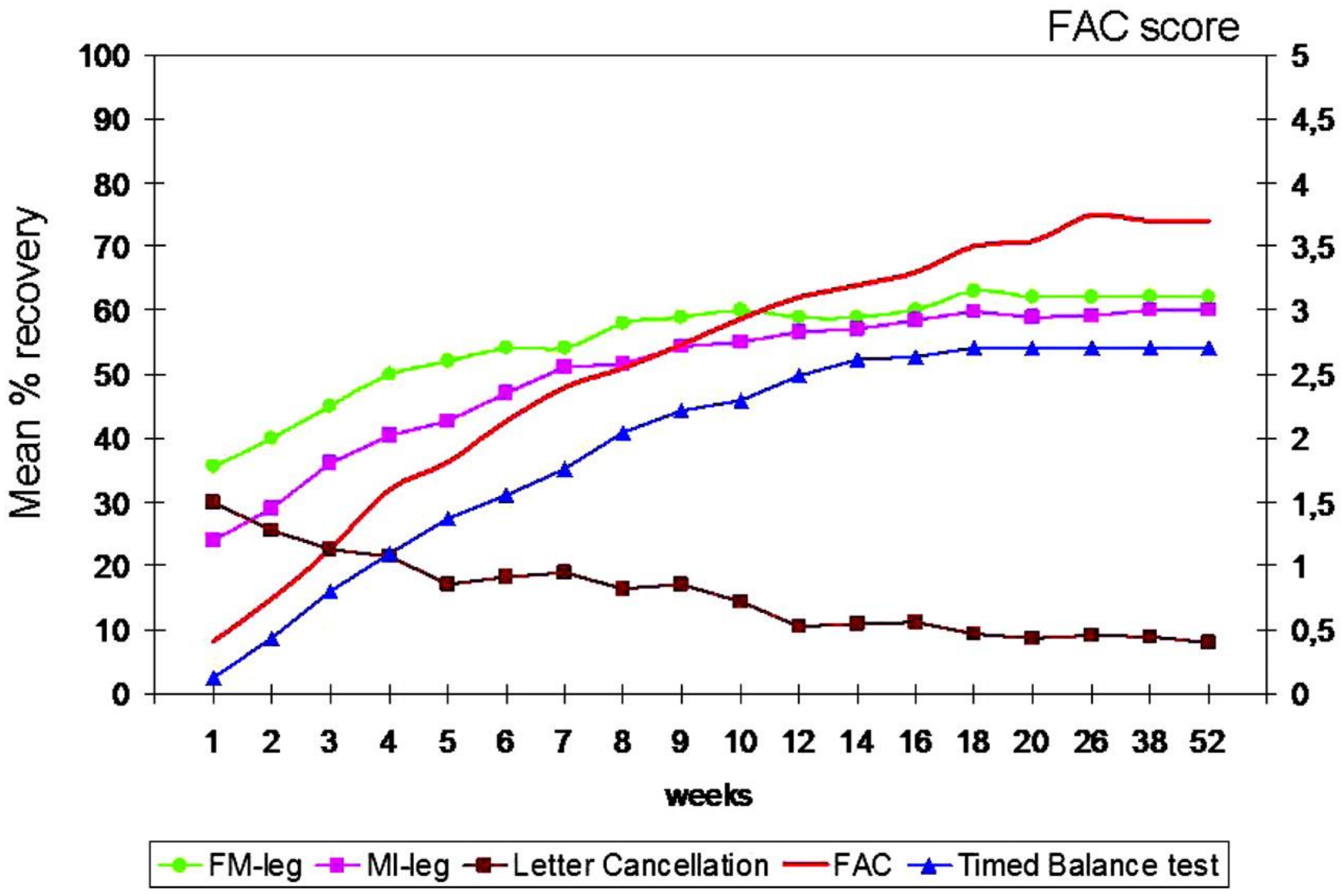
- Walking determinants -
An abondant literature in many diseases and conditions

Weakness (coordination, fatigue) +++

Balance +++

Propulsion may be attenuated by neuro-orthopaedic problems

- Balance disorders as a major determinant of gait disorders



5 marche indépendante
4 marche indépendante sur surfaces places
3 marche sous supervision

Kollen et al Stroke 2005

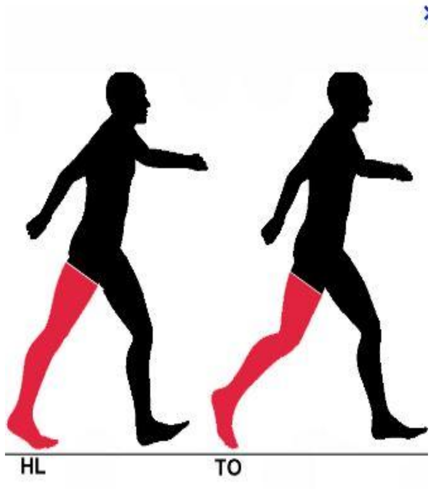
Improving gait: what is the goal ?

Improving gait via a better balance ?

Improving (velocity) via a better propulsion ?

Improving gait via a better coordination ?

Fall prevention ?



Suited assessment tools in addition to balance and gait scales dedicated to stroke

Delay since stroke

acute/subacute phases: rather orientation and stabilisation rehabilitation

late subacute/chronic phases: rather stabilisation, propulsion, navigation rehabilitation

Most meta-analyses do not conclude positively as regards balance-mobility rehabilitation

- Insufficient rationale or theoritical background
- Inclusion criteria not sufficiently appropriate
- Outcome criteria not satisfactory, or not mastered
- Trials designed to test a technique, not a program
- Limited sample sizes
- Risk of bias not sufficiently mastered
- Research integrity : some articles retracted

→ Practical recommandations

Mobility requires

Mobility

Verticalisation

Orientation

Stabilisation

Propulsion

Energy consomption

Navigation

For small distances, does not seem to be the limitant factor, in neurological conditions / diseases

Mobility requires

Mobility

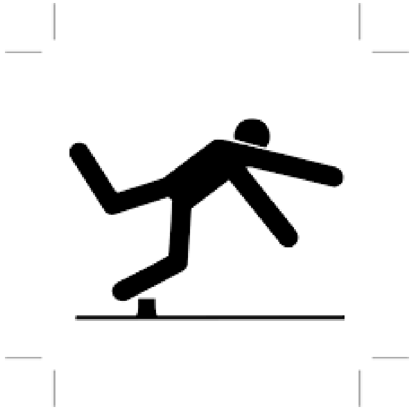
Verticalisation

Orientation

Stabilisation

Propulsion

Navigation



Détection du risque

Vision, audition, cognition spatiale, schéma corporel
Conscience des troubles
Fonctions cognitives adaptées
Alerte, fonctions attentionnelles

Mise en place stratégie adaptée

fonctions exécutives etc..
Modification paramètres du pas, direction
Réactions posturales : boucles transcorticales > 120 ms

L'analyse des facteurs de risque de chute doit être faite sur le nombre de chutes et pas sur des indicateurs indirect +- fiables

Idem pour interventions pour prévenir les chutes
Valeur de l'interrogatoire pour suivi des chutes

Which function is altered ?

Which funtions must be relearned – trained ?

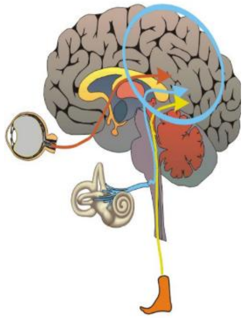
Verticalisation
Orientation
Stabilisation

} Postural control

Propulsion
Energy consomption
Navigation in the environnent

} Gait

Thanks for your attention



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