Second Course "Motion Analysis and clinics: why to set up a Motion Analysis Lab ?"

TRAMA Project

January 14 - 17th 2008

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Title:…European Journal of Padiatric Neurology 1999;3: 159-165
Adaptive motor strategy for squatting in spastic diplegia.

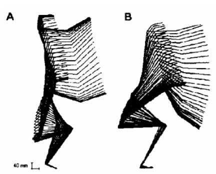
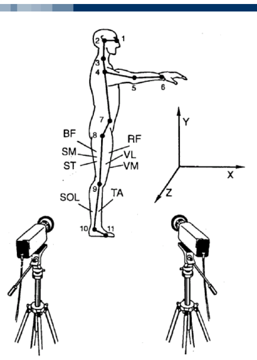


Fig. 1. Sagittal kinogram of the squatting movement, representing the superimposition of the sagittal projections of the segments defined by the markers every 80 ms from the standing posture to the squatting posture. (A) In a normal child. (B) In a child with spastic diplegia.

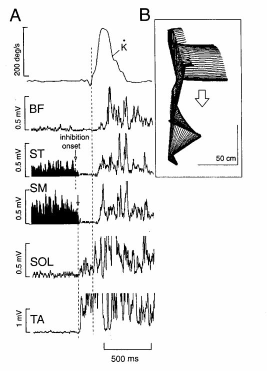
Matériels



- 11sujets sains
- 3 instructions:
  1. Flexion sans frein
  2. Flexion avec frein final
  3. Mi-Flexion
- Analyse du mouvement le plus rapide de chaque instruction

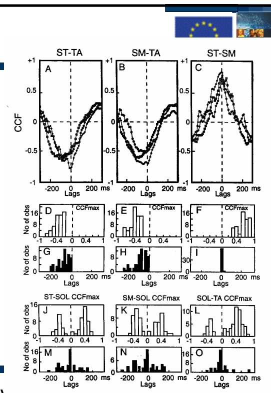
Inhibition de l'activité tonique: premier événement déclencheur du mouvement

(présent dans 64% des cas pour ST et 79% pour SM)

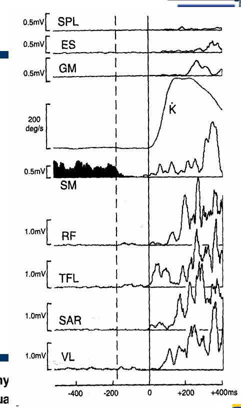


$$\mathrm{CCF}_{d_1 d_2}(\tau) = \frac{1}{T}\int_0^T d_1(t)\, d_2(t-\tau)\, dt$$

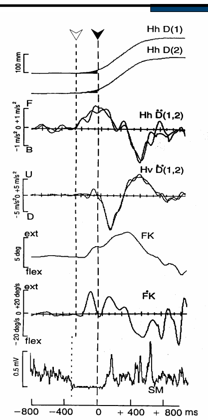
L'analyse en CCF des patterns EMG illustre la relation temporelle existant entre l'inhibition de l'activité tonique du ST et SM avec l'activité du TA



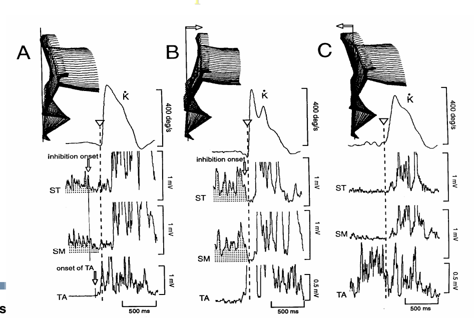
L'inhibition précoce de l'activité tonique du ST et SM correspond-elle à une inhibition de type réciproque?



L'inhibition de l'activité tonique du ST et SM est-elle influencée par les mouvements précoces de la tête?



