Stratégies de préhension chez des patients ayant des désordres neurologiques

Déficits très variables :

- sensibilité tactile
- proprioception
- mouvements des doigts et de la main
- coordination individuelle des doigts
- dextérité manuelle => problème pour effectuer des activités !

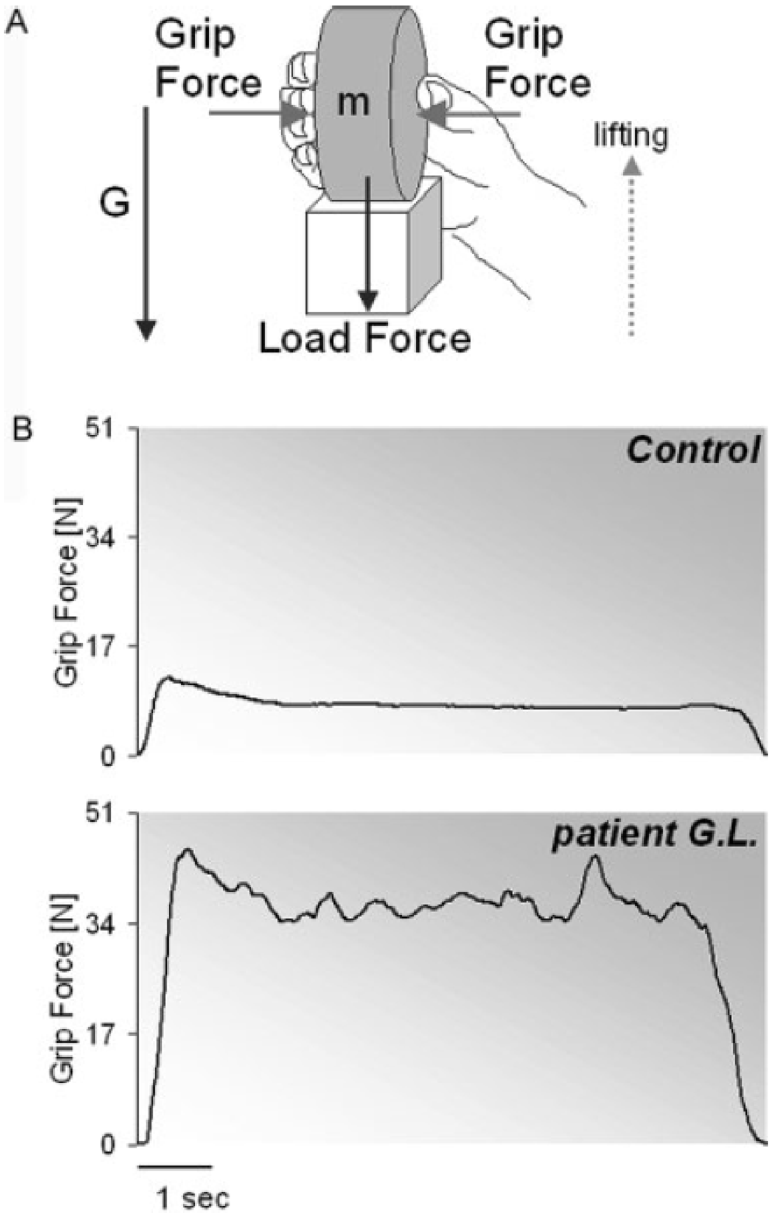
$\Rightarrow$ De manière générale, ces déficits (centraux ou périph) se traduisent par une mauvaise coordination GF/LF

$\Rightarrow$ De maniere simplifiée: GF trop↑

	Efficiency of grip force scaling	Predictive temporal coordination between grip and load force profiles
Healthy subjects	Efficient scaling of grip force; grip force exceeds load force by 10–30 %	Predictive coupling between grip and load force profiles
Digital anesthesia in healthy subjects	Impaired; excessive grip forces are used; grip force exceeds load force by 100–250 %	Predictive coupling between grip and load force profiles
Digit cooling in healthy subjects	Impaired; excessive grip forces are used; grip force exceeds load force by 40–90 %	Predictive coupling between grip and load force profiles
Reduced sensibility of the fingers due to peripheral nerve lesions (polyneuropathy and nerve compression syndrome)	Normal or impaired; if impaired, established grip force exceeds load force by 40–70 %	Predictive coupling between grip and load force profiles
Complete loss of tactile and proprioceptive sensibility	Impaired; excessive grip forces are established; grip force exceeds load force by 150–300 %	If the complete loss of tactile sensibility and proprioception is permanent, there is actually no temporal coupling between grip and load force profiles
Motor neuron disease	Impaired; excessive grip forces are generated; grip force exceeds load force by 50–100 %	Normal or impaired; if impaired, grip force is not processed in anticipation of movement-induced load force profiles
Cerebral lesion (acute and chronic stroke)	Impaired; the use of excessive grip force is most pronounced when central deficits of manual sensibility are present; grip force exceeds load force by 70–80 %	In general, only minor reduction of the precision of the grip-load force coupling; predictive force coupling may be completely lost in individual patients

	Efficiency of grip force scaling	Predictive temporal coordination between grip and load force profiles
Cerebellar degeneration	Impaired; excessive grip forces are produced; grip force exceeds load force by 50–100 %	Impaired; grip force does not anticipate movement-induced loads; the temporal coupling between grip and load force profiles is inaccurate
Parkinson's disease	Normal or impaired; the use of excessive grip force has been attributed to levodopa-induced dyskinesias; if impaired, grip force exceeds load force by 40–150 %	Slight to moderate dyscoordination of the temporal coupling between grip and load force profiles; prolongation of grip force generation, which is most pronounced in the levodopa OFF condition
Huntington's disease	Impaired; excessive grip forces are produced; grip force exceeds load force by 50–100 %	Slight dyscoordination of the coupling between grip and load force profiles; prolongation of grip force generation
Gilles de la Tourette syndrome	Impaired; excessive grip forces are produced; grip force exceeds load force by 40–60 %	Predictive coupling between grip and load force profiles during both voluntary movements and involuntary tics
Task-specific dystonia (writer's and musician's cramp)	Impaired; excessive grip forces are produced; grip force exceeds load force by 40–90 %	Predictive coupling between grip and load force profiles

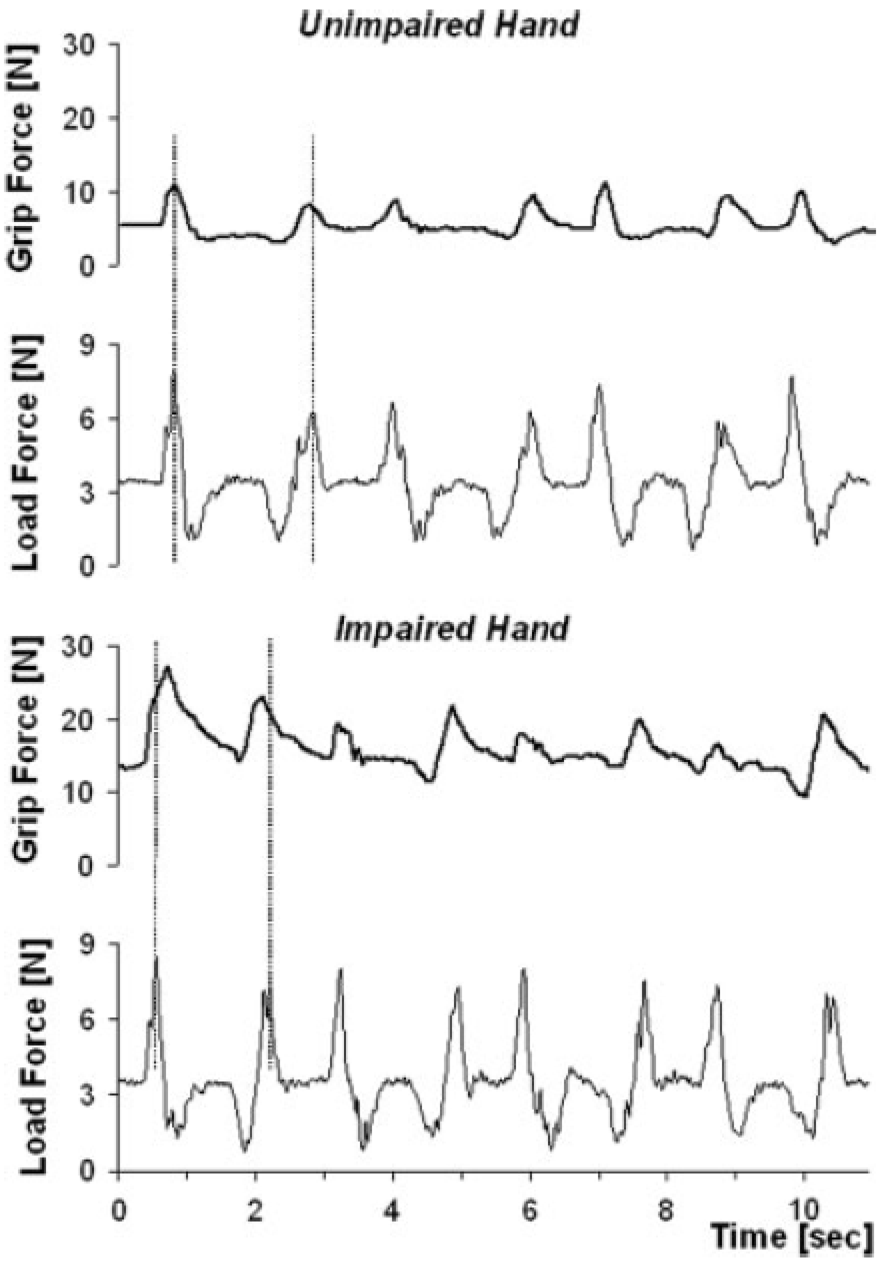
Perte totale de sensibilité tactile et proprioception



Déafférentée depuis 20 ans

- Pas possible de coder friction, poids

Stroke



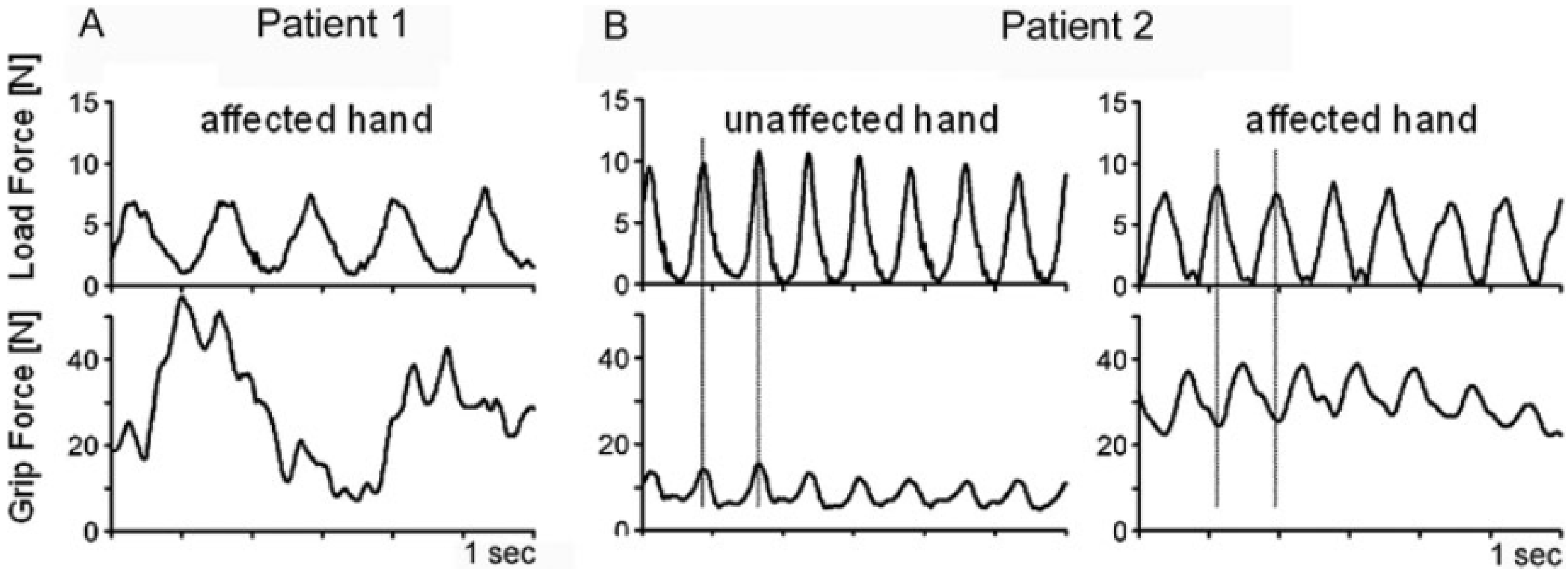
Stroke depuis 4 jours

- *Coordination temporelle OK*
- *Offset important GF*

Ce type de patient rapporte souvent des problèmes de dextérité manuelle fine (raideurs)

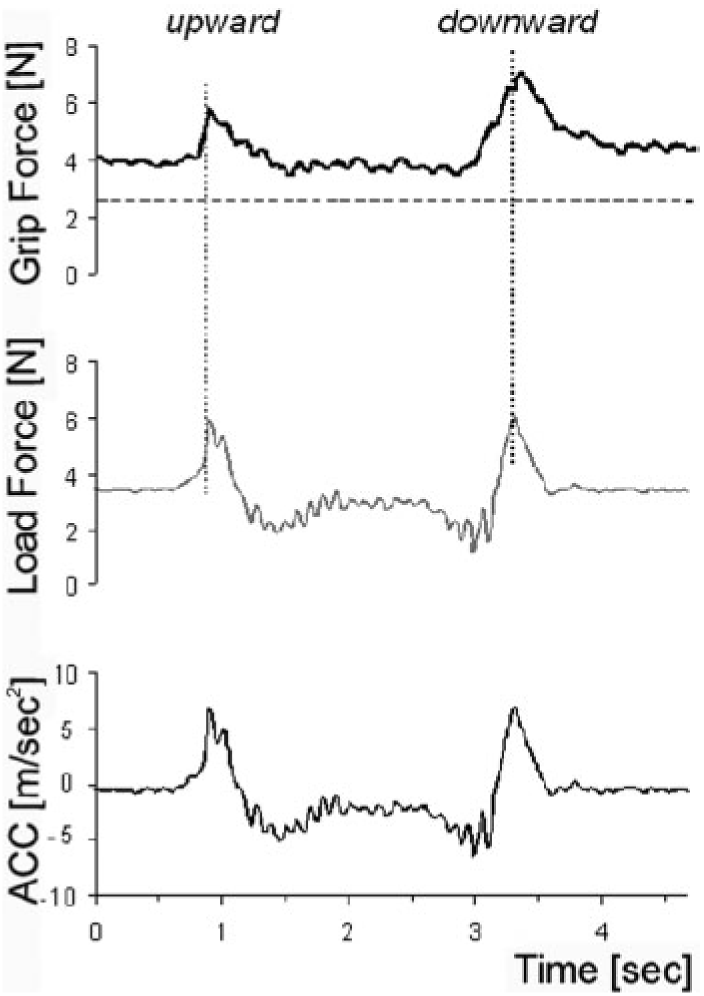
Spasticité seule peut expliquer la raison pour laquelle GF est↑
(Stratégie pour éviter de perdre l'objet)

Stroke: très variable



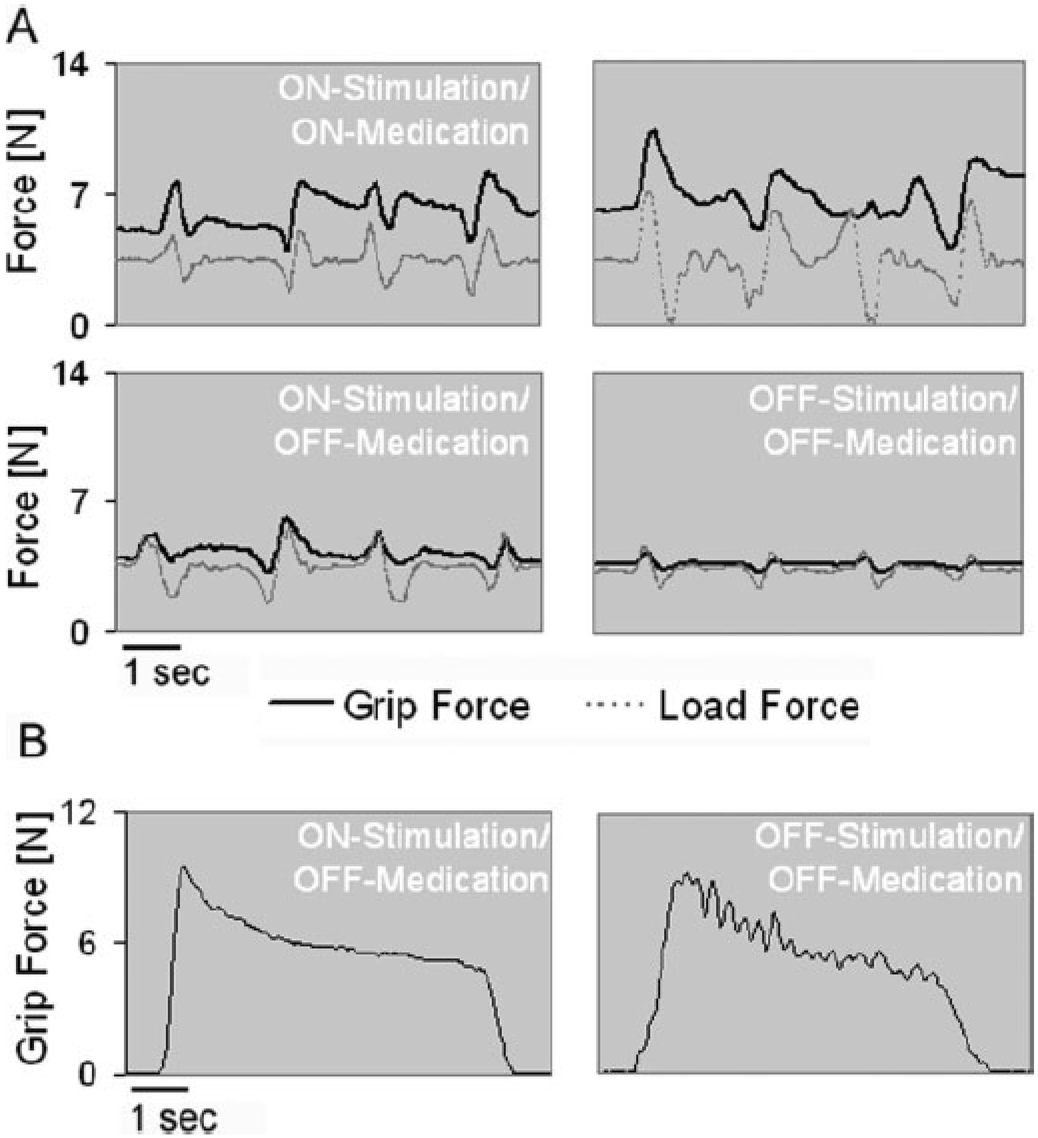
Cinématique régulière mais
- Aucun contrôle de la GF ou
- Déphasage de la GF

