université PARIS-SACLAY | FACULTÉ DES SCIENCES DU SPORT

EU Enjeux de l'évaluation pour la réadaptation et de la réhabilitation par les APA-S

Approche biomécanique

Nicolas VIGNAIS

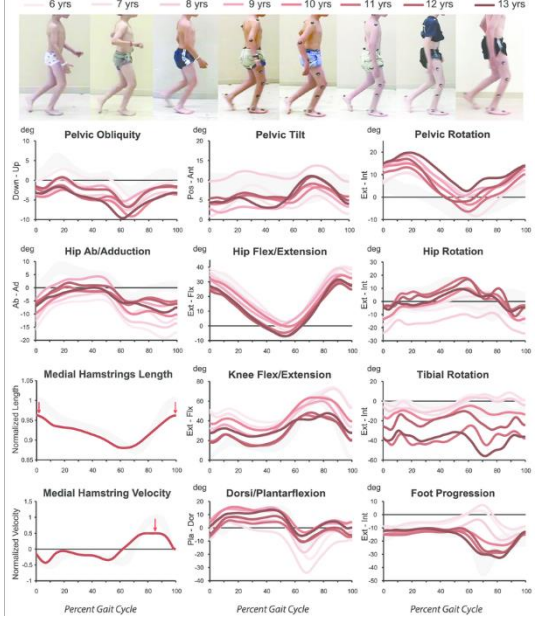
Laboratoire CIAMS, Université Paris-Sud

CIAMS Complexité, Innovation, Activités Motrices et Sportives

Cinématique

Décrire le mouvement visible

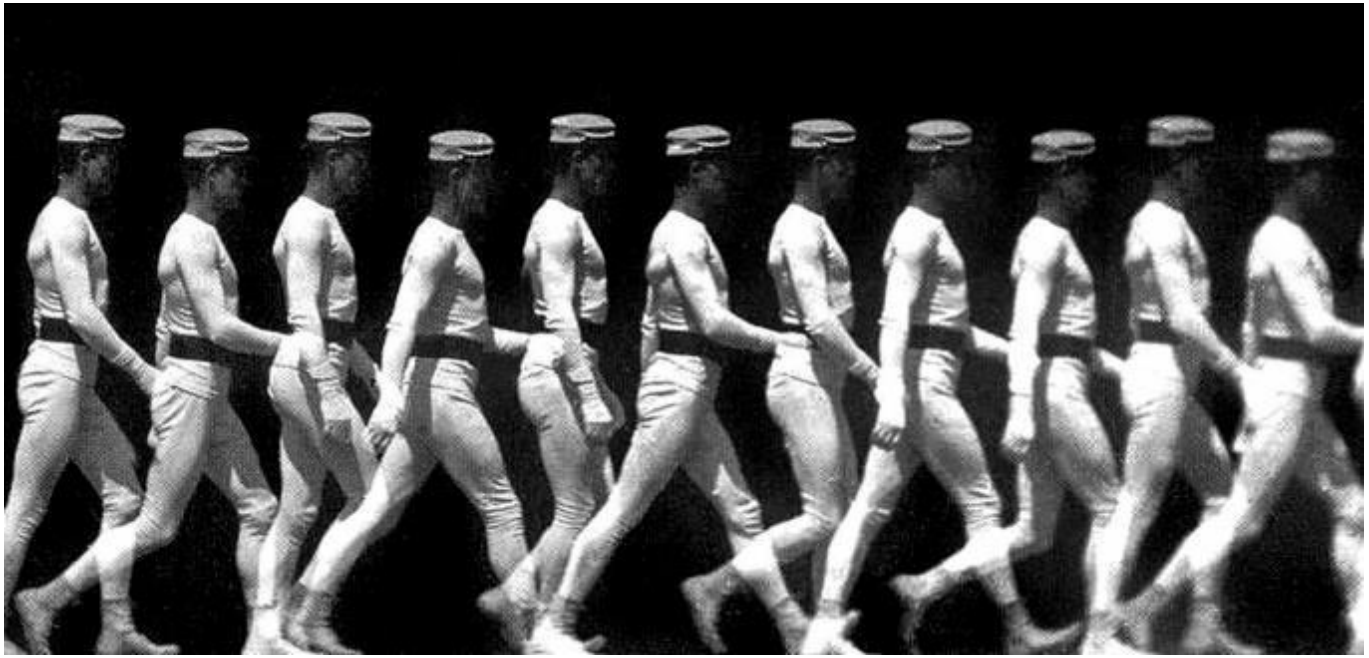
Cinématique



[Butler et al., 2016]