L'inhibition précoce de l'activité tonique du ST et du SM est en relation avec la position initiale en station debout



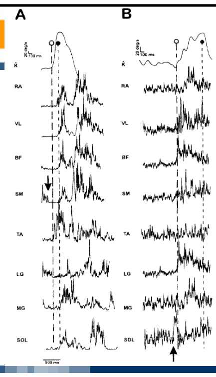


Table 2 Kinematic data for normal children and children with spastic diplegia.

	Normal children	Spastic diplegia		
Head orientation	−2.61° (SD 8.92)	−25.30° (SD 15.77)	F(1,218) = 87.68	p ≪ 0.001
Trunk orientation	−35.00° (SD 8.80)	−54.20° (SD 11.90)	F(1,206) = 72.77	p ≪ 0.001
Arm orientation	−28.38° (SD 18.24)	−68.84° (SD 28.49)	F(1,204) = 93.86	p ≪ 0.001
Hip angle	88.48° (SD 16.74)	68.36° (SD 27.10)	F(1,200) = 25.68	p ≪ 0.001
Knee angle	103.43° (SD 18.59)	58.31° (SD 24.54)	F(1,208) = 173.51	p ≪ 0.001
Ankle angle	12.66° (SD 8.60)	0.24° (SD 4.01)	F(1,198) = 29.40	p ≪ 0.001
Maximal knee angular velocity	251.85°/s (SD 47.30)	112.46°/s (SD 59.61)	F(1,204) = 128.23	p ≪ 0.001
Duration of movement	823.35 ms (SD 264.18)	1388.70 ms (SD 409.66)	F(1,205) = 86.43	p ≪ 0.001

Differential angles between the onset and the end of the movement in the sagittal field are shown for all considered segments.

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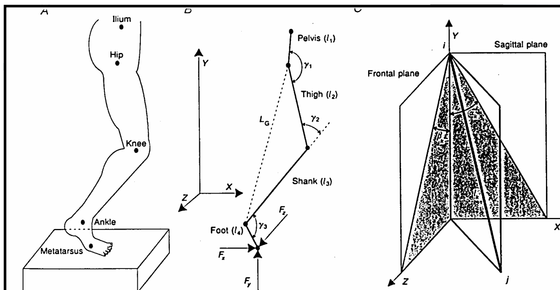

Figure 1. Schematic illustration of the mechanical variables analysed

A, markers placed on right lower limb were monitored by the ELITE system, and ground reaction forces by the Kistler platform. *B*, *X*, *Y*, *Z* co-ordinate system for kinematic and kinetic analysis. Pelvis, thigh, shank and foot are the limb segments identified by the markers, of length l_1, l_2, l_3 and l_4, respectively. The corresponding 3D angles of flexion–extension between adjacent segments are γ_1, γ_2 and γ_3. L_G is the variable length of the main limb axis. Ground reaction forces along the vertical (F_y), longitudinal (F_x) and lateral (F_z) directions are shown schematically at the metatarsus, but in fact are applied at different points of the foot during different phases of stance. *C*, absolute angles of elevation (α_k) in the sagittal plane *XY*, and adduction (β_k) in the frontal plane *YZ* are indicated for an arbitrary segment *k*, whose proximal and distal end-points are denoted by *i* and *j*, respectively.

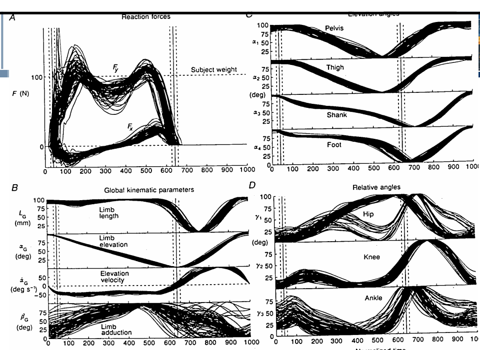

Figure 6. Comparison of kinetic and kinematic waveforms across subjects and speeds

Normalized traces from all subjects and speed conditions are plotted superimposed. In each trial data were interpolated over the gait cycle *T* to fit a time base of 1000 units. *A*, vertical and longitudinal reaction forces scaled in amplitude to the subject's weight and expressed as a percentage of the latter. *B*, global kinematic variables of limb axis. *C*, elevation angles. *D*, flexion–extension angles. In *B–D* kinematic variables were scaled to the difference between minimum and maximum of each trial and expressed as a percentage of this difference. Mean values (±1 s.d.) of the start and end of stance phase are indicated by the vertical continuous (dashed) lines.