Parkinson



- Patient sous traitement
- Bonne modulation temporelle
- Bon niveau moyen de GF (voir seuil glissement)
- Fréquences 5-7Hz
- Mouvements plus lents que contrôles

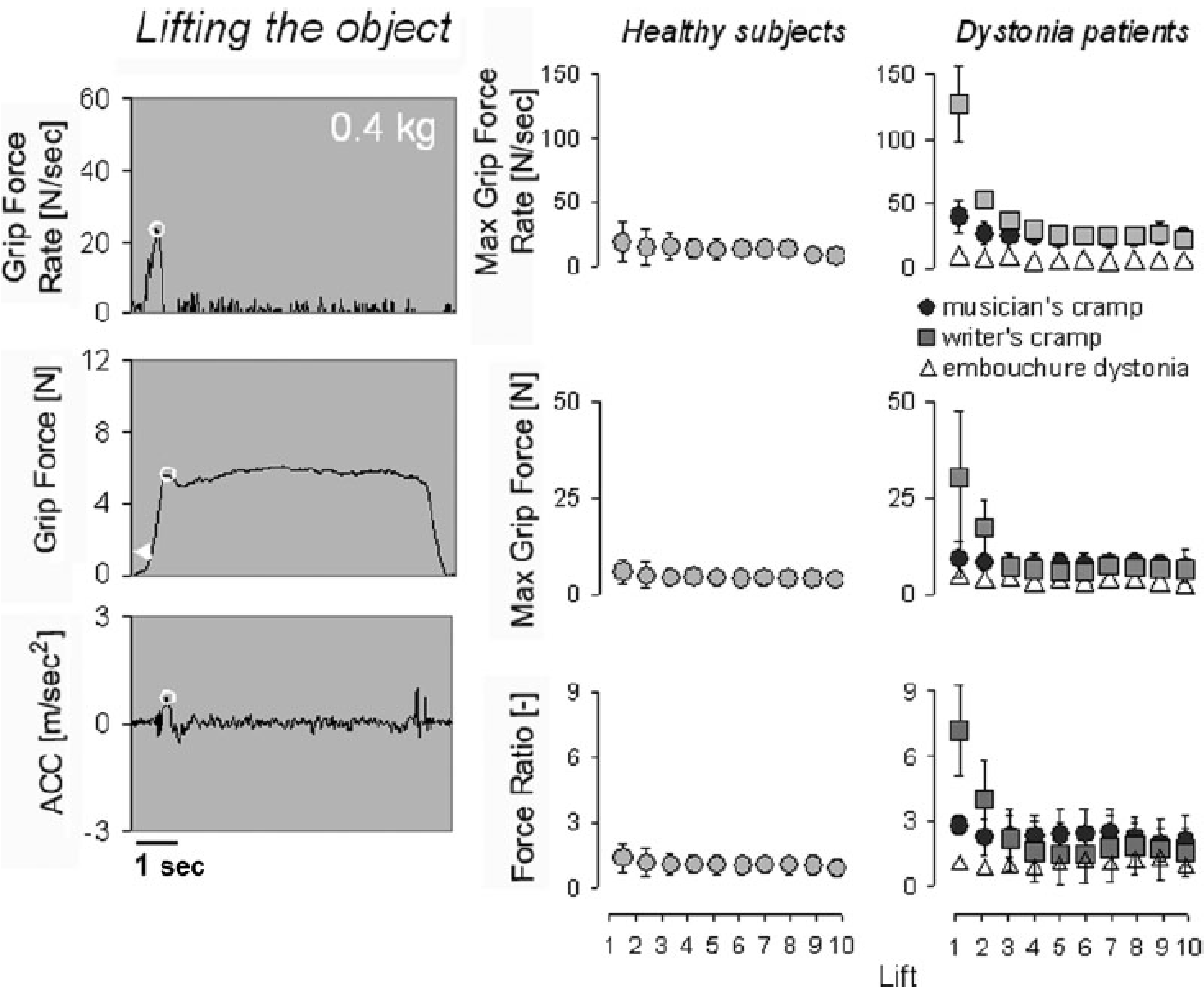
Parkinson: effets de deep brain stim



- Stimulation du noyau subthalamique

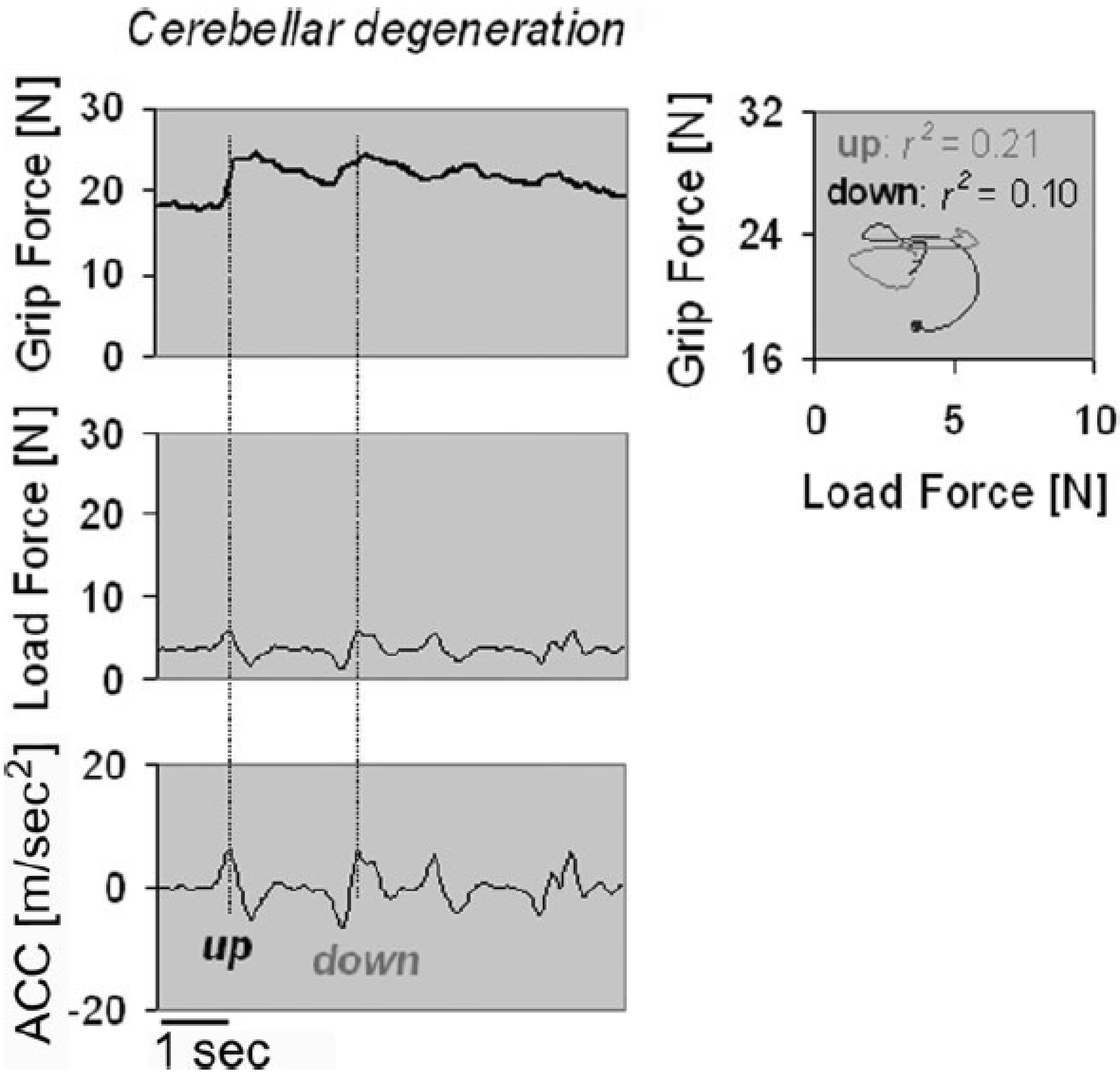
- Si medic: overshoot
- Si off stim et off medic: mouvements lents
- Si off medic et ON stim: bons niveaux de forces

Dystonia



- Focalisé
- Autres tâches non perturbées
- Apprentissage

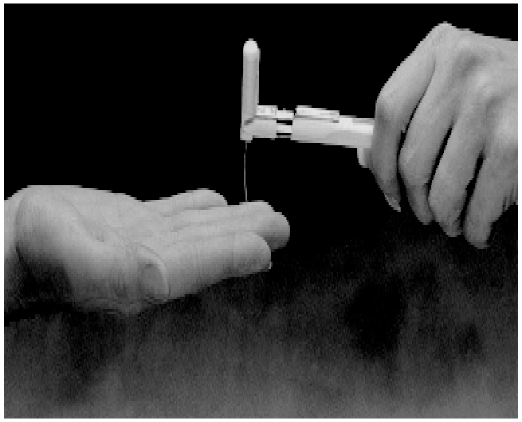
Dégénération CB



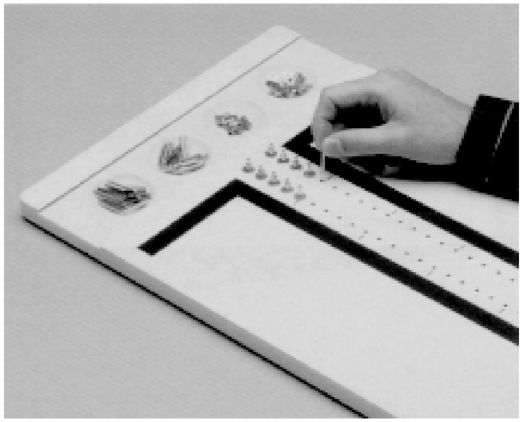
- Prédiction: modèles internes
- Candidat: CB
- Lésion du CB => impossibilité de prédire les conséquences de ses actions

Sensori-motor qualities explored

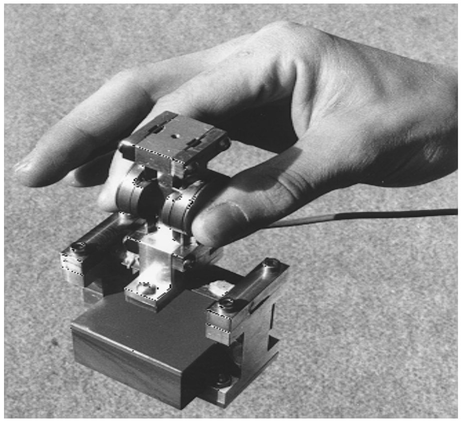
Sensation



Digital dexterity



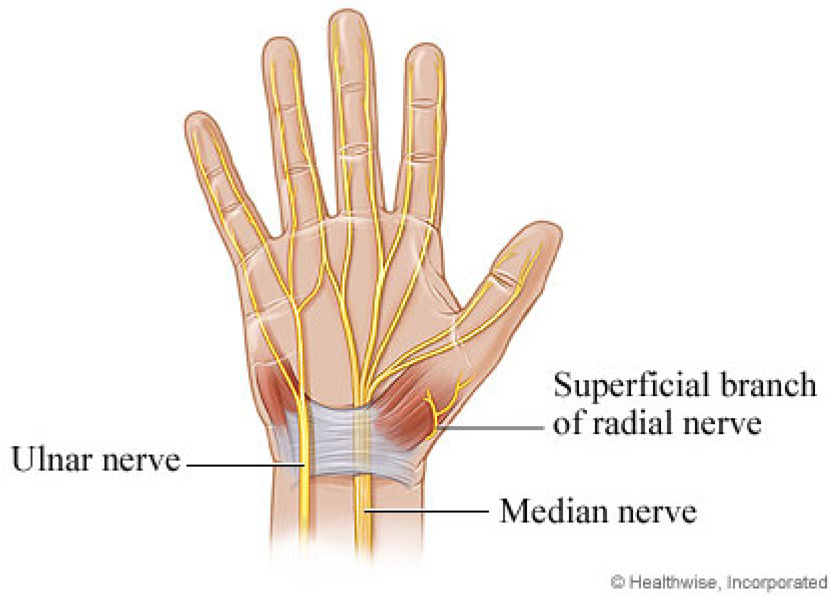
Precision grip



Case report

- 37 year-old man
- laceration at the left wrist
- median and ulnar nerves cut
- radial and ulnar arteries cut
- severance of some long flexor tendons
- suture of nerves, arteries and tendons
- plaster immobilisation
- splinting and rehabilitation

Case report


Superficial branch
of radial nerve
Ulnar nerve
Median nerve
© Healthwise, Incorporated

Electrodiagnostic studies

MOTOR NERVE CONDUCTION TESTING	6 M	12 M	18 M	24 M	Norms
Ulnar CMAP (mV)	1.8	8.5	7.8	10.7	>6.6
Ulnar DML (ms)	6.5	4.4	3.8	3.8	<3.3
Median CMAP (mV)	NO	0.3	1.8	1.6	>4
Median DML (ms)	NO	8.7	7.0	6.1	<4.4

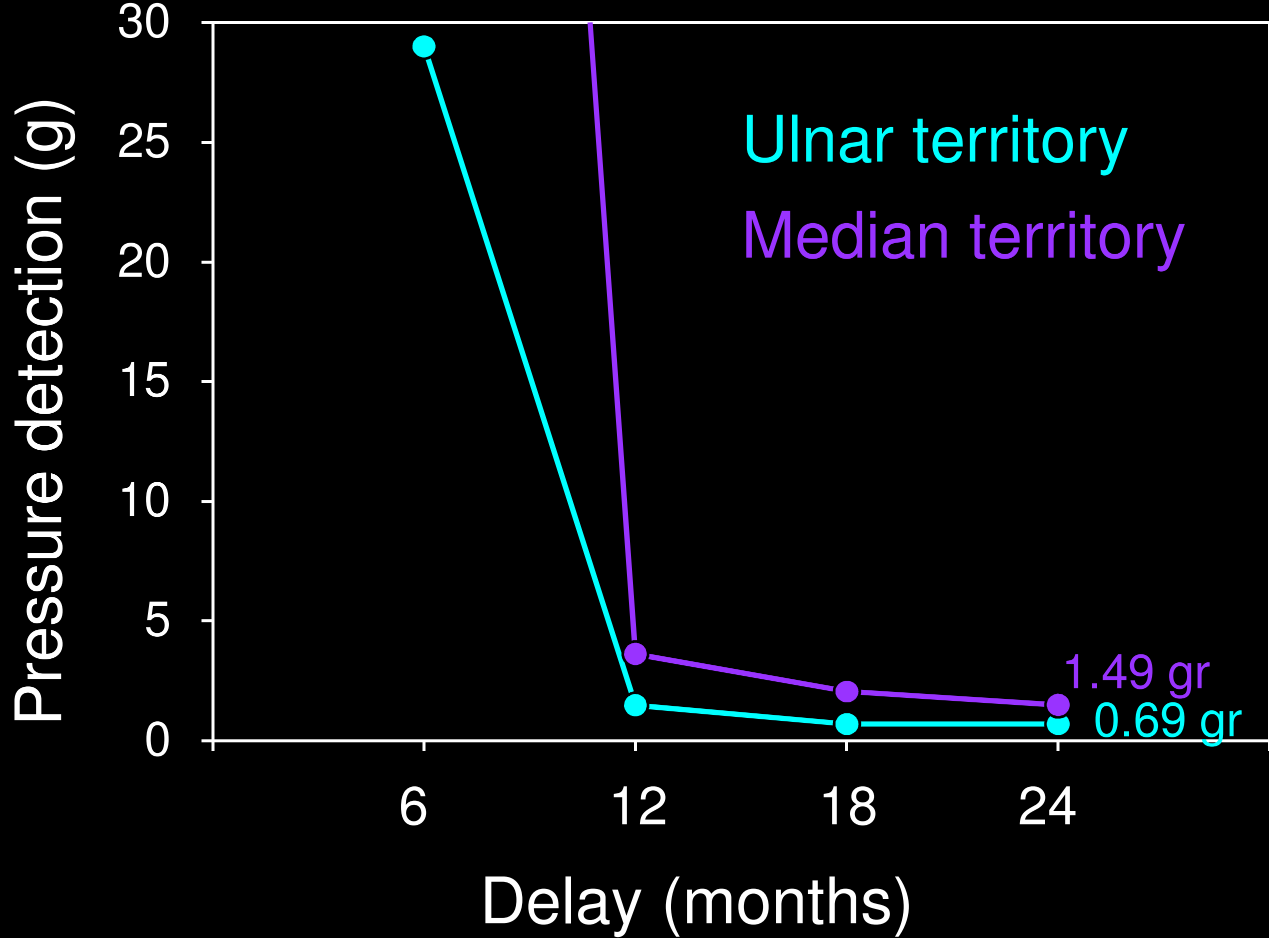
SENSORY NERVE CONDUCTION TESTING	6 M	12 M	18 M	24 M	Norms
Ulnar SNAP (mV)	NO	5.6	3.2	8.3	>17
Ulnar DSL (ms)	NO	3.9	3.8	2.7	<3.1
Median SNAP (mV)	NO	NO	NO	5.6	>20
Median DSL (ms)	NO	NO	NO	3.2	<3.5

