Studio e Analisi del Movimento

ANDREA DI CANDIA

BARI, 12 APRILE 2019

ARD Research LAB

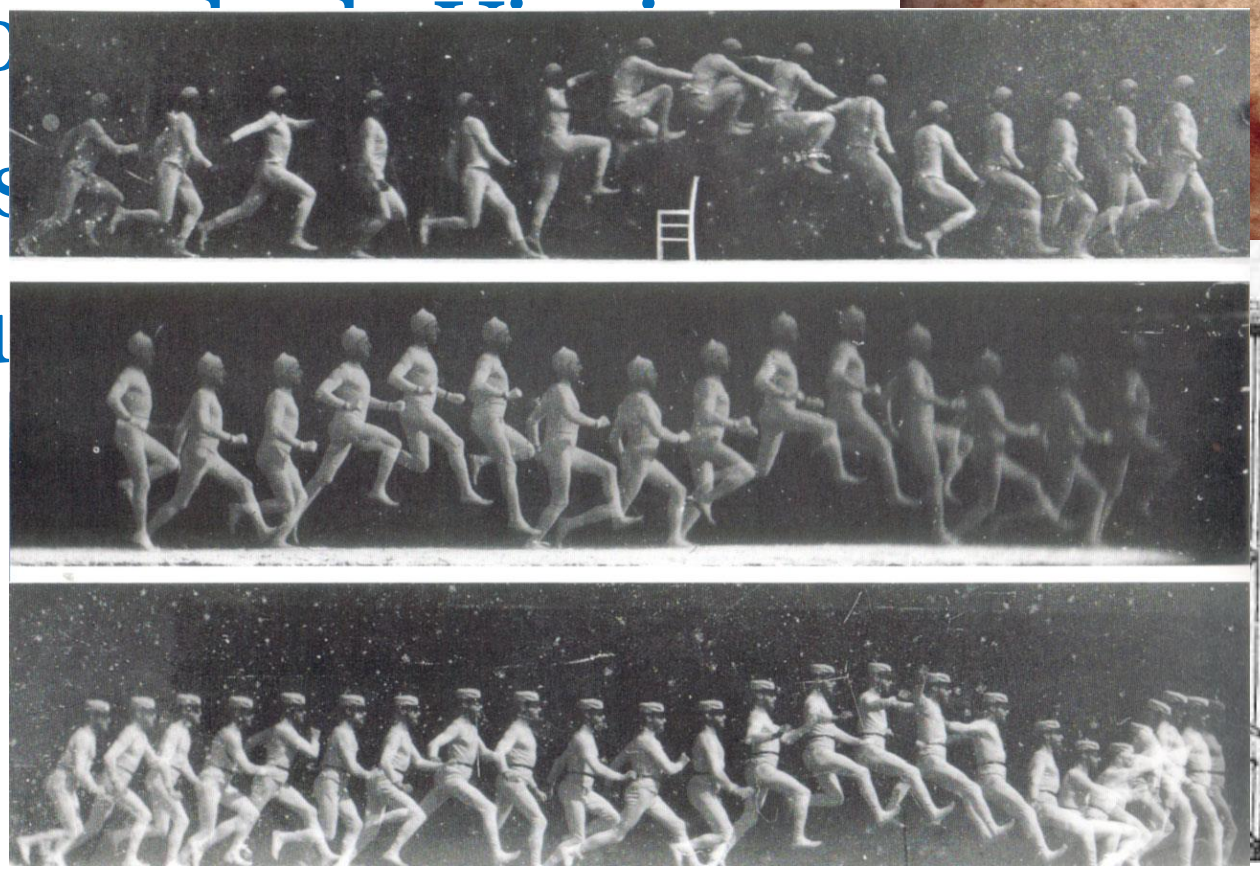
Metodologia, terminologia e fisiologia dell'analisi del cammino

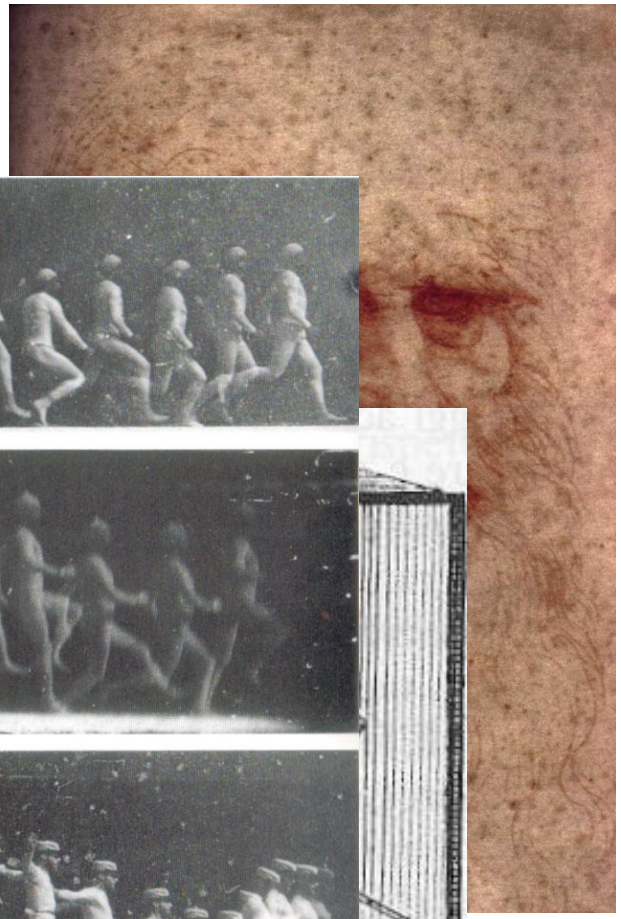
- Cenni storici
- Tecniche per l'analisi automatica del movimento
- Fasi di un esame di gait analysis
- Alcuni esempi
- Conclusioni