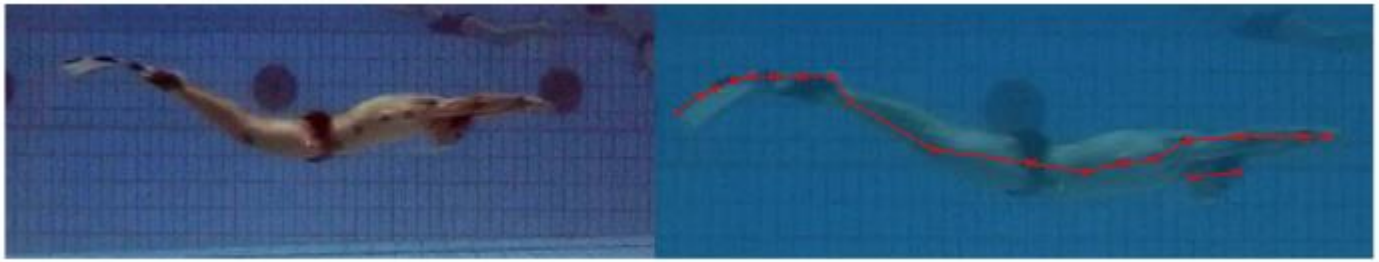
Cinématique – outils

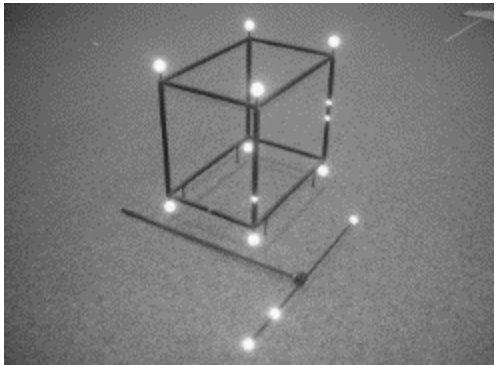
- Chronophotographie (*Marey et Demenÿ, 1885*)