Combined Motor Action Potential

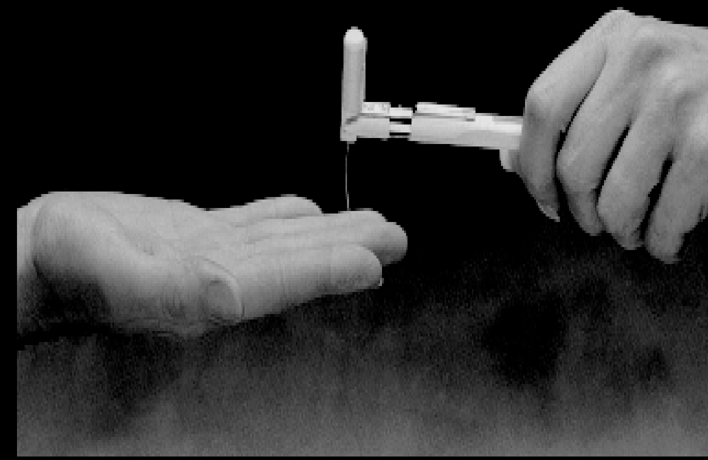
Sensory Nerve Action Potential

Distal Motor/Sensory Latency

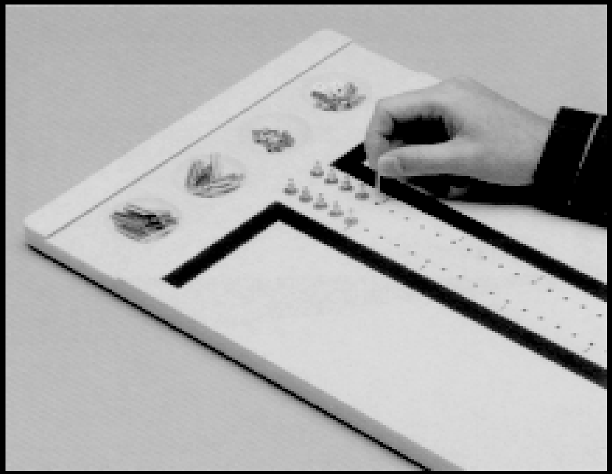
Sensation Tactile

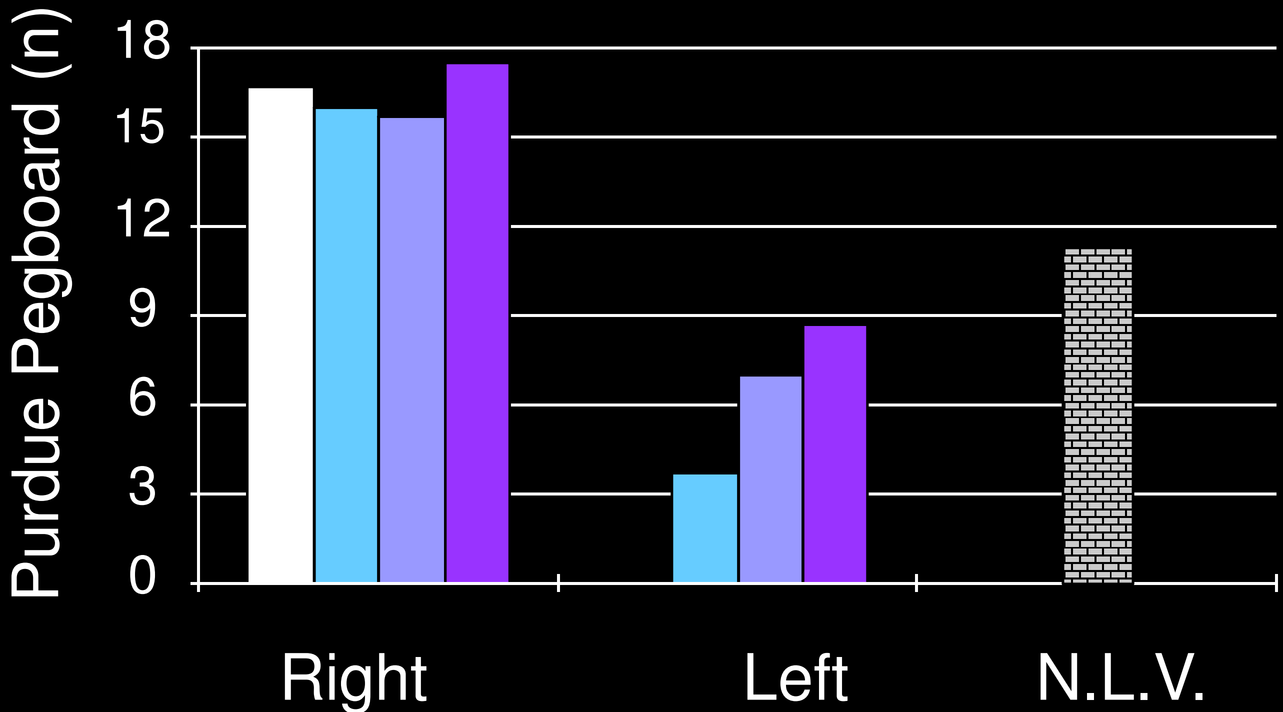


N.U.V.<0.41gr



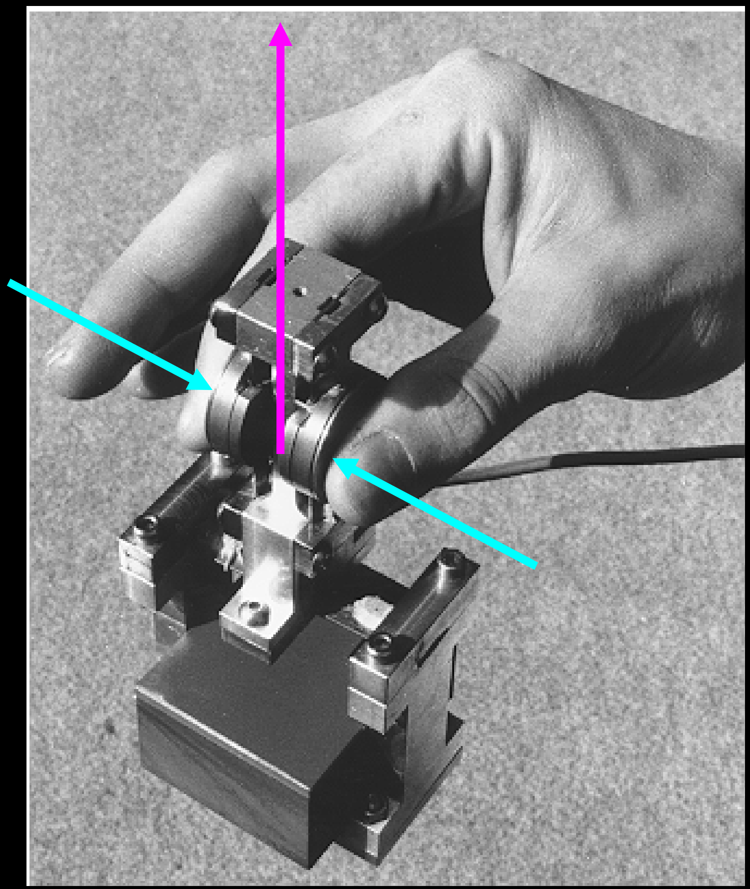
Digital dexterity

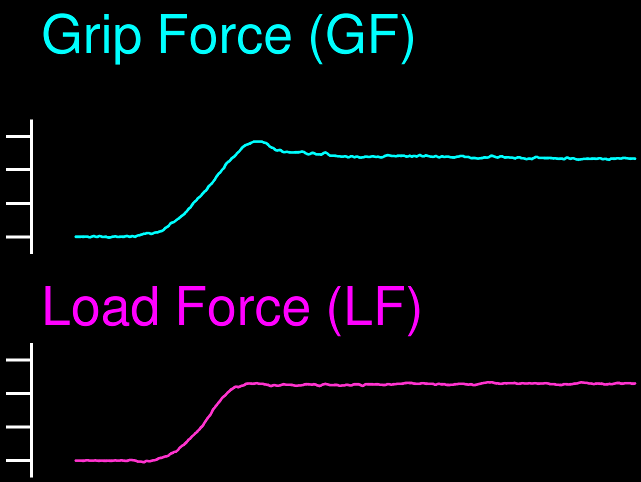




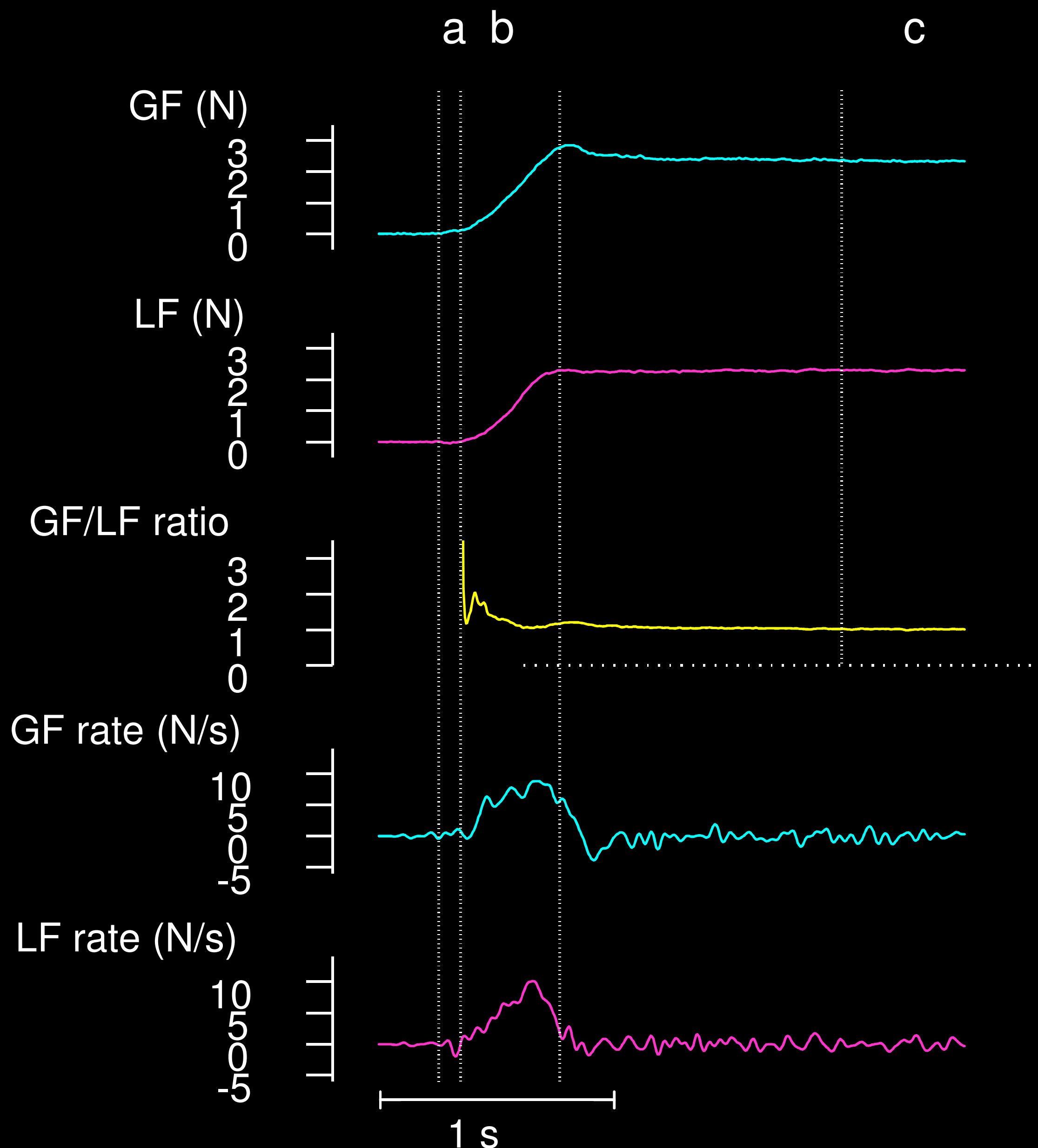
6 months; 12 months; 18 months; 24 months