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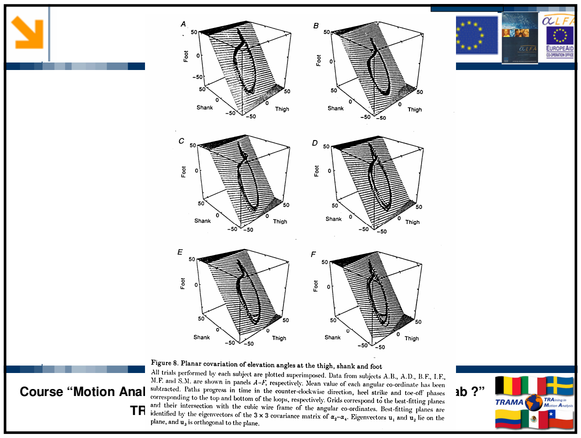
Foot
Shank
Thigh
Figure 8. Planar covariation of elevation angles at the thigh, shank and foot
All trials performed by each subject are plotted superimposed. Data from subjects A.B., A.D., B.F., I.F., M.F. and S.M. are shown in panels A–F, respectively. Mean value of each angular co-ordinate has been subtracted. Paths progress in time in the counter-clockwise direction, heel strike and toe-off phases corresponding to the top and bottom of the loops, respectively. Grids correspond to the best-fitting planes and their intersection with the cubic wire frame of the angular co-ordinates. Best-fitting planes are identified by the eigenvectors of the 3 × 3 covariance matrix of α_2–α_4. Eigenvectors u_1 and u_2 lie on the plane, and u_3 is orthogonal to the plane.
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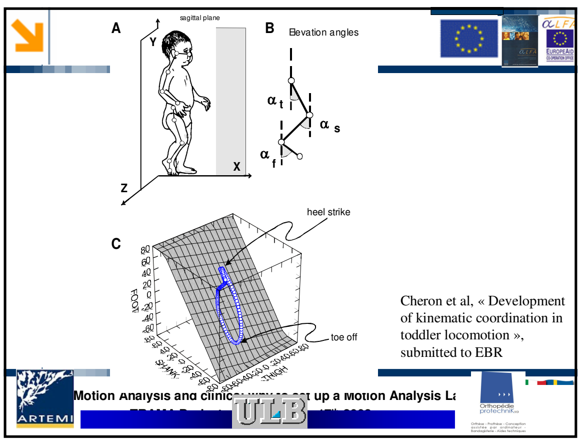
A
sagittal plane
Y
X
Z
B
Elevation angles
α_t
α_s
α_f
C
heel strike
toe off
FOOT
SHANK
THIGH
Cheron et al, « Development of kinematic coordination in toddler locomotion », submitted to EBR
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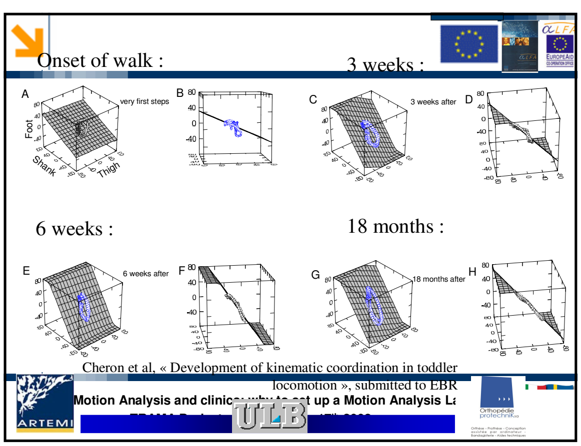
Onset of walk :
3 weeks :
very first steps
3 weeks after
Foot
Shank
Thigh
6 weeks :
18 months :
6 weeks after
18 months after
Cheron et al, « Development of kinematic coordination in toddler locomotion », submitted to EBR
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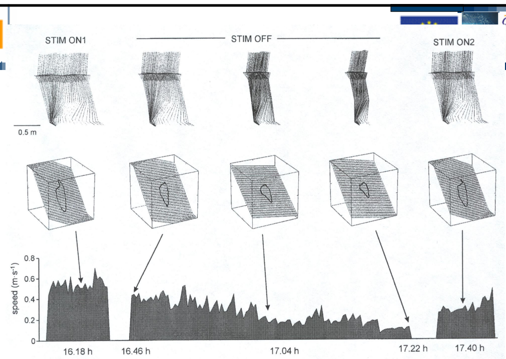
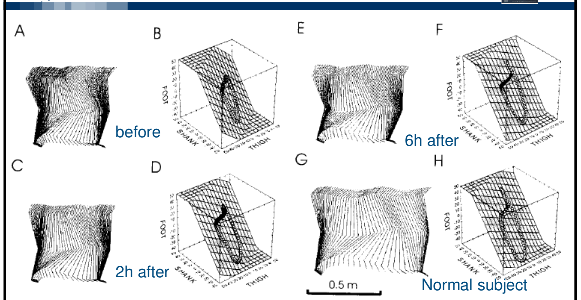