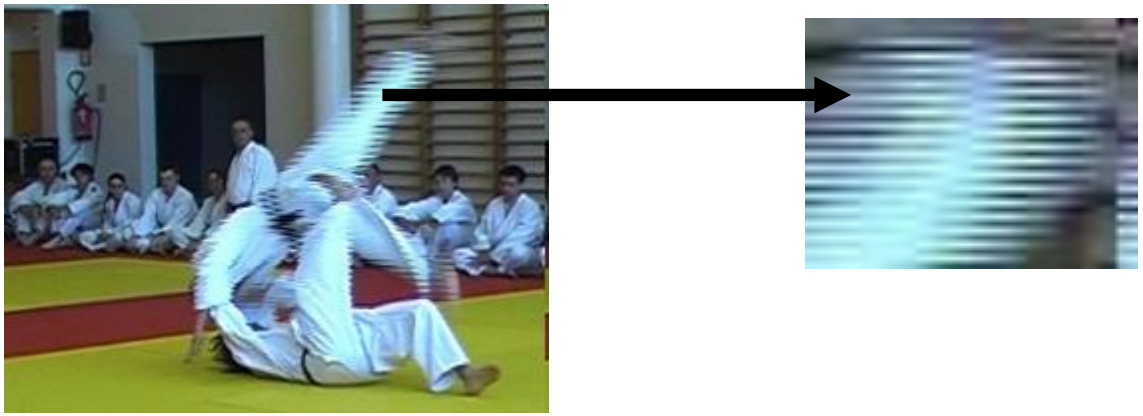
Cinématique – outils

Cinématique – outils





Cinématique – outils



Cinématique – outils

Interlaced video

Deinterlaced video

Cinématique – outils

Cinématique – outils

NB : Tracker

Cinématique - outils

Finkbiner et al., 2017

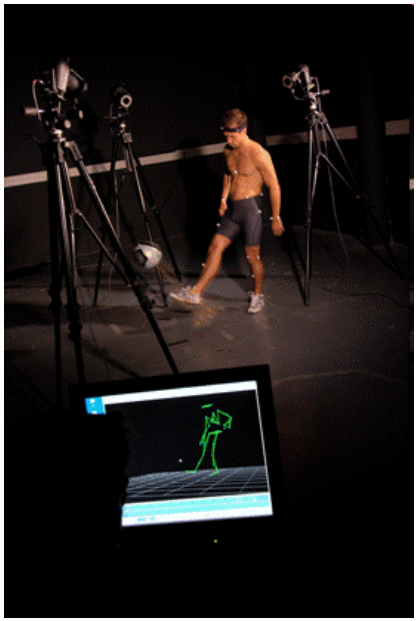
Cinématique – outils

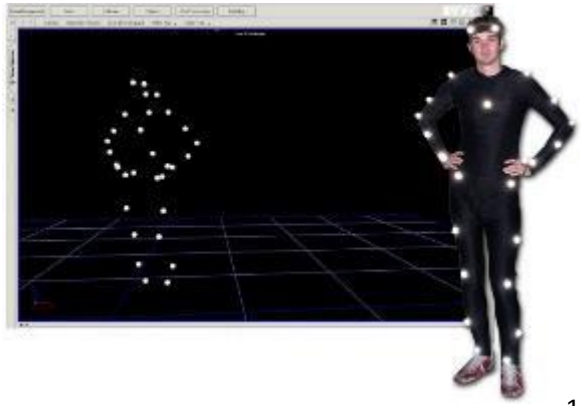
$$h_{MAX} = \frac{1}{8} \times g \times {t_v}^2$$

MyJump validé par Balsalobre-Fernández et al., 2014

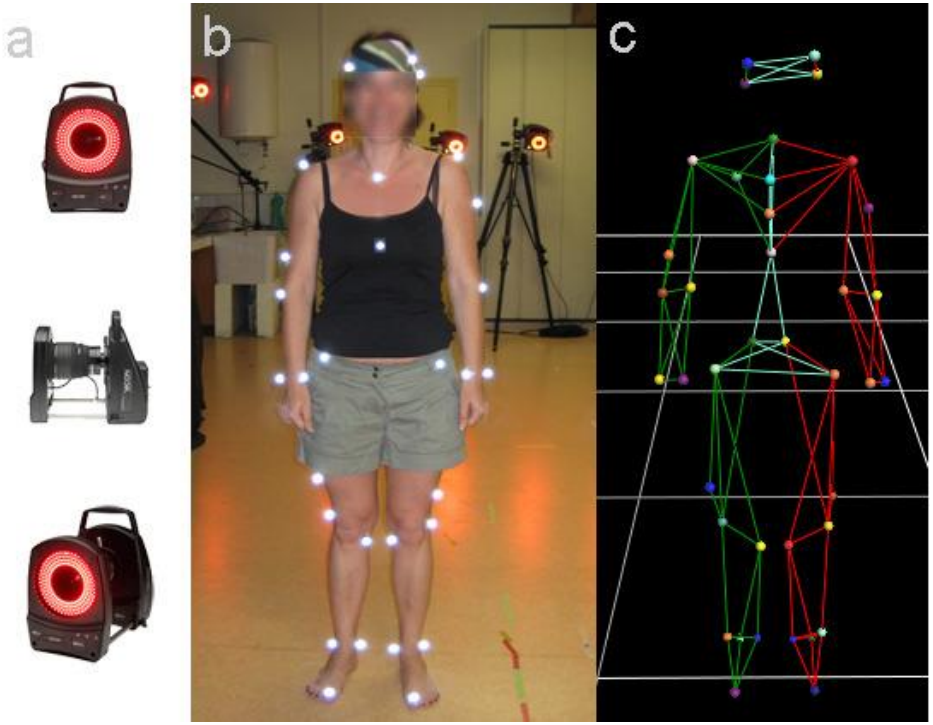
Cinématique – outils

Cinématique – outils





Cinématique – outils



Cinématique – outils

Table 4. Adjusted parameters for females (F; body mass = 61.9 kg, stature = 173.5 m) and males (M; 73.0 kg, 1.741 m). Segment masses are relative to body mass; segment CM positions are referenced either to proximal or cranial endpoints (origin). Both segment CM positions and radii of gyration (r) are relative to the respective segment lengths. A set of easy-to-use endpoints is considered in the first part of the table; for some segments, alternative endpoints are considered in the second part (UPT, MPT, and LPT are the Upper, Middle, and Lower Parts of Trunk)