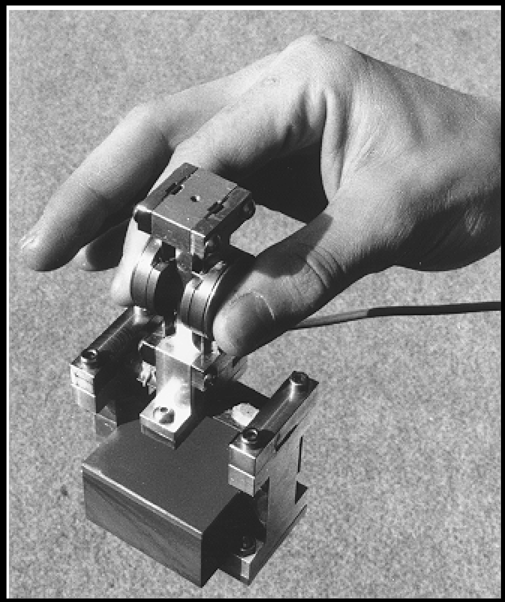
Precision grip





Grip/Lift Synergy



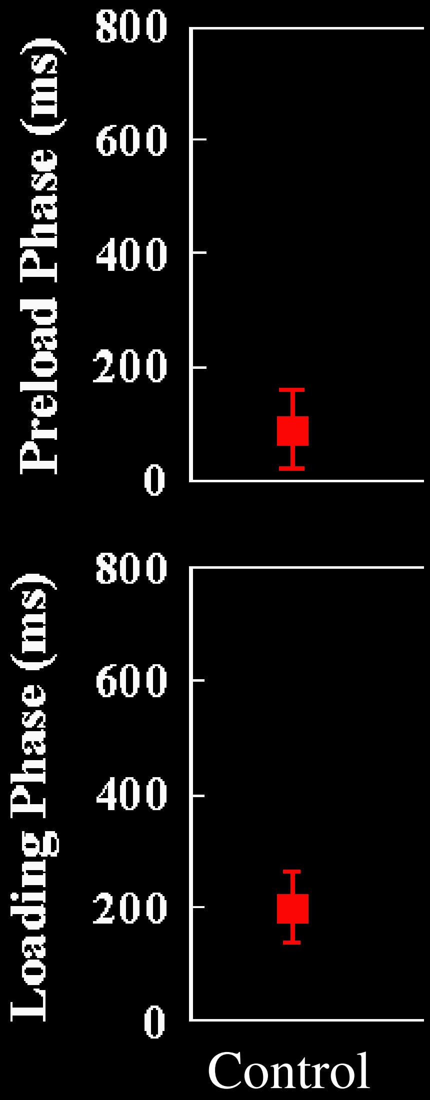


Phases

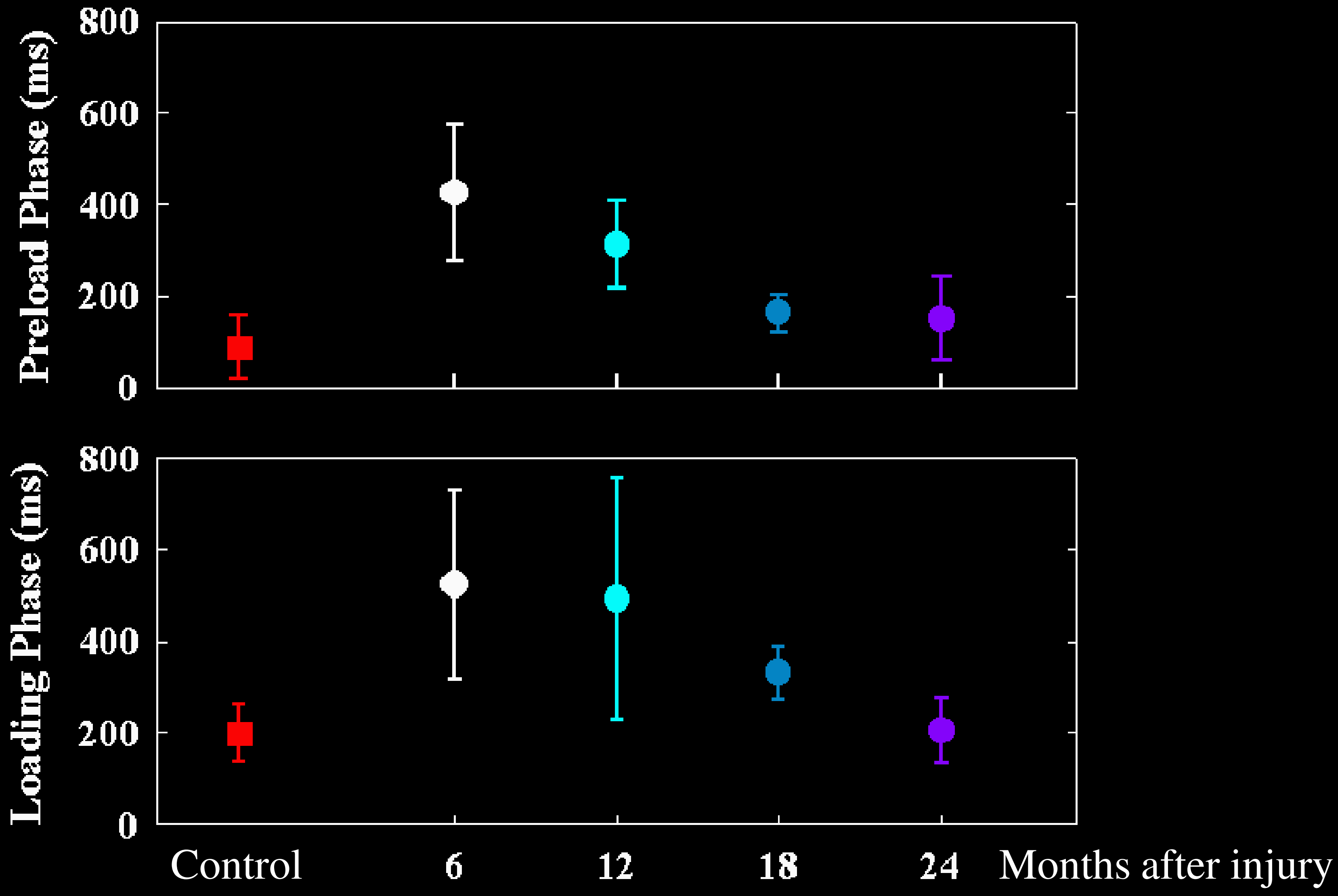
a preload
b loading
c static

NB: M1 + voie cortico-spinale

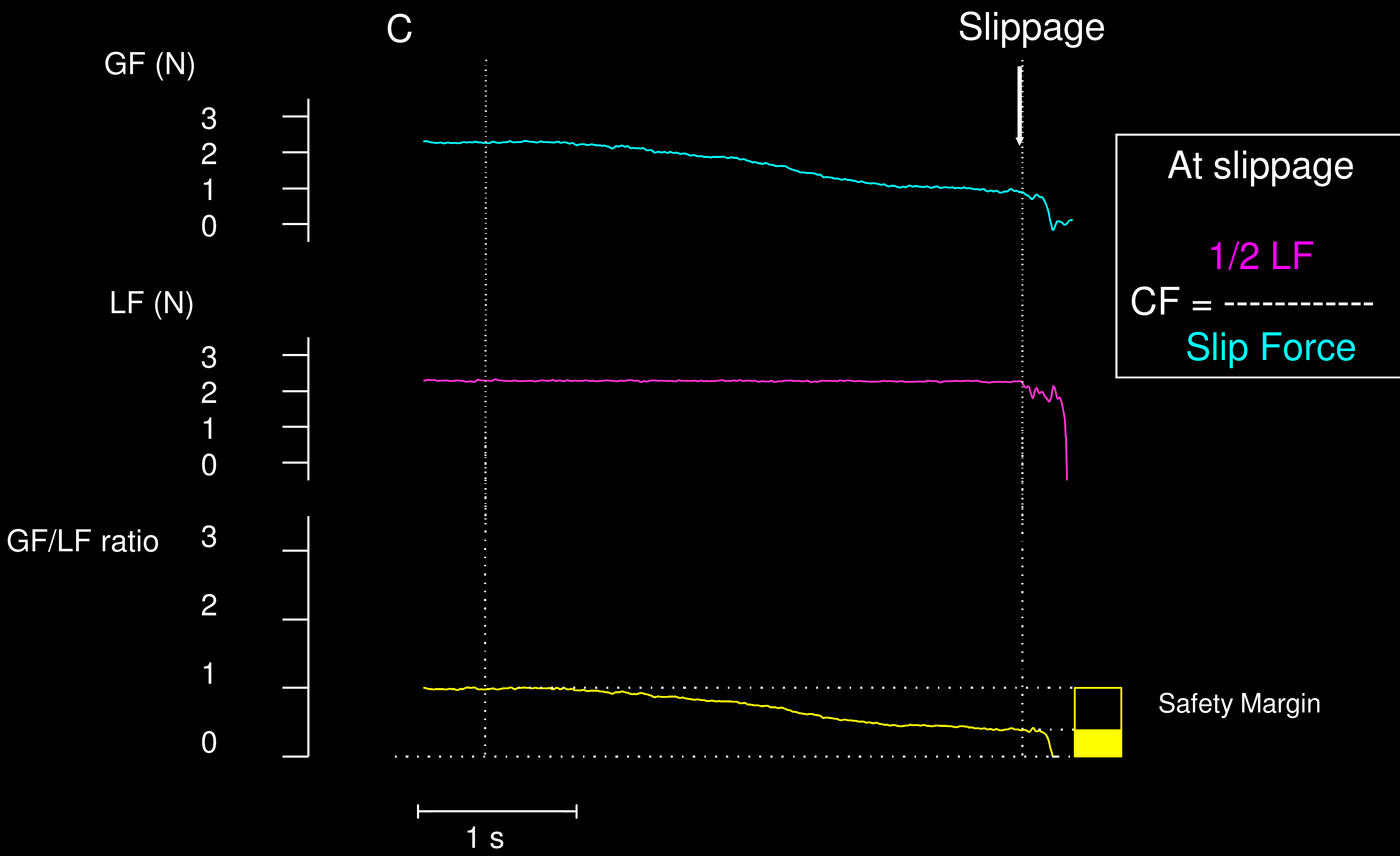
Temporal parameters



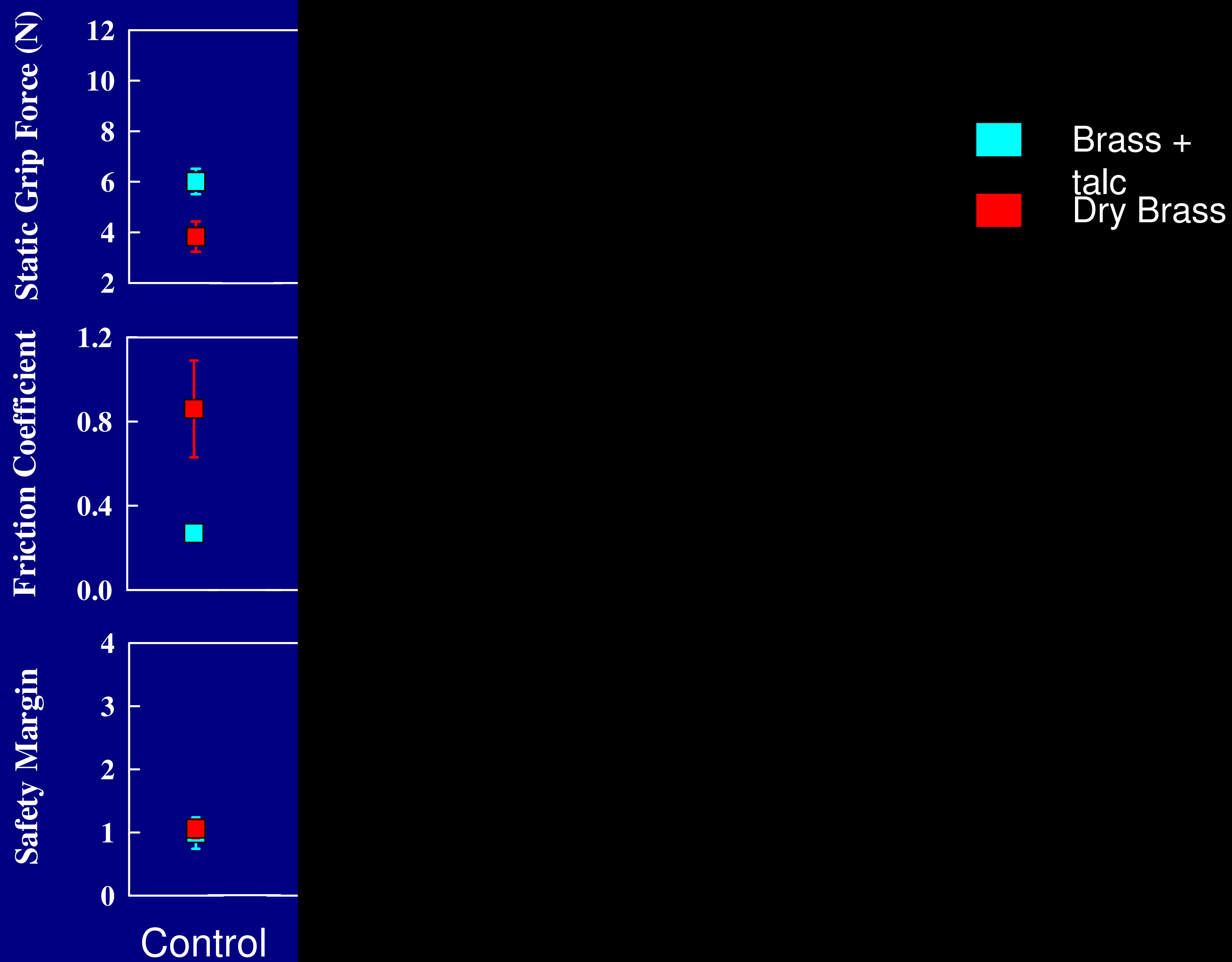
Temporal parameters



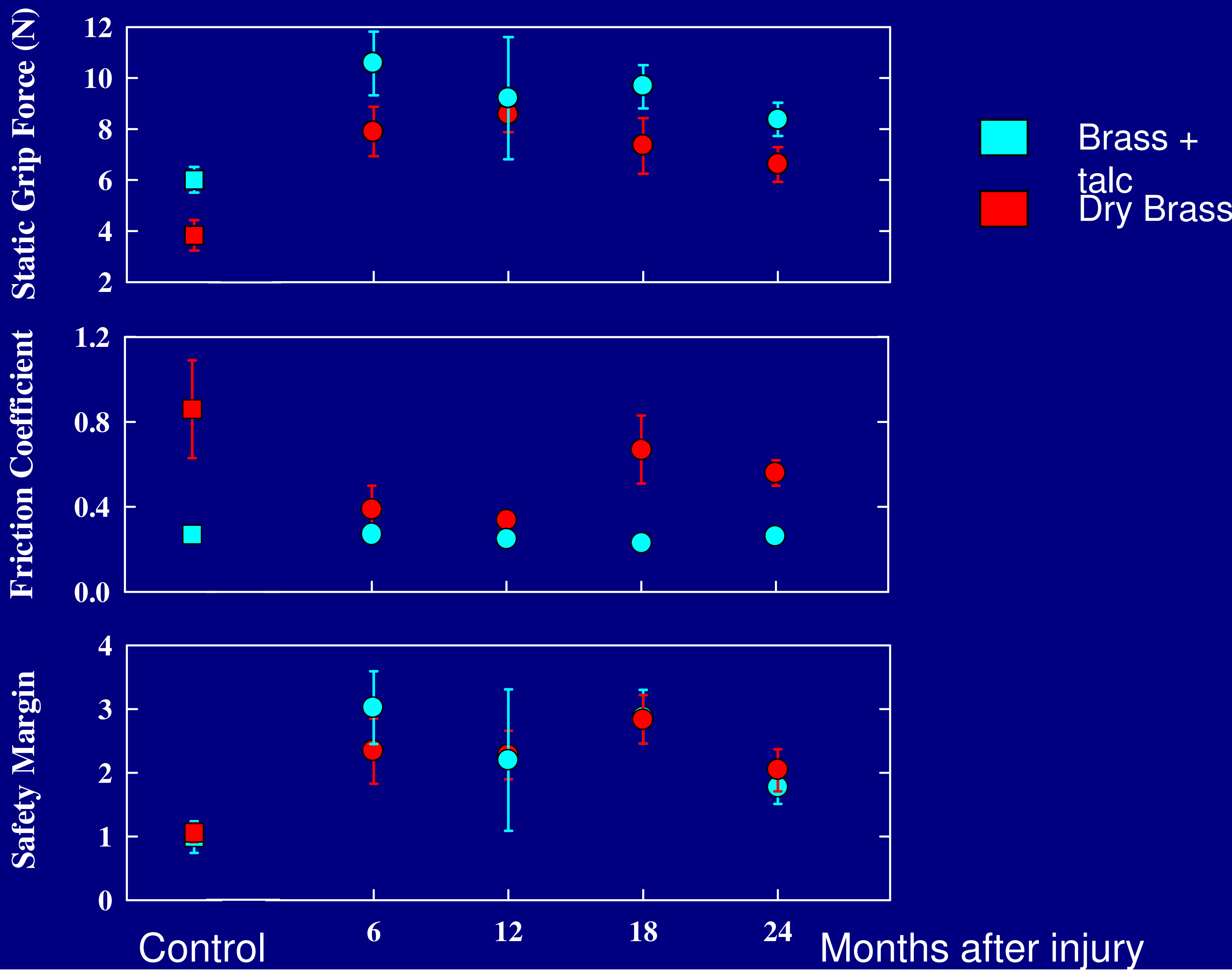
Grip/Lift Synergy

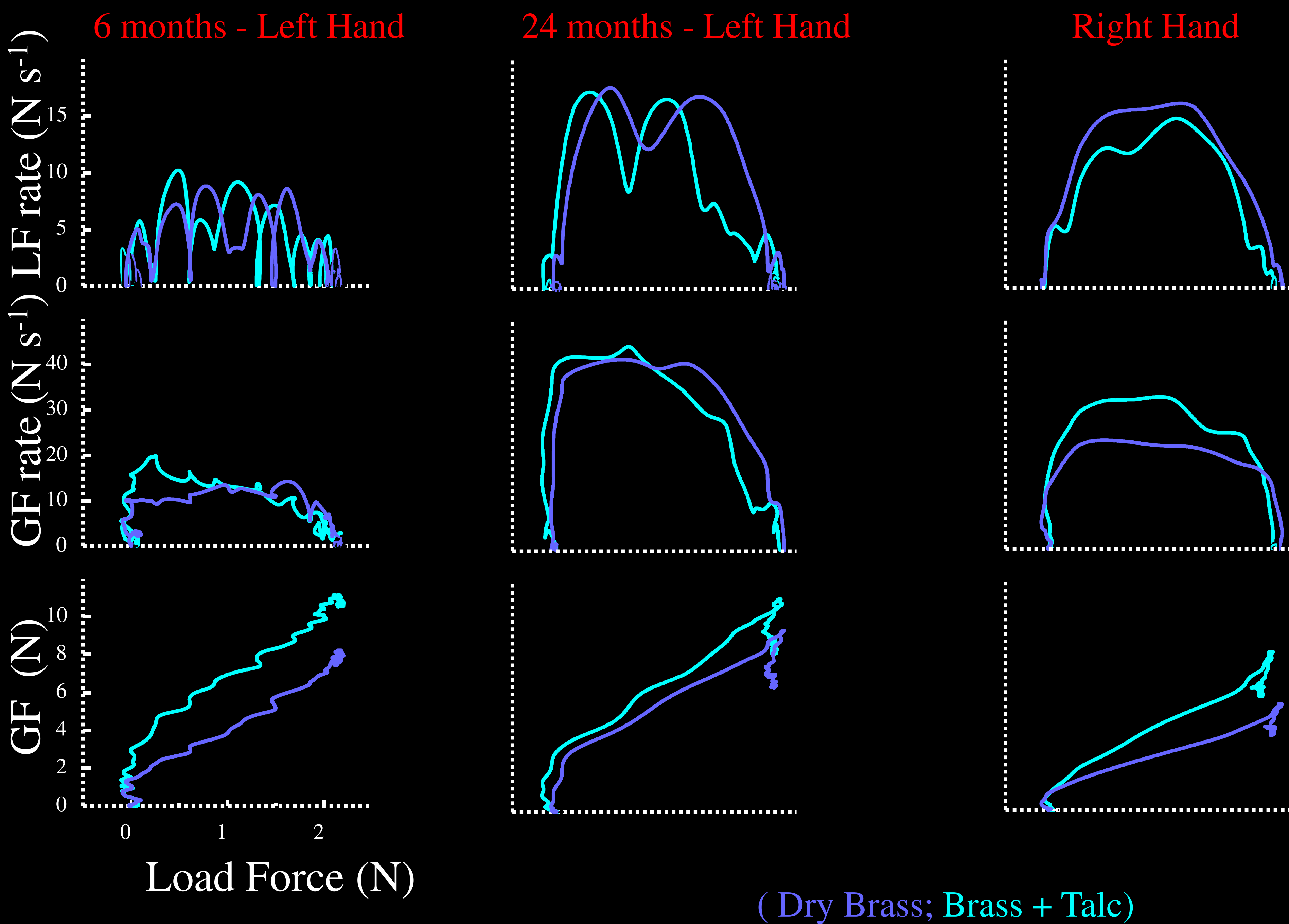


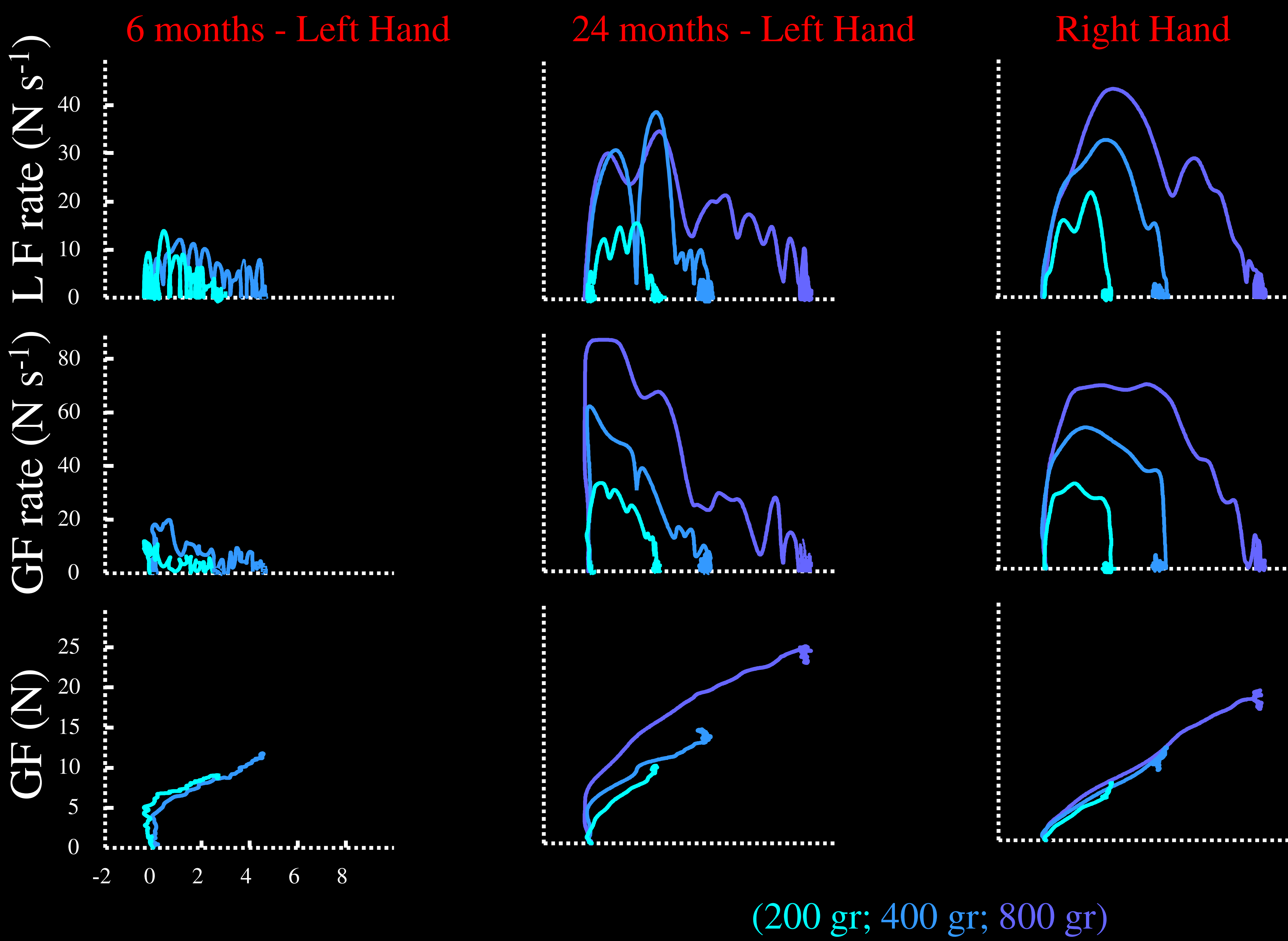
Static phase parameters



Static phase parameters




6 months - Left Hand
24 months - Left Hand
Right Hand
LF rate (N s-1)
GF rate (N s-1)
GF (N)
15
10
5
0
40
30
20
10
0
10
8
6
4
2
0
0
1
2
Load Force (N)
(Dry Brass; Brass + Talc)


6 months - Left Hand
24 months - Left Hand
Right Hand
L F rate (N s-1)
GF rate (N s-1)
GF (N)
40
30
20
10
0
80
60
40
20
0
25
20
15
10
5
0
-2
0
2
4
6
8
(200 gr; 400 gr; 800 gr)

CONCLUSIONS