Grasso et al, EBR 1999, vol 126(2), p 139-148

Neuroscience Letters 280 (2000) 11 75-178Effect of intrathecal baclofen on gait control in human hereditary spastic paraparesis Bernard Dan,Ethel Bouillot Ana Bengoetxea Guy Cheron

As a GABA3 agonist, baclofen reduces the release by primary afferent terminals in laminae II and III of excitatory neurotransmitters onto ventral horn motoneurons in the spinal cord.Although intrathecal baclofen (ITB) is becoming a standard treatment of spinal origin spasticity, its effect on locomotor control is unclear. A recent approach has revealed a specific covariation of elevation angles of the lower limb segments along an attractor planeduring locomotion in healthy humans. The plane orientation and the shape of the loop that defines it reflect the phase relationships between these angles and therefore intersegmental co-ordination, on which postural stability with respect to gravity and dynamic equilibrium for forward progression depend. In this study, we analysed this covariation in a patient with uncomplicated autosomal dominant hereditary spastic paraparesis (HSP) before and after an ITB bolus.



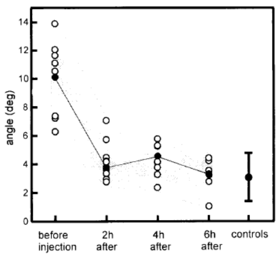
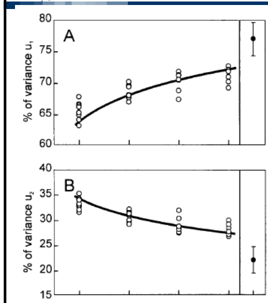


Fig. 2. Effect of intrathecal baclofen on the percentage of variance accounted for by each principal component of the planar covariation. Percentage of variance accounted for by the principal component of eigenvectors u_1 (A), u_2 (B) and u_3 (C). u_1 and u_2 lie on the plane and u_3 is orthogonal to it. All trial values of the patient are shown as open circles. The mean (black dot) and standard deviation of the control subjects are presented in the right part of the figure.



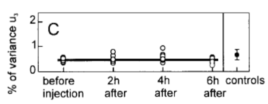


Fig. 3. Effect of intrathecal baclofen on the angular orientation θ of the covariation plane. The black dots represent the mean of each set of data. All trial values of the patient are shown as open circles. The mean and standard deviation of the control subjects are presented in the right part of the figure.