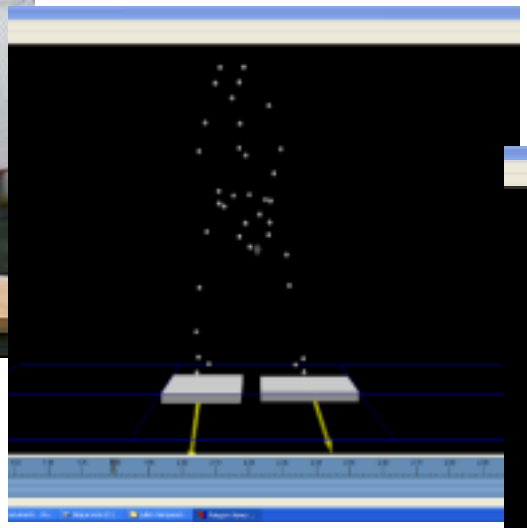
	Endpoints		Longitudinal length (mm)		Mass* (%)		Longitudinal CM position (%)		Sagittal r (%)		Transverse r (%)		Longitudinal r (%)	
Segment	Origin	Other	F	M	F§	M¶	F	M	F	M	F	M	F	M
Head	VERT†	MIDG†	200.2	203.3	6.68	6.94	58.94	59.76	33.0	36.2	35.9	37.6	31.8	31.2
Trunk	SUPR†	MIDH‡	529.3	531.9	42.57	43.46	41.51	44.86	35.7	37.2	33.9	34.7	17.1	19.1
UPT	SUPR†	XYPH†	142.5	170.7	15.45	15.96	20.77	29.99	74.6	71.6	50.2	45.4	71.8	65.9
MPT*	XYPH†	OMPH†	205.3	215.5	14.65	16.33	45.12	45.02	43.3	48.2	35.4	38.3	41.5	46.8
LPT	OMPH†	MIDH‡	181.5	145.7	12.47	11.17	49.20	61.15	43.3	61.5	40.2	55.1	44.4	58.7
Upper arm	SJC‡	EJC‡	275.1	281.7	2.55	2.71	57.54	57.72	27.8	28.5	26.0	26.9	14.8	15.8
Forearm	EJC‡	WJC‡	264.3	268.9	1.38	1.62	45.59	45.74	26.1	27.6	25.7	26.5	9.4	12.1
Hand	WJC‡	MET3†	78.0	86.2	0.56	0.61	74.74	79.00	53.1	62.8	45.4	51.3	33.5	40.1
Thigh	HJC‡	KJC‡	368.5	422.2	14.78	14.16	36.12	40.95	36.9	32.9	36.4	32.9	16.2	14.9
Shank	KJC‡	LMAL†	432.3	434.0	4.81	4.33	44.16	44.59	27.1	25.5	26.7	24.9	9.3	10.3
Foot*	HEEL†	TT1P†	228.3	258.1	1.29	1.37	40.14	44.15	29.9	25.7	27.9	24.5	13.9	12.4
Using alternative endpoints:														
Head*	VERT†	CERV†	243.7	242.9	6.68	6.94	48.41	50.02	27.1	30.3	29.5	31.5	26.1	26.1
Trunk	CERV†	MIDH‡	614.8	603.3	42.57	43.46	49.64	51.38	30.7	32.8	29.2	30.6	14.7	16.9
Trunk	MIDS‡	MIDH‡	497.9	515.5	42.57	43.46	37.82	43.10	37.9	38.4	36.1	35.8	18.2	19.7
UPT*	CERV†	XYPH†	228.0	242.1	15.45	15.96	50.50	50.66	46.6	50.5	31.4	32.0	44.9	46.5
Forearm	EJC‡	STYL†	262.4	266.9	1.38	1.62	45.92	46.08	26.3	27.8	25.9	26.7	9.5	12.2
Hand	WJC†	DAC3†	170.1	187.9	0.56	0.61	34.27	36.24	24.4	28.8	20.8	23.5	15.4	18.4
Hand*	STYL†	DAC3‡	172.0	189.9	0.56	0.61	35.02	36.91	24.1	28.5	20.6	23.3	15.2	18.2
Hand	STYL†	MET3†	79.9	88.2	0.56	0.61	75.34	79.48	51.9	61.4	44.3	50.2	32.7	39.2
Shank	KJC‡	AJC‡	438.6	440.3	4.81	4.33	43.52	43.95	26.7	25.1	26.3	24.6	9.2	10.2
Shank	KJC‡	SPHY†	426.0	427.7	4.81	4.33	44.81	45.24	27.5	25.8	27.1	25.3	9.4	10.5