- La méthode est assez sensible pour quantifier objectivement les performances sensori-motrices de la main pendant la régénération du nerf périphérique,

- Le niveau de l'information recueillie par cette évaluation est différent et complémentaire des examens cliniques de routine et des explorations neurophysiologiques.

Importance of cutaneous feedback in maintaining a secure grip during manipulation of hand-held objects

- Examine the grip-load force coupling during cyclic arm movements while tactile feedback was suppressed by anesthetizing the thumb and index finger.

- **Determine the respective contribution of feedforward and feedback processes during objects manipulation.**

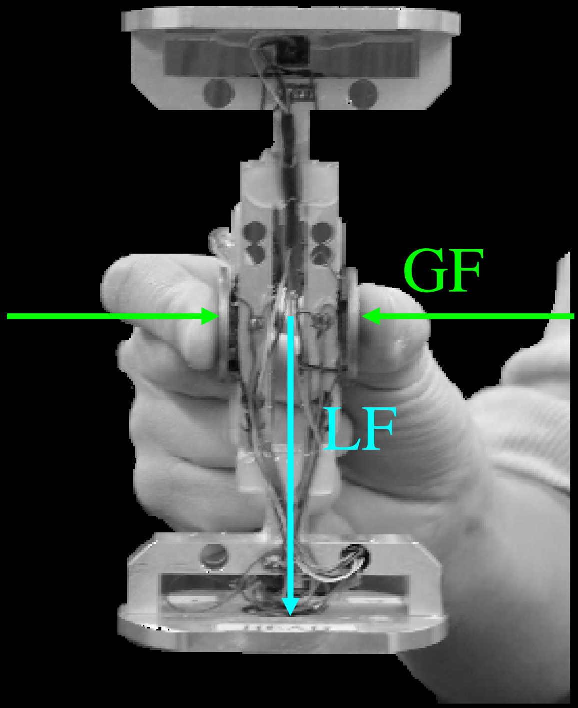
Methods

- 10 subjects, 11 trials before and during anaesthesia.

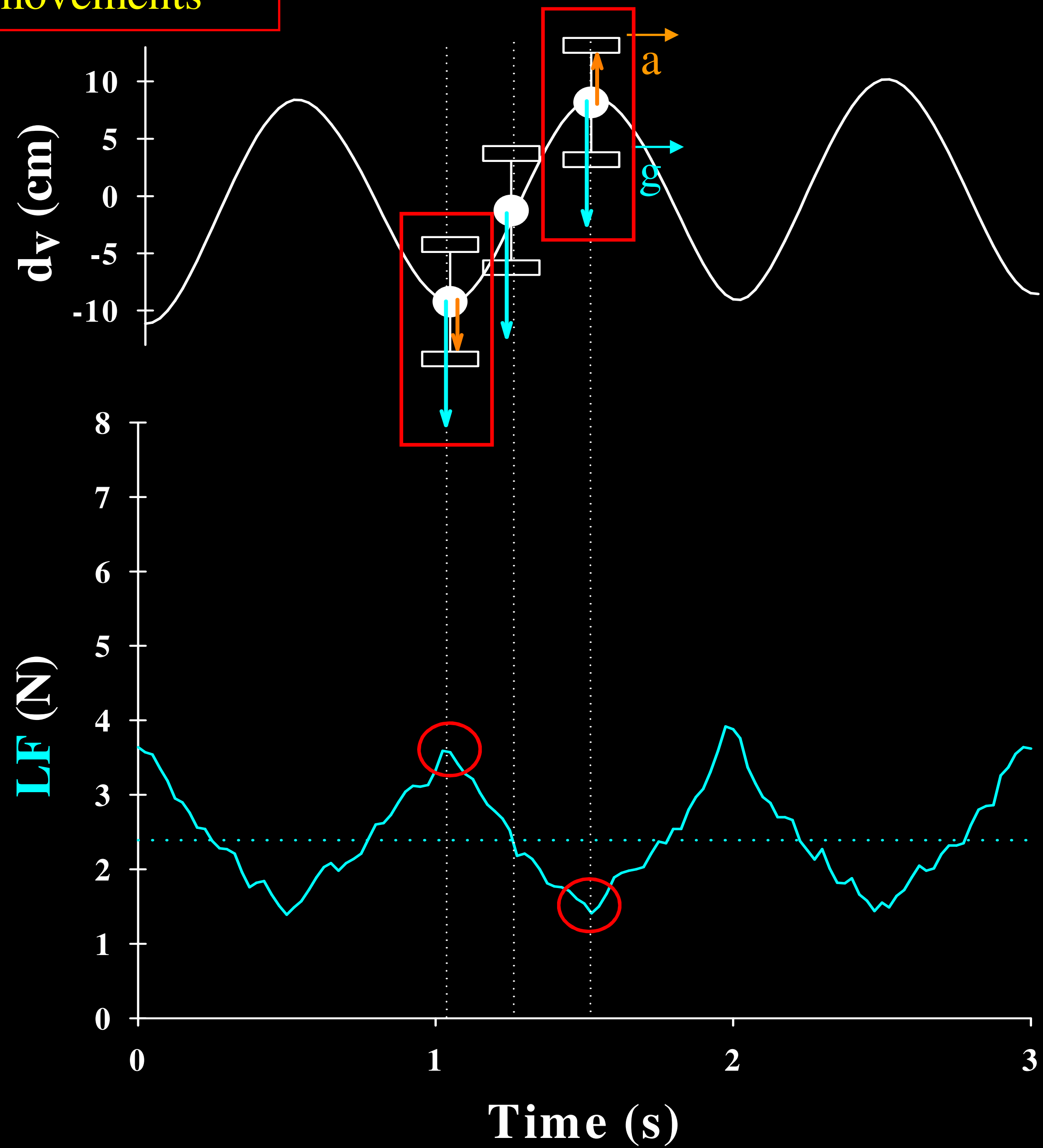
- Static Phase : grasp a 250 g load, lift it and held the object for 20 sec,

- Dynamic Phase : cyclic vertical arm movement (1Hz, 20cm) during 30 sec,

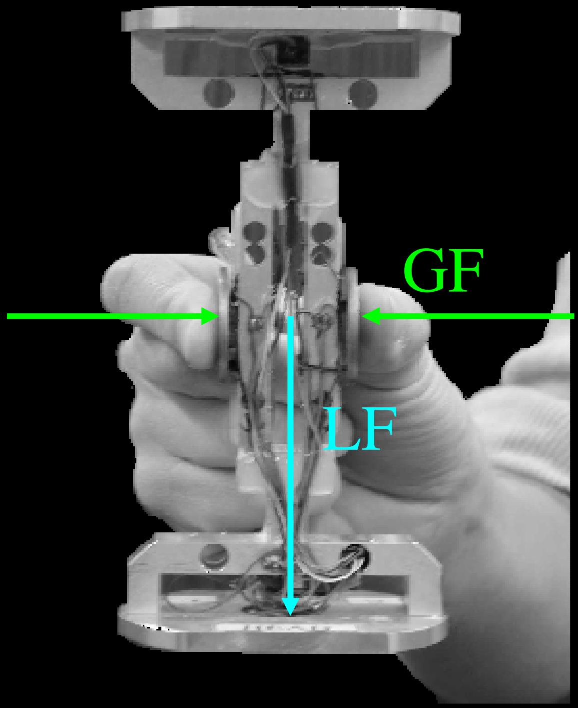
Grip-load force coupling during active movements