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In conclusion, the orthogonal planar regression analysis of the elevation angles of the lower limb segments consistently revealed abnormal orientation of the covariation plane and abnormal shape of the loop path that defines it in a patient with HSP. ITB restored physiological covariation. Although this does not demonstrate at which level the control of phase coupling for the co-ordination of lower limb segments is normally controlled, it shows that alteration of this control can be reversed by reducing abnormal alpha motoneuron excitability.

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Distinct multi-joint control strategies in spastic diplegia associated with prematurity or Angelman syndrome **Clinical Neurophysiology** 112 (2001) 1618-1625.

B. Dan, E. Bouillot, A. Bengoetxea, S.G. Boyd and G.Cheron

Spastic diplegia is commonly due to periventricular leucomalacia associated with premature birth. It is also a feature of Angelman syndrome (AS), a neurogenetic disorder with developmental delay, absent speech and mirthful behaviour. We studied the kinematics and kinetics of the squatting movement and associated electromyographic (EMG) activities in 20 children with spastic diplegia associated with periventricular leucomalacia (SDPL) or AS and 18 unimpaired children.

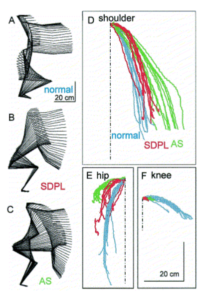

Fig. 1. Sagittal kinogram of the squatting movement. Kinograms represent the superimposition of the sagittal projections of the segments defined by the markers every 40 ms from the standing posture to the squatting posture in a normal child (A), a child with SDPL (B) and a child with AS (C). Trajectories of the shoulder (D), hip (E) and knee (F) during one movement trial performed by 10 children from each group are represented superimposed (blue, normal group; red, periventricular leucomalacia, SDPL; green, Angelman syndrome, AS).

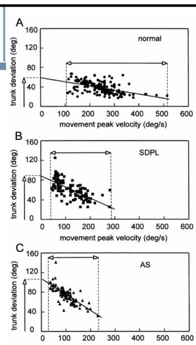

Fig. 2. Relationship between trunk forward excursion and peak angular velocity of the knee. (A) In the normal children. (B) In the children with SDPL. (C) In the children with AS. Horizontal arrows index the range of movement velocities for each group. Vertical arrows index the projection of the regression line of trunk deviation at zero-velocity.

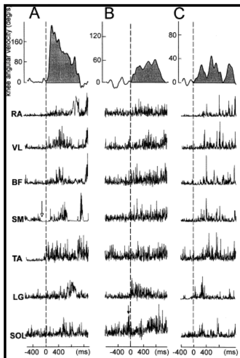

Fig. 3. Knee angular velocity and muscle activities during the squatting movement. (A) In a normal child. (B) In a child with SDPL. (C) In a child with AS. EMG signals are rectified. RA, rectus anterior muscle; VL, vastus lateralis muscle; BF, biceps femoris muscle; SM, semi-membranous muscle; TA, tibialis anterior muscle; LG, lateral gastrocnemius muscle; SOL, soleus muscle. The dotted line indexes the onset of movement. The open-headed arrow marks the anticipatory deactivation of the SM in the normal child. The black-headed arrow shows the anticipatory burst of SOL activity in the child with periventricular leucomalacia.

Conclusions:

We conclude that the motor patterns observed in SDPL and AS are different. They reflect individual adaptation to the impairment of the central nervous system characteristic of each condition. Taken phenomenologically, these patterns can contribute to the clinical approach to spastic diplegia. They may also have implications on the management of the motor disorder of affected patients, as understanding of relatively simple but important motor skills such as squatting will likely have an increasing clinical relevance in the context of the development of new therapies to improve motor skills, including pharmacological and surgical procedures directed at neurological disorders with muscle tone impairment. This study stresses the importance of multi-joint movements involving intersegmental interactions for postural control. In particular, the present paradigm could be practically applied at a gait and posture laboratory before and following specific treatments.