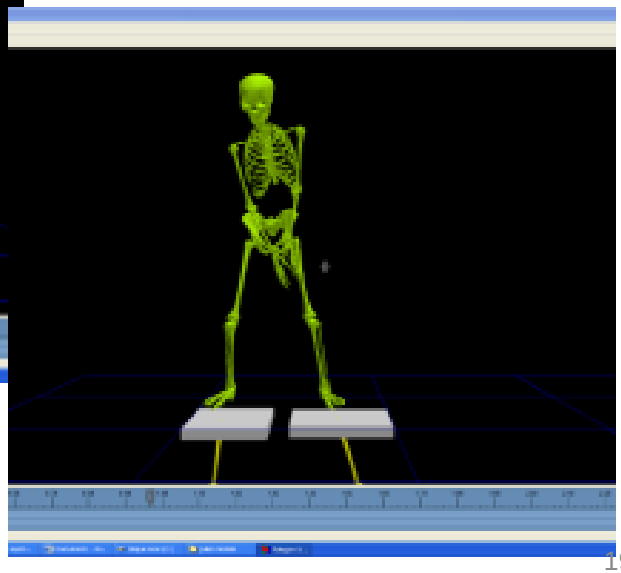
Proximal point Distal point

(DeLeva, 1996)

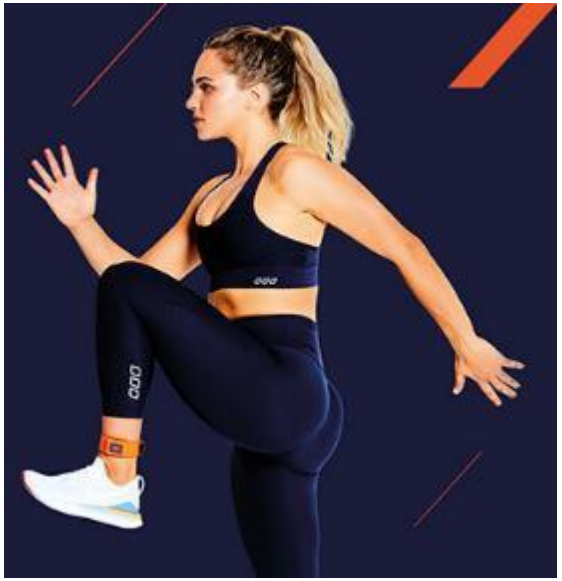
Cinématique – outils

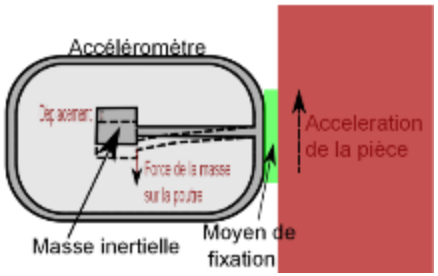
Cinématique – outils



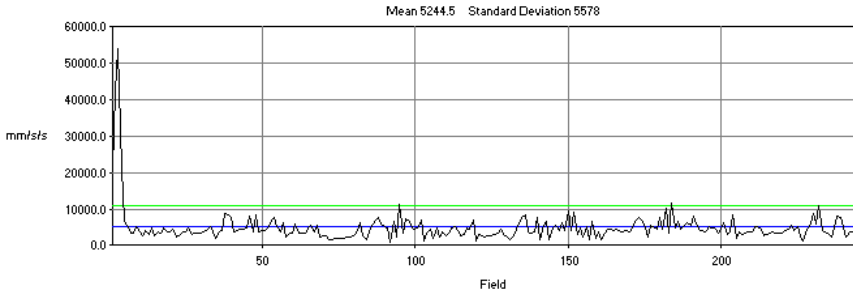


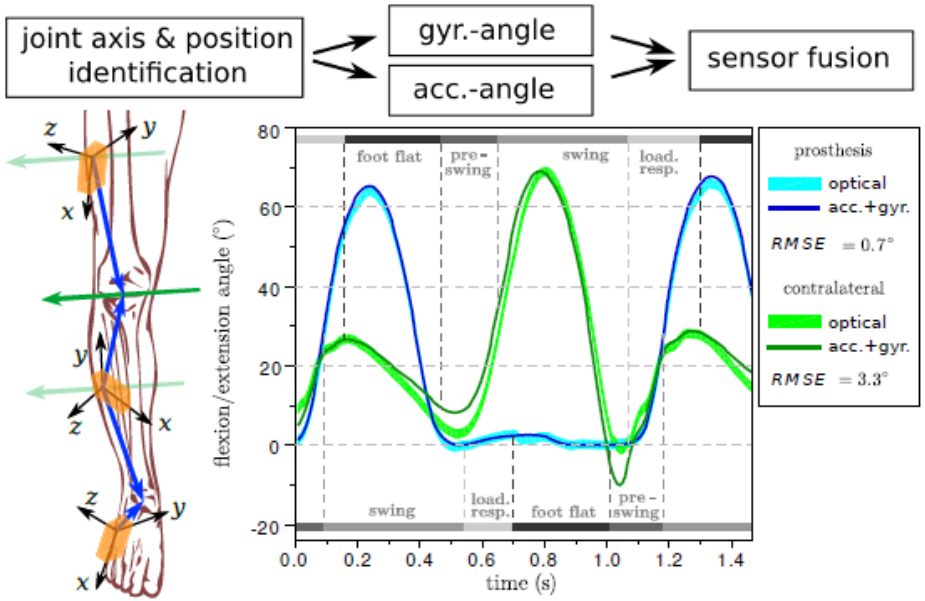
Cinématique – outils



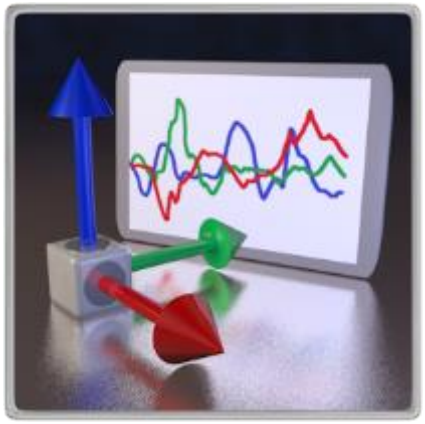


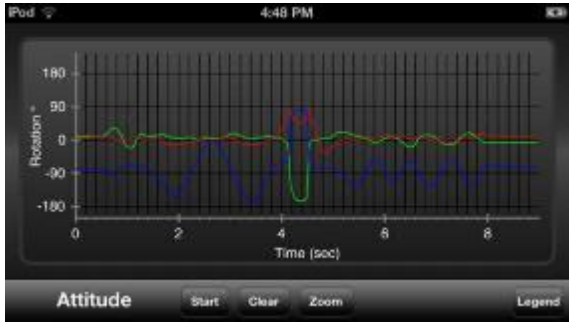
Cinématique – outils





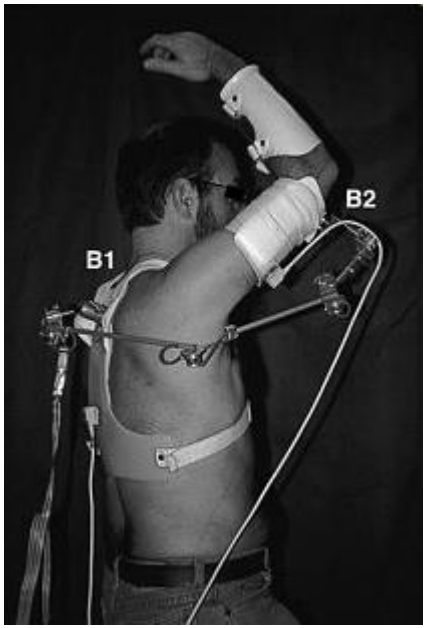
Applications



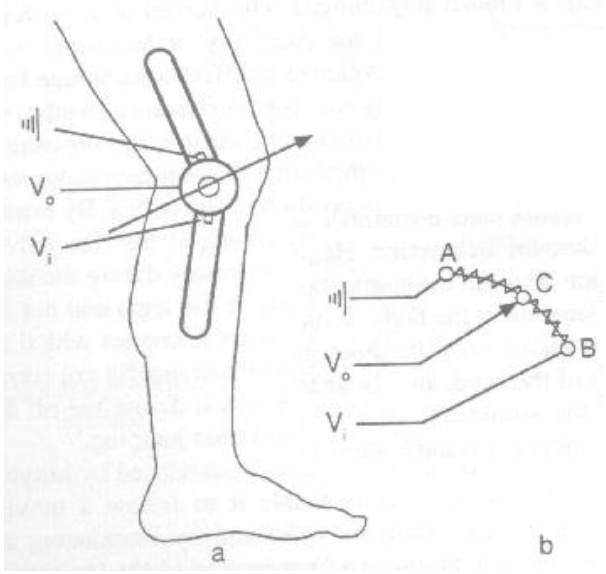