$$LF = mg + ma$$

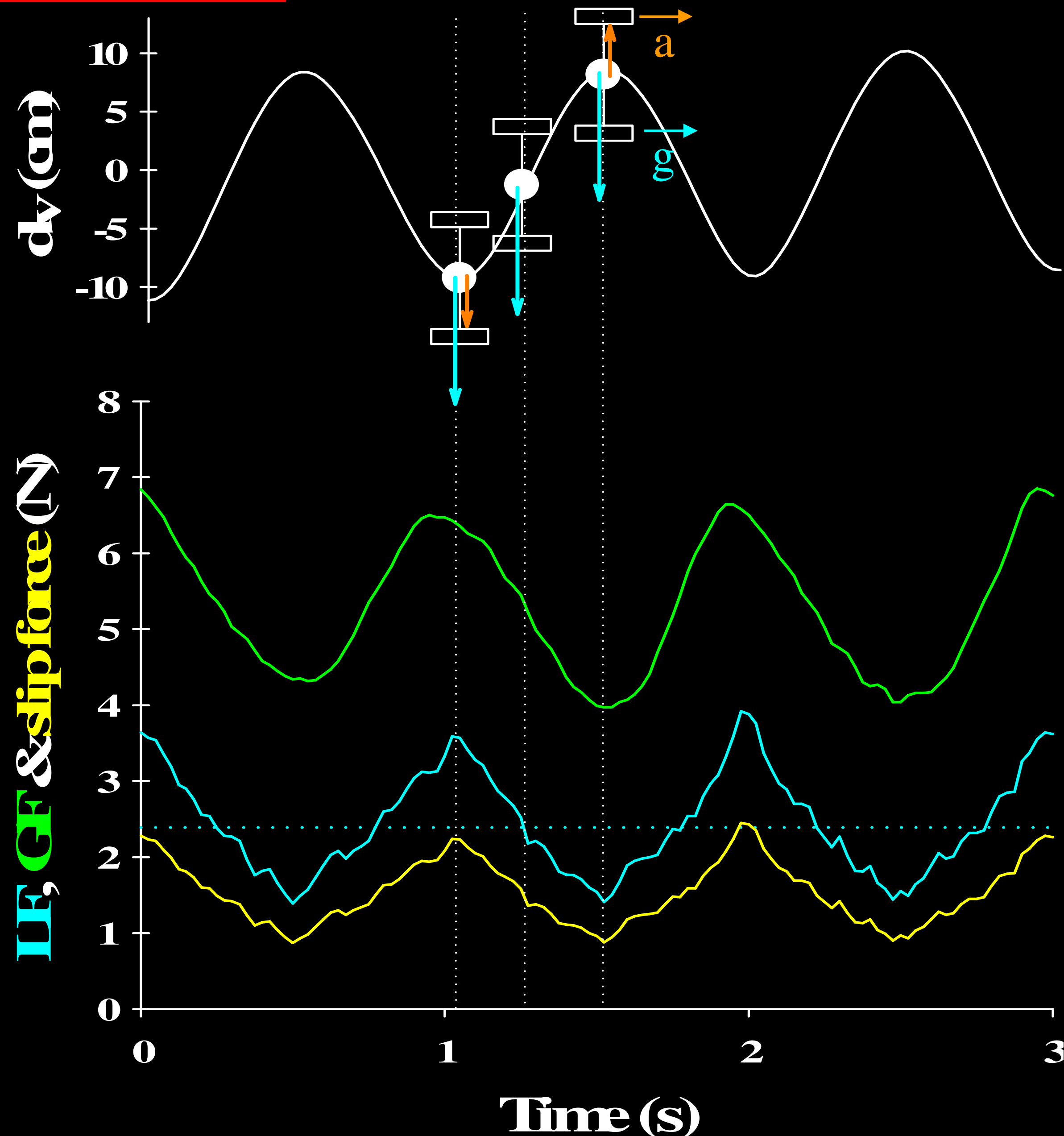


Grip-load force coupling during active movements

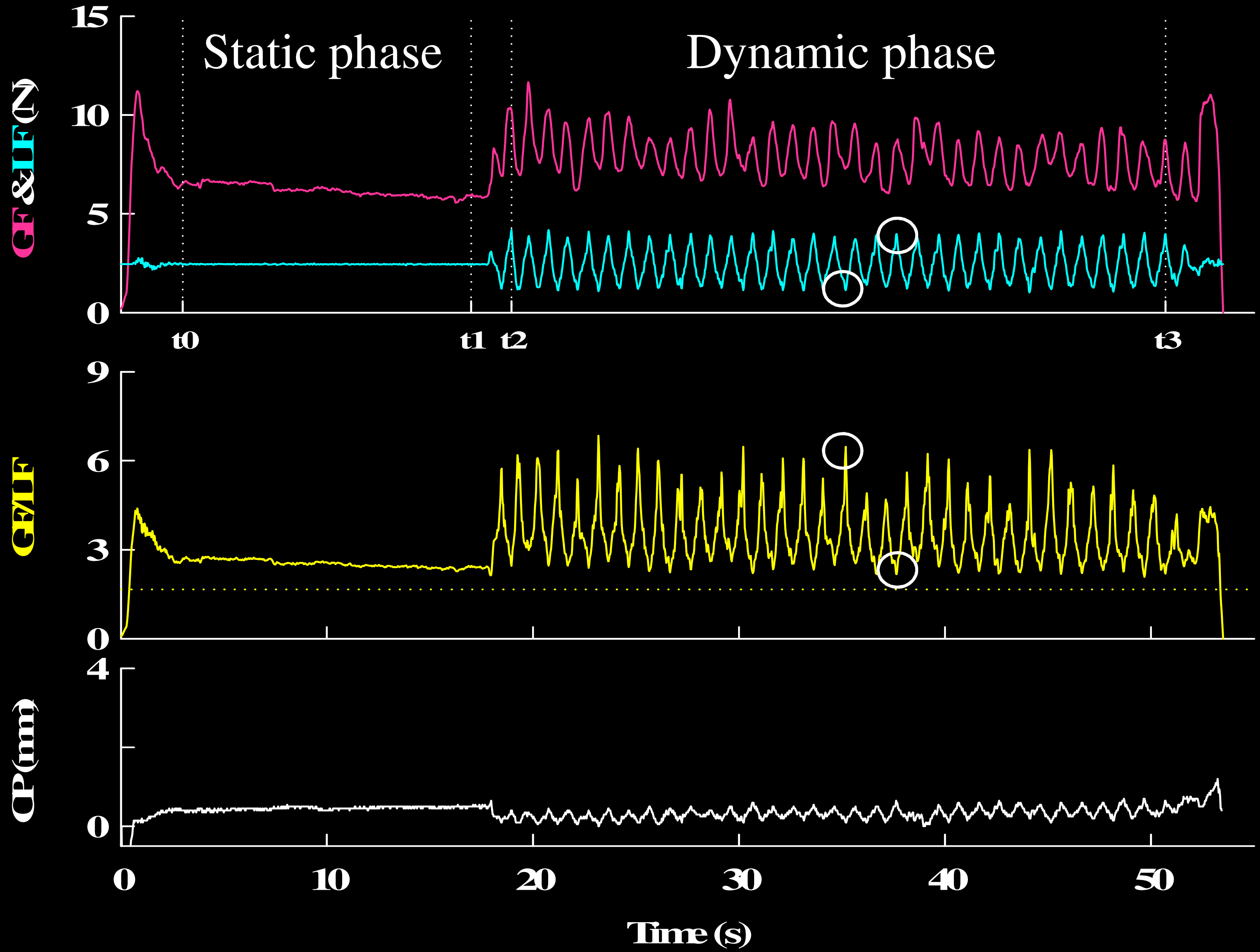


$LF = mg + ma$

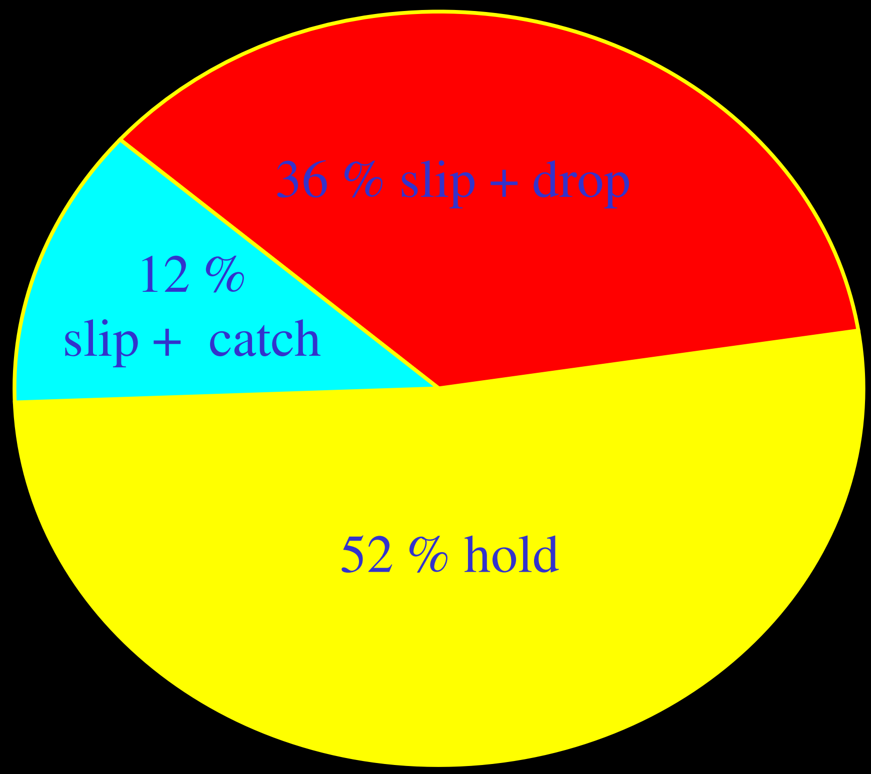
$SF = 0.5 * LF / CF$



GF-LF coupling before anaesthesia

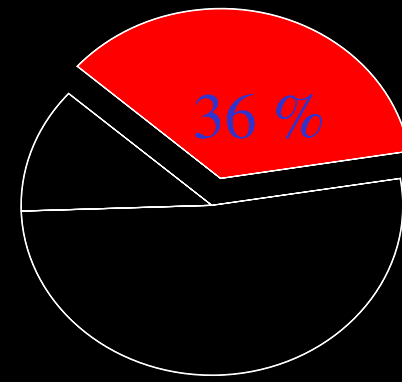


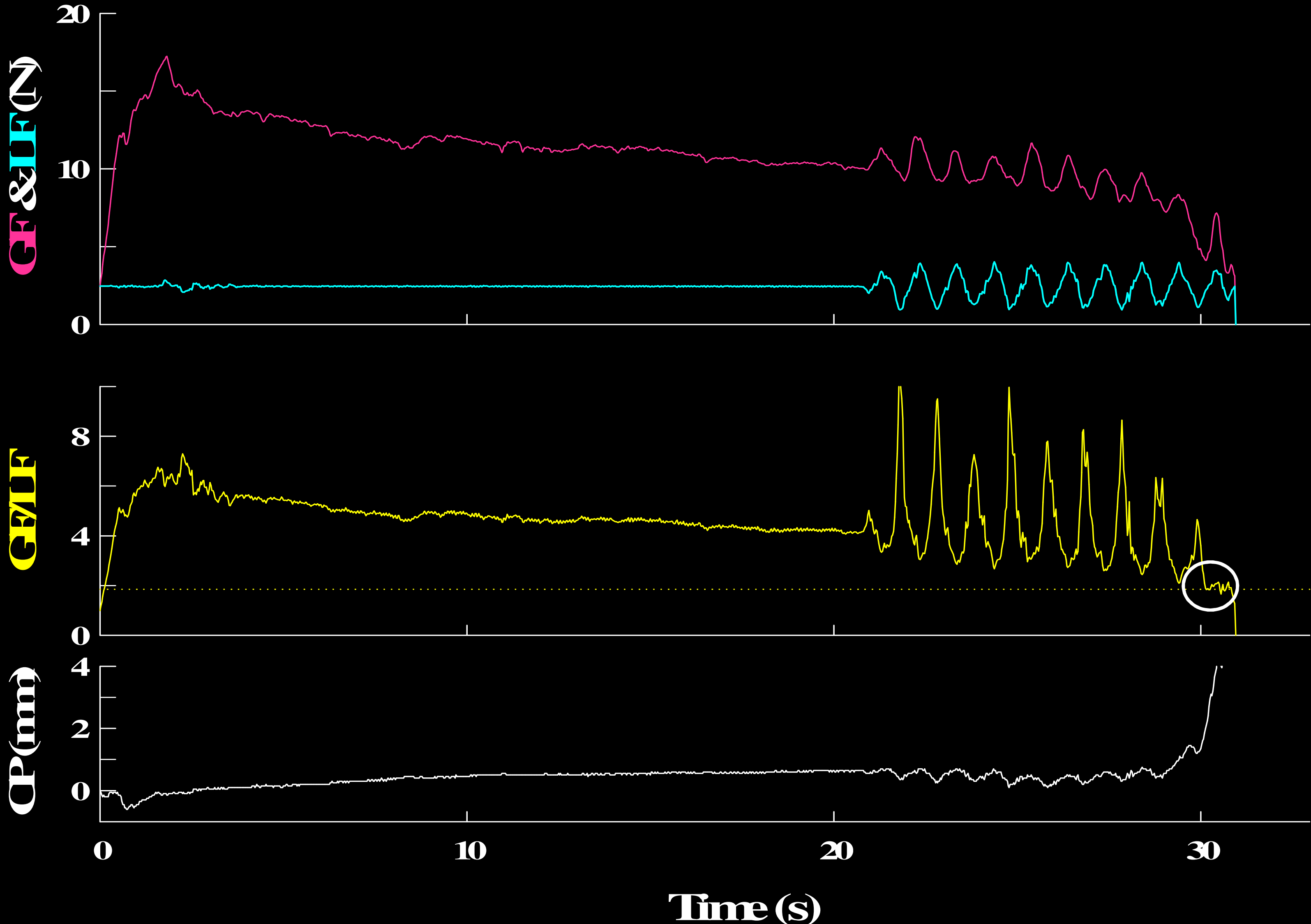
GF-LF coupling during anaesthesia



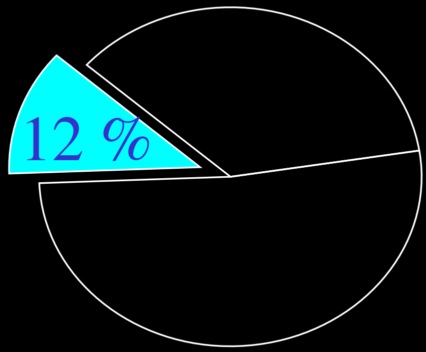
n = 110 (10 subjects x 11 trials)

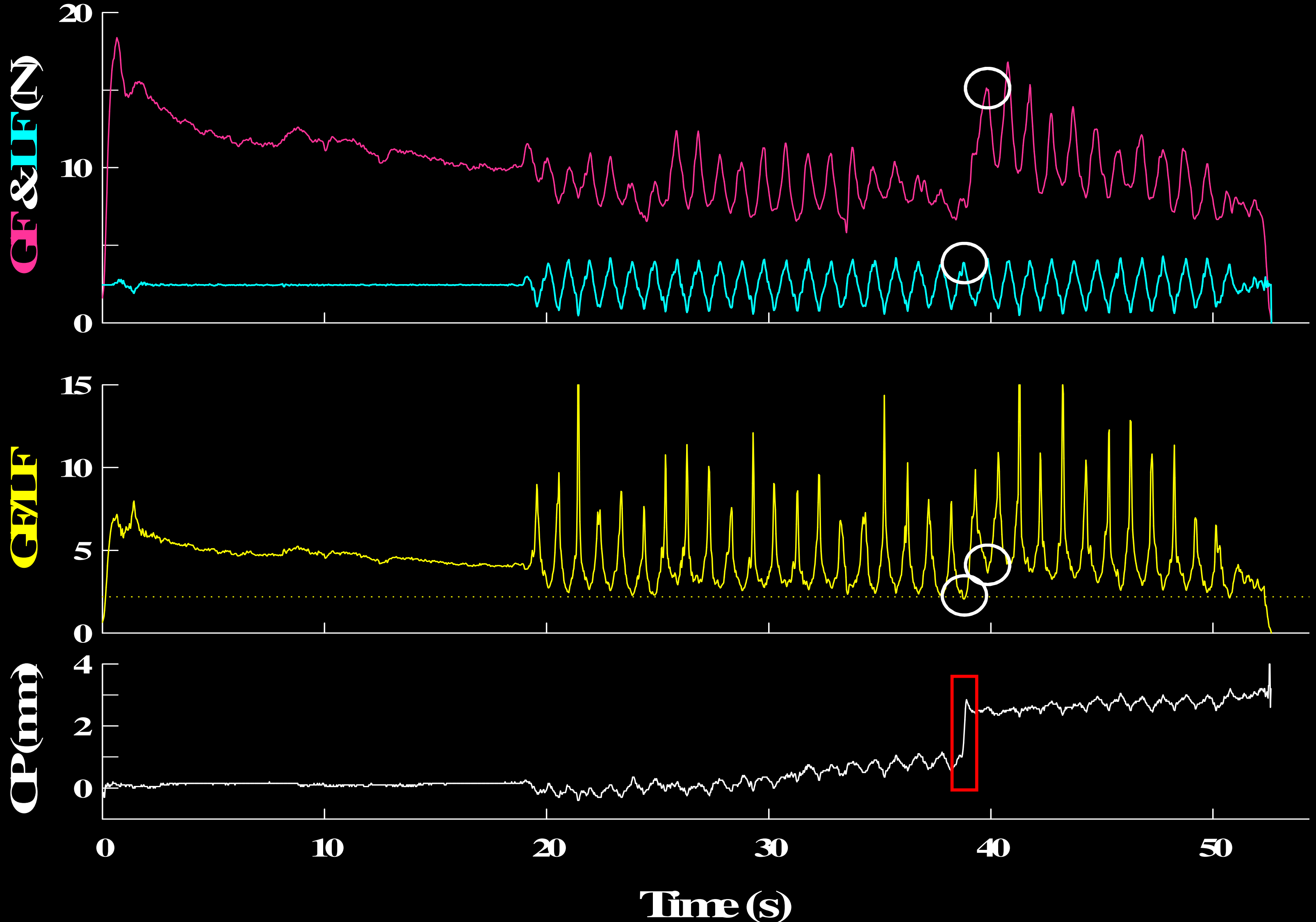
GF-LF coupling during anaesthesia: Slip + drop



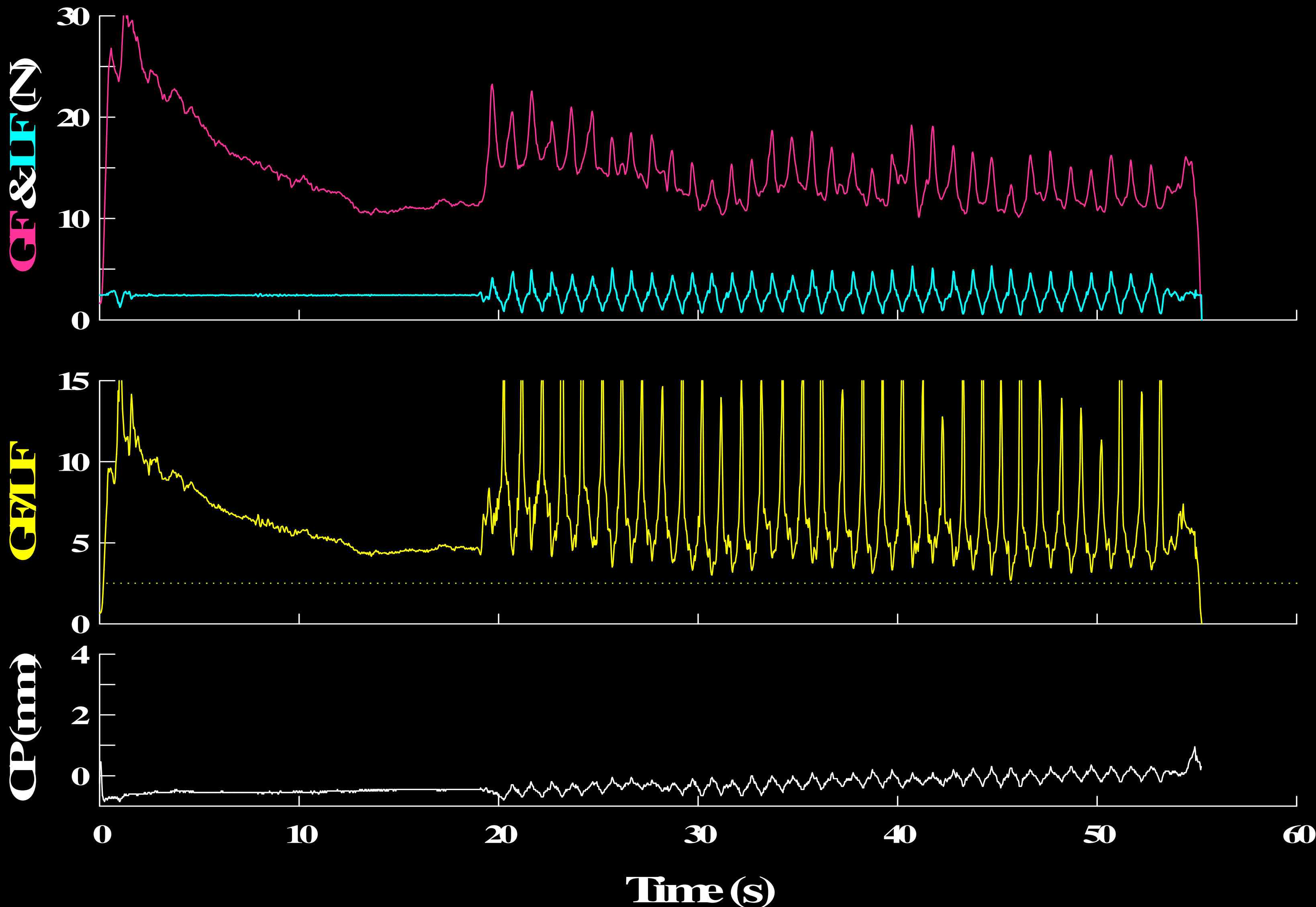


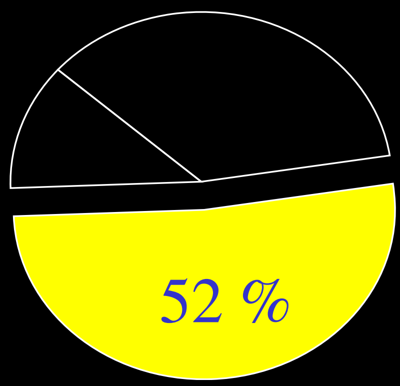
GF-LF coupling during anaesthesia: Slip + catch