Accéléromètre + GPS

Cinématique – outils



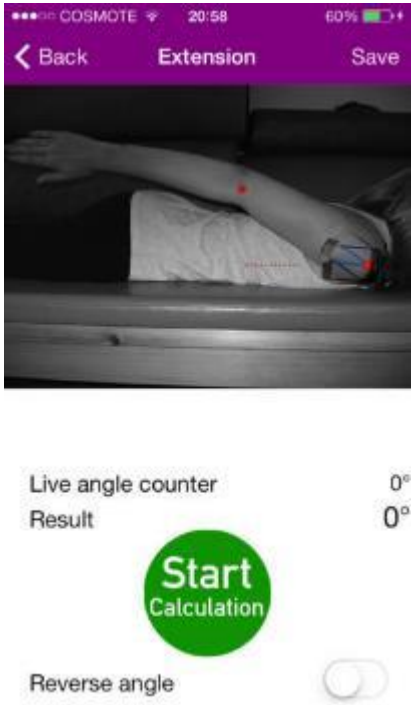
Cinématique - outils



Cinématique – outils

- Smartphone apps:

Application	Overall Ranking	User Interface	Navigation	Features	Content	Value
Joint Goniometry	1	1	1	2	3	2
DrGoniometer	2	6	5	1	1	6
Clinometer	3	4	6	8	10	5
GetMyROM	4	8	7	3	2	1
TiltMeter	5	3	4	5	8	4
Angulus ROM	6	2	2	9	6	8
Goniometer	7	7	8	11	7	11
Angle	8	5	3	7	9	3
PhotoGoniometer	9	10	11	6	5	10
ROM Camera	10	9	9	4	4	7
Simple Goniometer	11	11	10	10	11	9