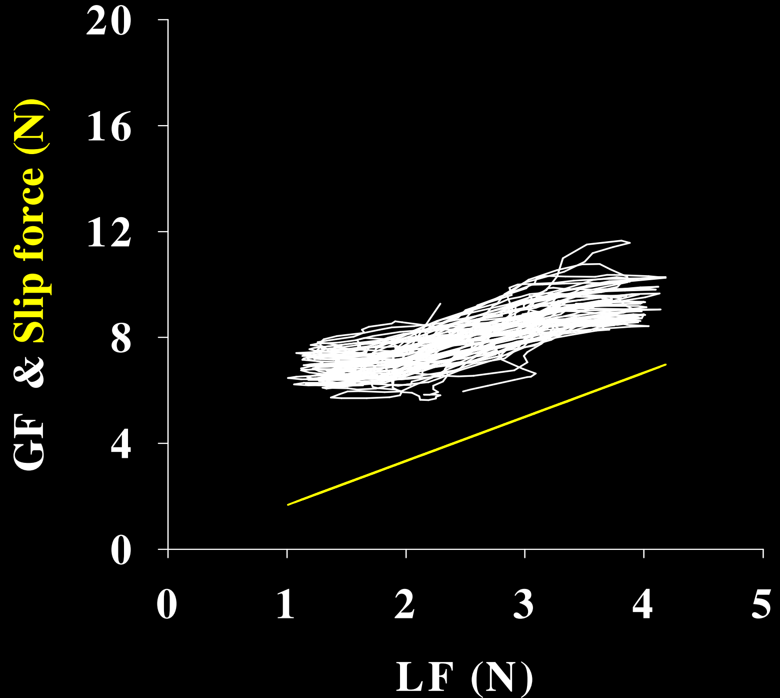
GF-LF coupling during anaesthesia: Hold





GF-LF relationship before and during anaesthesia

Before anaesthesia

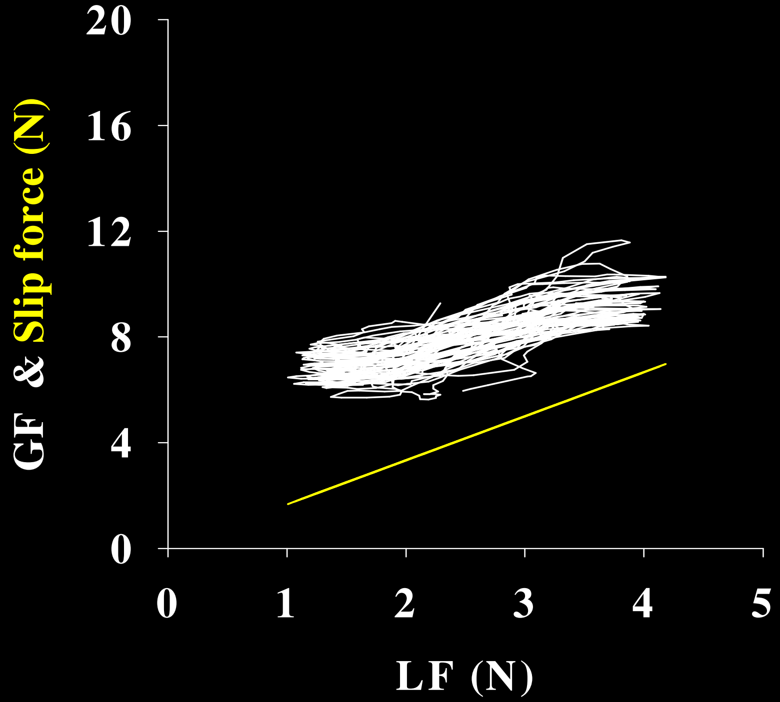


Time lag = -7 ± 21 ms

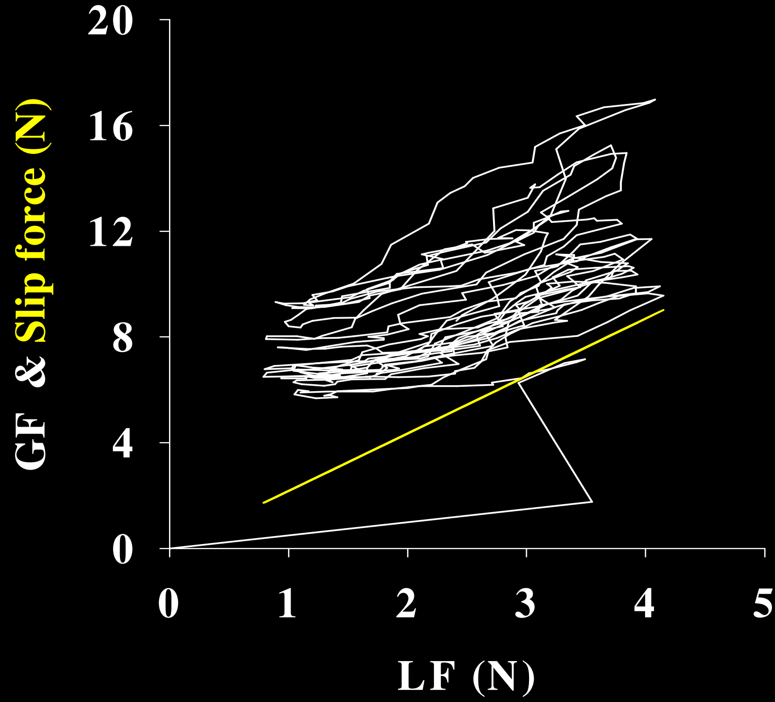
Cross correlation
r = 0.75 ± 0.13

GF-LF relationship before and during anaesthesia

Before anaesthesia



Digital anaesthesia



Time lag = -7 ± 21 ms

Cross correlation
r = 0.75 ± 0.13

Time lag = 2 ± 44 ms

Cross correlation
r = 0.48 ± 0.2

La préhension et le membre supérieur: aspects cliniques

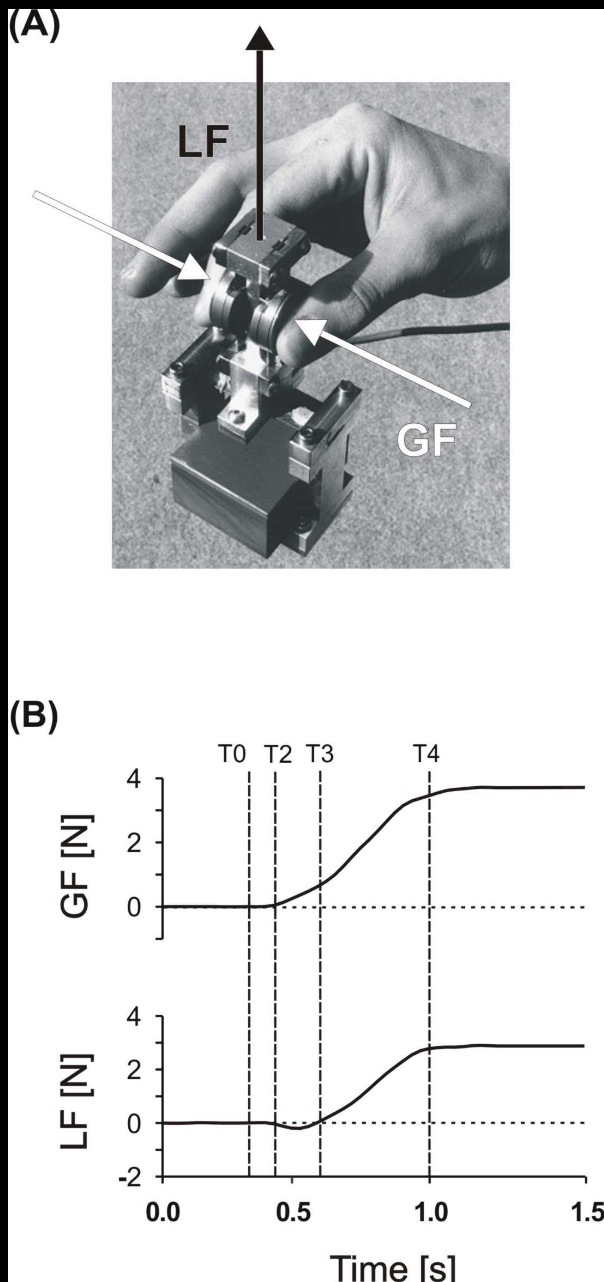
4. Exemples cliniques: régénération du nerf médian / hémiplégie

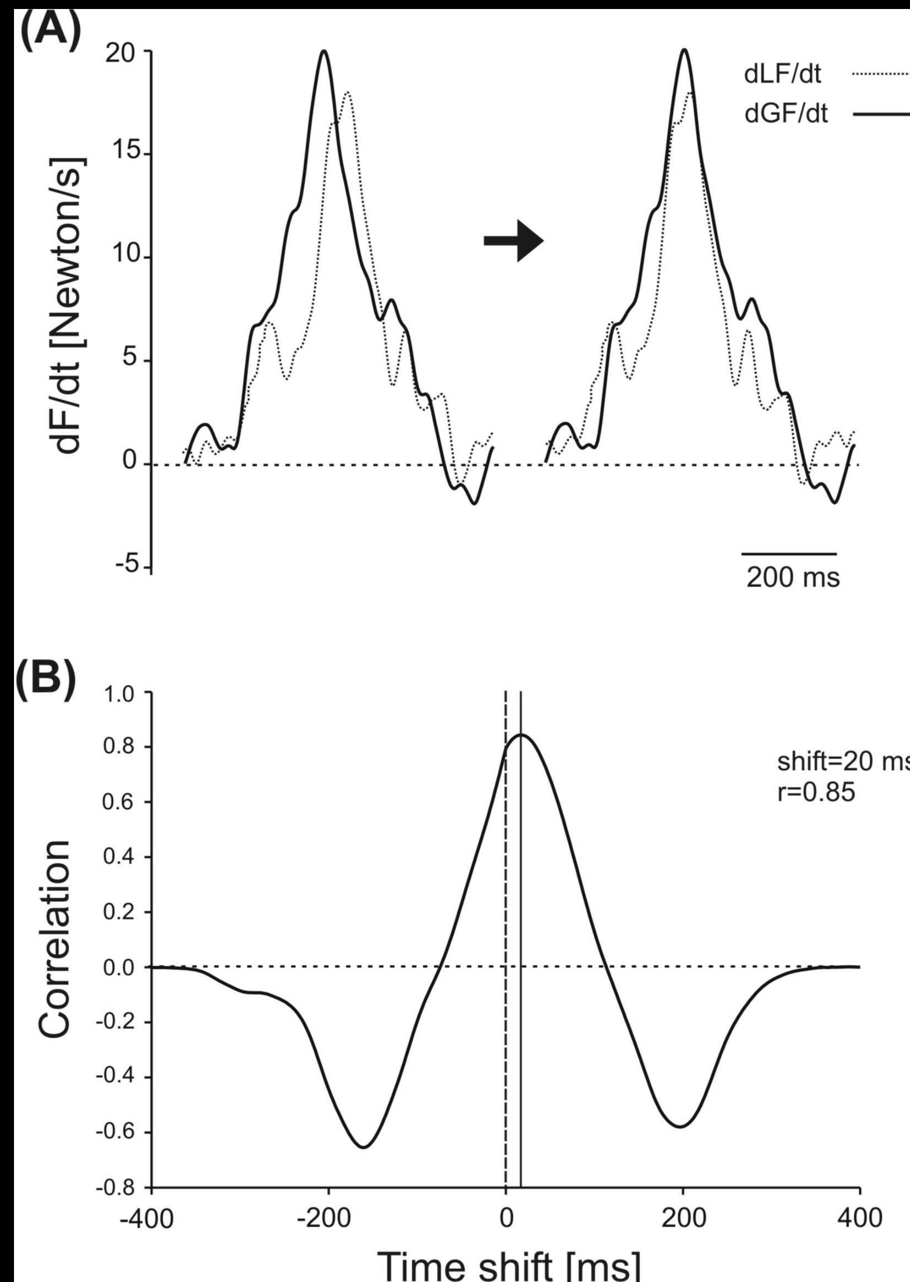
Correlation between impaired dexterity and corticospinal tract dysgenesis in congenital hemiplegia

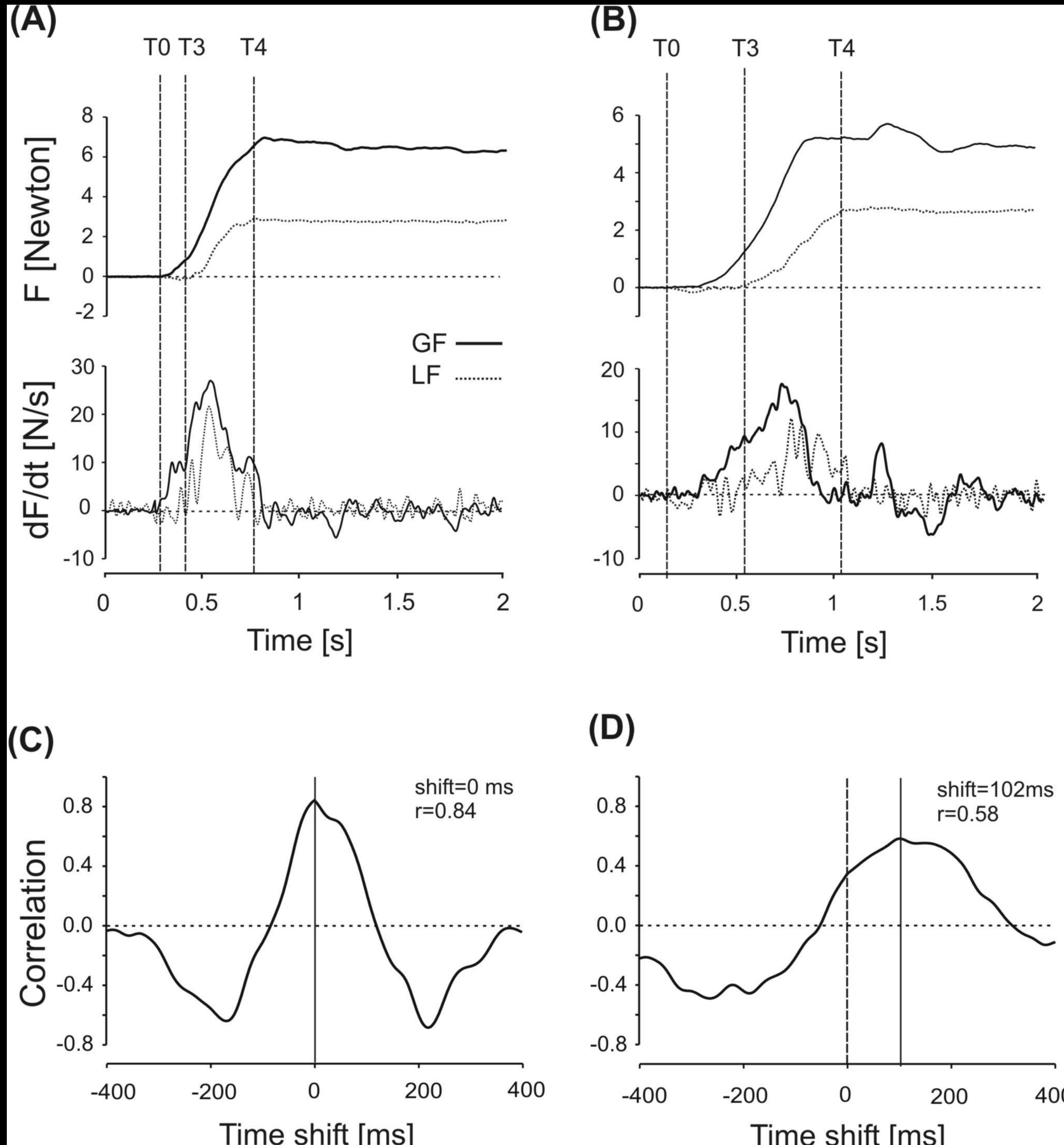
- Investigate the deficit in the grip-load coupling when children with hemiplegia grasp and lift objects between the thumb and index finger.
- Examine whether, deficits in hand movements are correlated with the extent of structural damage to the corticospinal tract.

Methods

- 32 children
  - 16 congenital hemiplegia patients (age:8-19 years)
  - 16 age and sex-matched control subjects
- Functional evaluation:
  - Grip-load force coupling during lifting and holding object
  - Digital dexterity (Purdue Pegboard test)
- Magnetic resonance imaging:
  - Measure of the cross-sectional area of cerebral peduncles
  - Calculate an index of symmetry between the 2 peduncles


(A)
LF
GF
(B)
T0
T2
T3
T4
GF [N]
LF [N]
4
2
0
4
2
0
-2
0.0
0.5
1.0
1.5
Time [s]


(A)
dLF/dt
dGF/dt
dF/dt [Newton/s]
20
15
10
5
0
-5
200 ms
(B)
shift=20 ms
r=0.85
Correlation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-400
-200
0
200
400
Time shift [ms]


(A)
T0 T3 T4
F [Newton]
8
6
4
2
0
-2
GF
LF
dF/dt [N/s]
30
20
10
0
-10
0
0.5
1
1.5
2
Time [s]
(B)
T0
T3
T4
6
4
2
0
20
10
0
-10
0
0.5
1
1.5
2
Time [s]
(C)
Correlation
0.8
0.4
0.0
-0.4
-0.8
shift=0 ms
r=0.84
-400
-200
0
200
400
Time shift [ms]
(D)
0.8
0.4
0.0
-0.4
-0.8
shift=102ms
r=0.58
-400
-200
0
200
400
Time shift [ms]

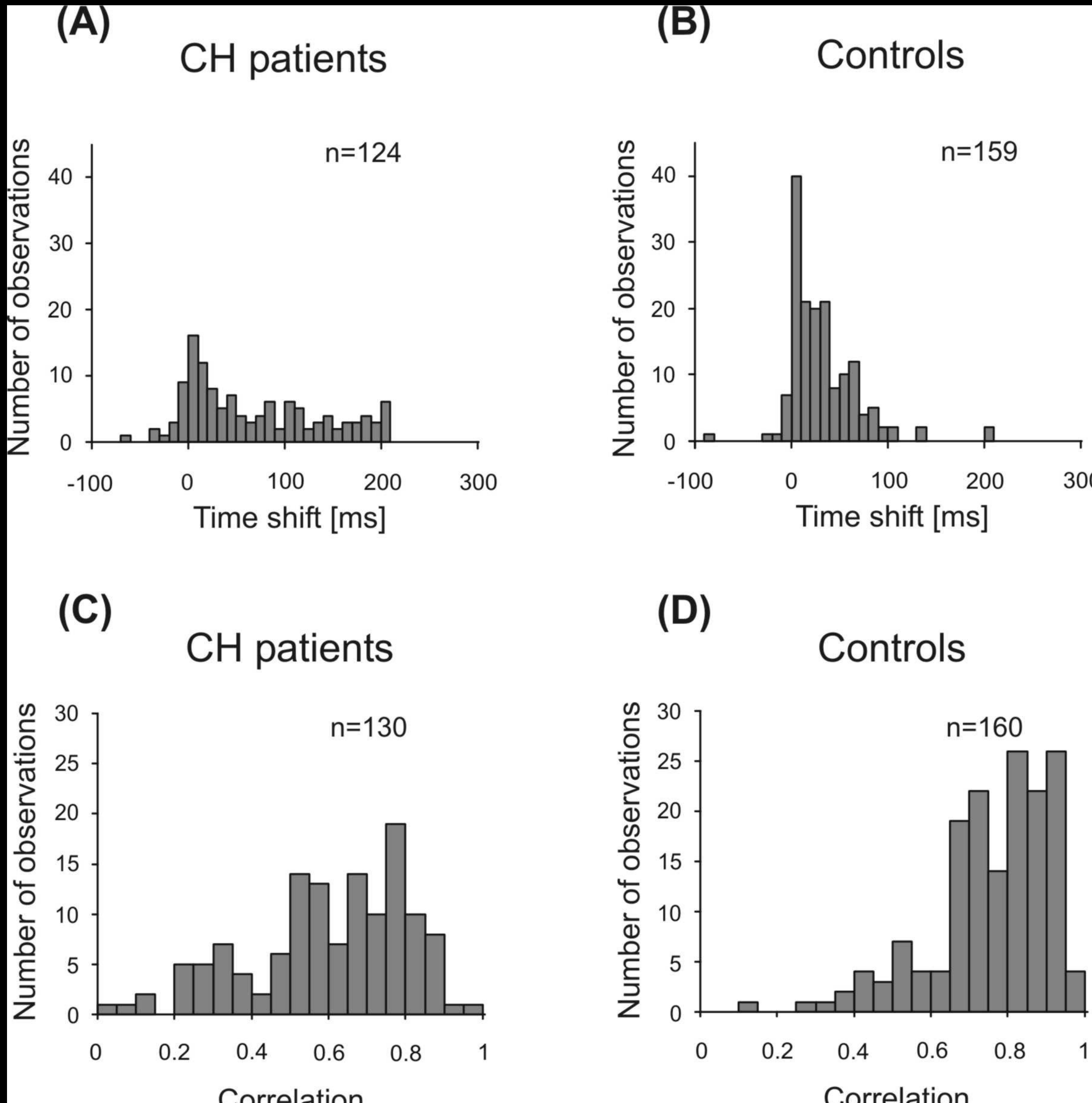

(A)
CH patients
n=124
Number of observations
Time shift [ms]
(B)
Controls
n=159
Number of observations
Time shift [ms]
(C)
CH patients
n=130
Number of observations
Correlation
(D)
Controls
n=160
Number of observations
Correlation

Table 2 *Dexterity and strength in CH patients and control subjects*

Tests	$CTRL_{ndom}$ Mean *(SD)*	$CTRL_{dom}$ Mean *(SD)*	*p value* ($CTRL_{ndom}$/$CTRL_{dom}$)	$CH_{paretic}$ Mean *(SD)*	*p value* ($CTRL_{ndom}$/$CH_{paretic}$)	$CH_{non-par}$ Mean *(SD)*	*p value* ($CTRL_{dom}$/$CH_{non-par}$)
Digital dexterity [n]	15 *(1.5)*	16 *(1.3)*	0.005*	5 *(4.7)*	<0.001*	14 *(2.1)*	<0.001*
Manual dexterity [n]	69 *(7.6)*	71 *(8.2)*	0.21	36 *(17.1)*	<0.001*	55 *(11.8)*	0.001*
Grip strength [Newton]	240 *(73.8)*	255 *(85.2)*	0.031	108 *(93.8)*	<0.001*	196 *(82.9)*	0.004*
Key pinch f. [Newton]	65 *(15.6)*	68 *(15.4)*	0.12	42 *(17.7)*	<0.001*	68 *(15.0)*	0.85
Tip pinch f. [Newton]	36 *(9.9)*	40 *(13.4)*	0.004*	24 *(9.6)*	<0.001*	40 *(15.8)*	1.00

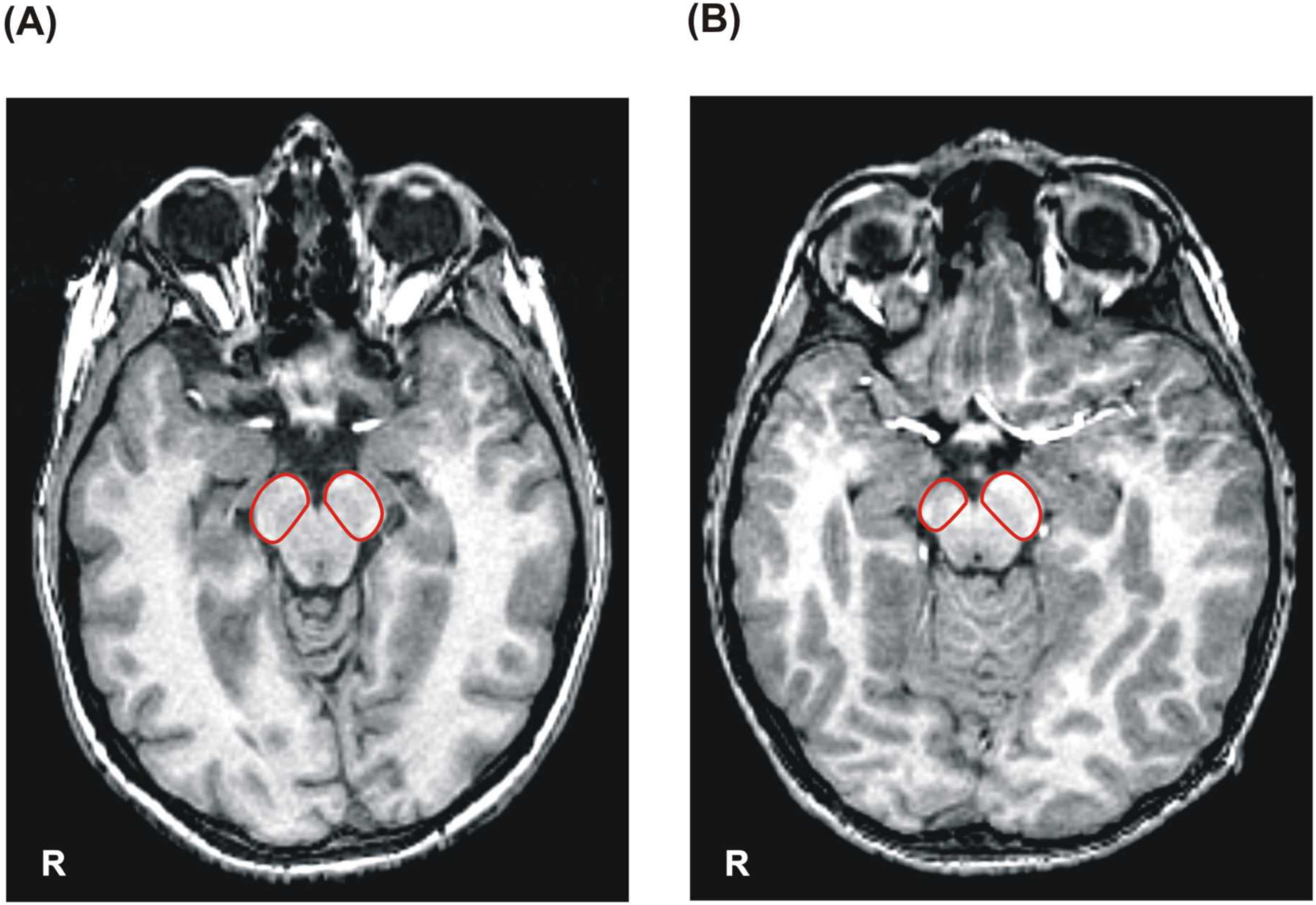
* = $p \leq 0.005$; $CTRL_{ndom}$ = non-dominant hand of control subjects; $CTRL_{dom}$ = dominant hand of control subjects; $CH_{paretic}$ = paretic hand of CH patients; $CH_{non-par}$ = non-paretic hand of CH patients; f. = force.

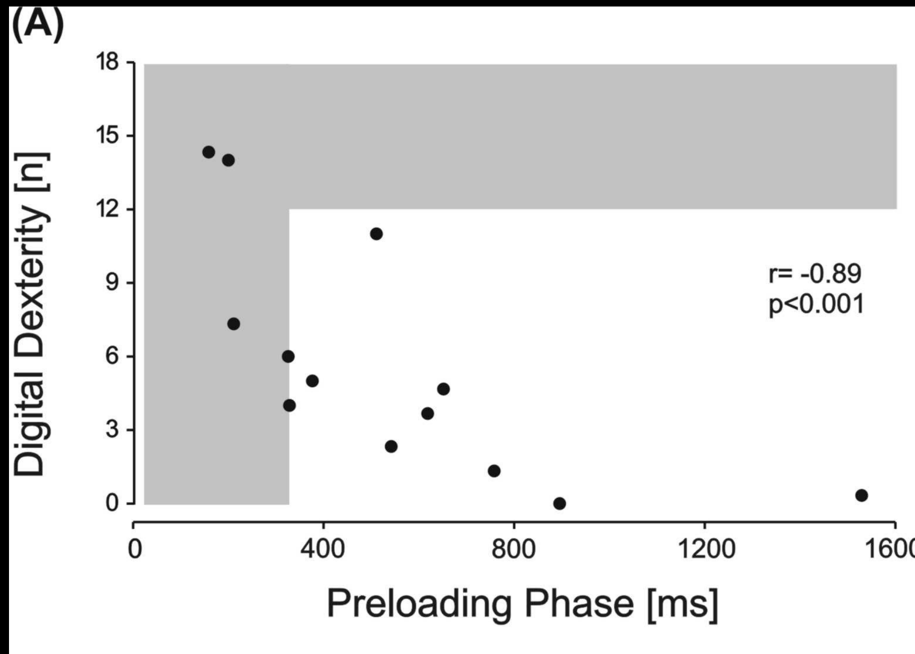
Table 4 *Correlation coefficients (r) between the grip-lift parameters and upper limb motor function*

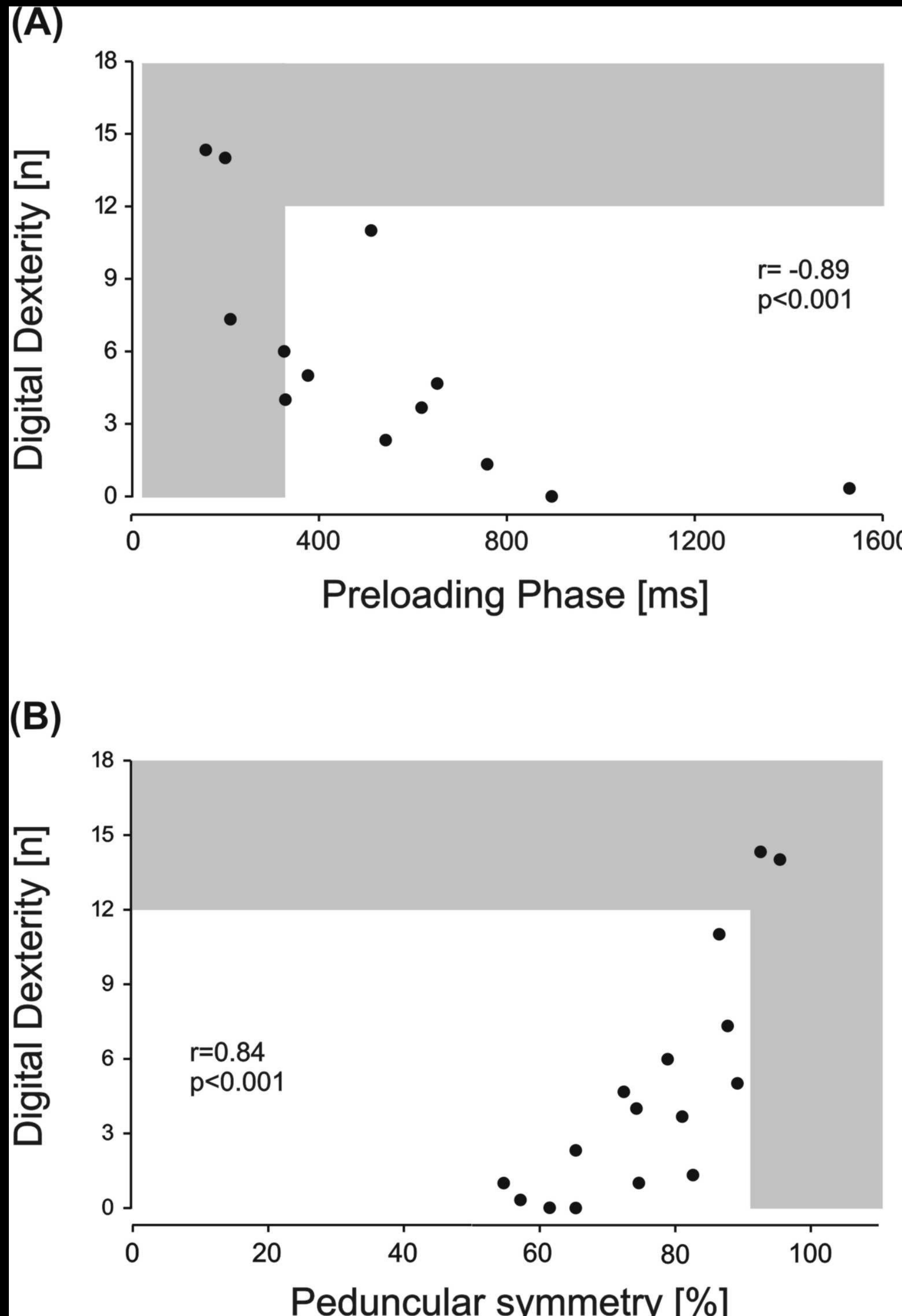
	Grip-lift parameters								
	Delay Th-Ind (T0-T1)	GF_{onset}-LF_{onset} (T2-T3)	Preloading (T0-T3)	Loading (T3-T4)	GF at LF>0	Mean GFr	GF/LF	Cross-corr	Abs-shift
Melbourne	-0.68	-0.63	-0.82*	-0.41	-0.66	0.43	0.42	0.50	-0.61
Digital dext	-0.58	-0.58	-0.89*	-0.48	-0.69	0.65	0.62	0.60	-0.77*
Manual dext	-0.36	-0.55	-0.79*	-0.69	-0.50	0.68	0.46	0.56	-0.58

Table 3 *Grip-lift parameters in CH patients and control subjects*

Parameters	$CTRL_{ndom}$ Mean *(SD)*	$CTRL_{dom}$ Mean *(SD)*	*p value* ($CTRL_{ndom}/CTRL_{dom}$)	$CH_{paretic}$ Mean *(SD)*	*p value* ($CTRL_{ndom}/CH_{paretic}$)	$CH_{non\text{-}par}$ Mean *(SD)*	*p value* ($CTRL_{dom}/CH_{non\text{-}par}$)
Delay Th-Ind,T0-T1 [ms]	62 *(22.7)*	58 *(29.9)*	0.62	127 *(87.1)*	0.026	81 *(22.4)*	<0.001*
GF_{onset}-LF_{onset}, T2-T3 [ms]	95 *(51.7)*	97 *(36.1)*	0.90	294 *(161.6)*	<0.001*	116 *(58.1)*	0.35
Preloading, T0-T3 [ms]	174 *(75.9)*	178 *(54.5)*	0.77	544 *(371.7)*	0.003*	227 *(52.8)*	0.03
Loading, T3-T4 [ms]	269 *(77.5)*	296 *(107.3)*	0.11	492 *(119.4)*	<0.001*	389 *(117.7)*	0.07
GF at LF>0 [%]	16 *(7.1)*	18 *(9.8)*	0.34	28 *(18.3)*	0.046	14 *(6.9)*	0.31
Mean GFr [Newton/s]	9 *(3.9)*	10 *(7.3)*	0.40	5 *(2.2)*	0.009	7 *(3.0)*	0.23
GF/LF	1.0 *(0.3)*	1.1 *(0.4)*	0.08	1.6 *(0.6)*	0.05	1.4 *(0.8)*	0.23
Cross-correlation	0.71 *(0.1)*	0.73 *(0.1)*	0.35	0.56 *(0.14)*	0.003*	0.69 *(0.05)*	0.14
Abs-shift [ms]	29 *(13.1)*	24 *(16.3)*	0.46	72 *(39.1)*	0.005*	28 *(11.5)*	0.51


(A)
R
(B)
R


(A)
Digital Dexterity [n]
18
15
12
9
6
3
0
0
400
800
1200
1600
Preloading Phase [ms]
r= -0.89
p<0.001


(A)
18
15
12
9
6
3
0
Digital Dexterity [n]
r= -0.89
p<0.001
0
400
800
1200
1600
Preloading Phase [ms]
(B)
18
15
12
9
6
3
0
Digital Dexterity [n]
r=0.84
p<0.001
0
20
40
60
80
100
Peduncular symmetry [%]

La préhension et le membre supérieur: aspects cliniques

4. Exemples cliniques: régénération du nerf médian / hémiplégie