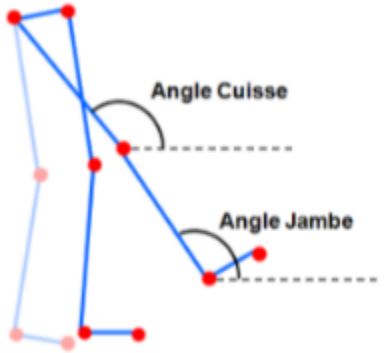


Validation scientifique :
Ferriero et al., 2013; Johnson et al., 2015 ; Hales et al., 2015

https://www.youtube.com/watch?v=9nENqz9xqOw

Cinématique 2D

- Par rapport à l'horizontale = angle segmentaire



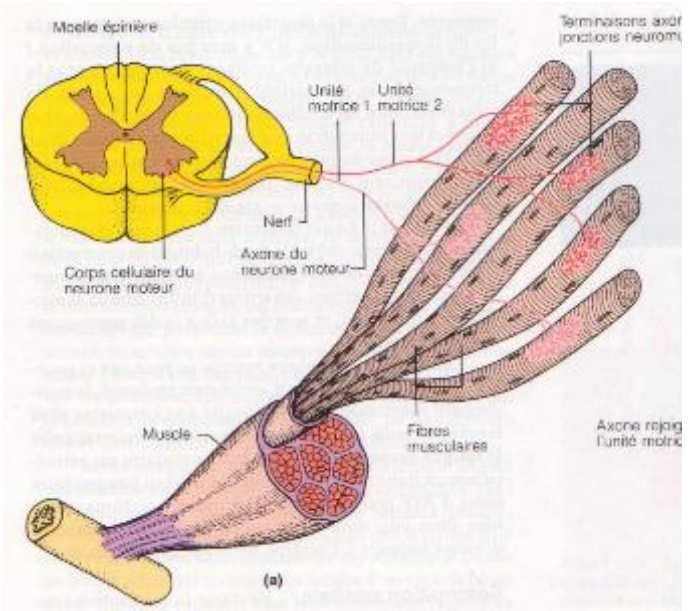
- Par rapport à un autre segment = intersegmentaire

$$\theta_{Genou} = \theta_{Cuisse} - \theta_{Jambe}$$

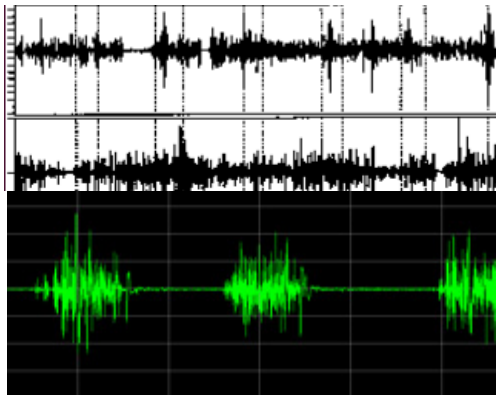
Analyse *in situ*

Investigation interne pour comprendre les structures biologiques à l'origine du mouvement

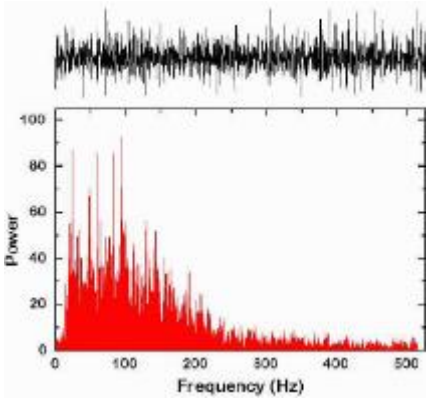
Analyse *in situ*



Analyse *in situ*

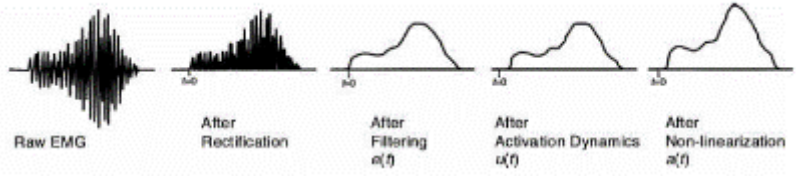


electromyogramme



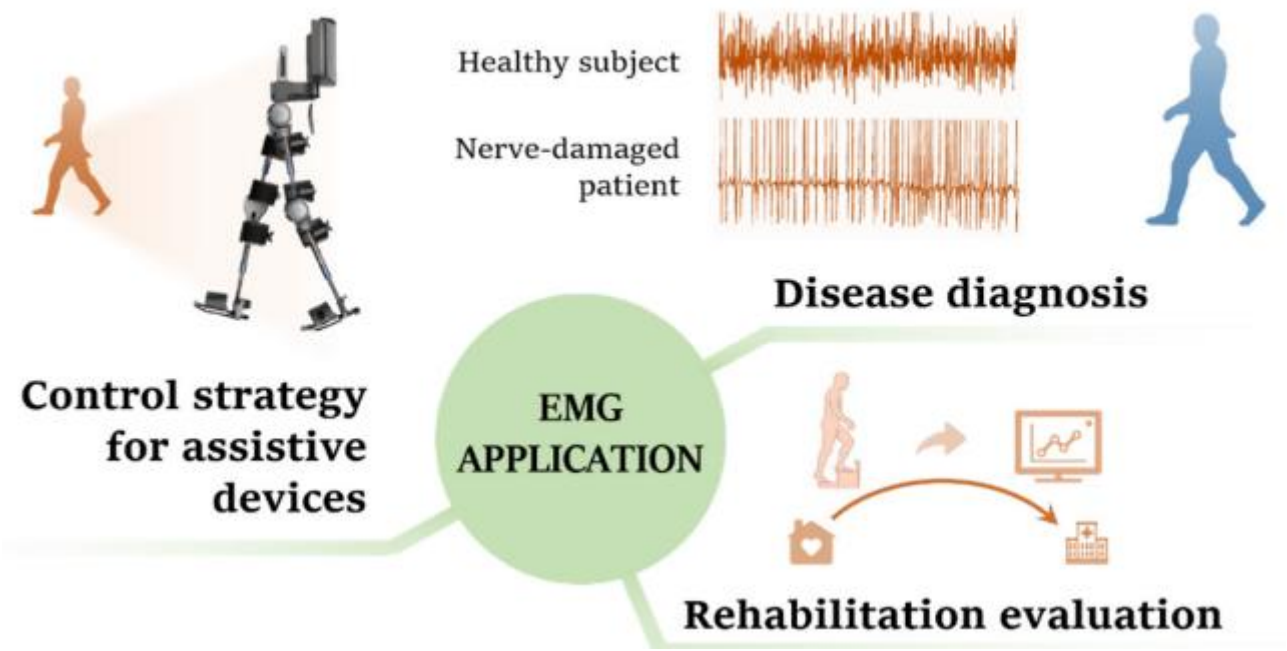
temporel

frequentiel



(Buchanon et al., 2004)

Analyse *in situ*



Des livres pour aller plus loin :

Analyse du mouvement humain par la biomécanique par Jean-Pierre Blanchi et Paul Allard aux éditions Decarie.

Biomécanique : Eléments de mécanique musculaire par Francis Goubel, Ghislaine Corbeil aux éditions Masson.

La Biomécanique par Jean-Pierre Blanchi et Paul Allard aux éditions Que sais-je?

Biomécanique du mouvement et APS de JP Blanchi aux éitions Vigot

Biomechanics and Motor Control of Human Movement de DA Winter, A Wiley-Interscience publication, 1990.