ARD Research LAB

Cenni storici

- ✓ Leo
- ✓ Nas
- ✓ Mu

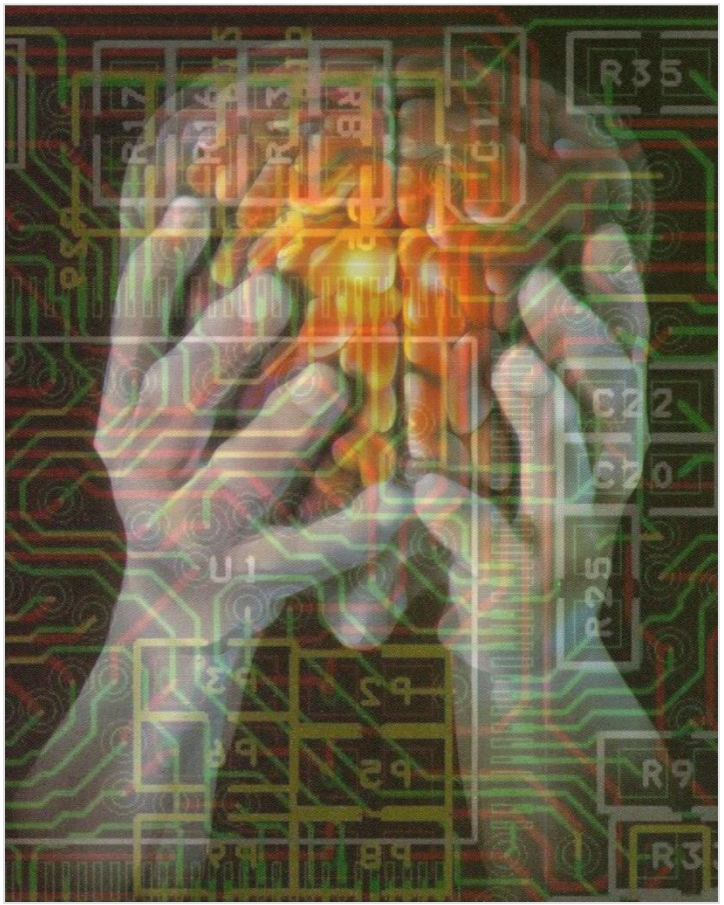




Tecniche per l'analisi automatica del movimento

I sistemi automatici permettono:

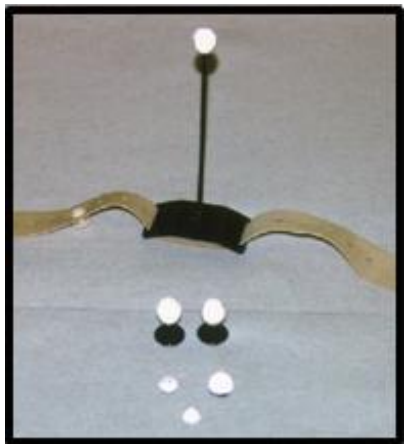
- Rilievo coordinate spaziali o angolari
- Trattamento del segnale
- Elaborazione dei dati
- Rappresentazione e memorizzazione dei dati

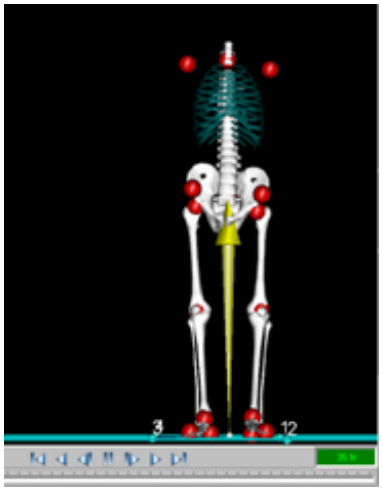


ARD Research LAB

Tecniche per l'analisi automatica del movimento

Sistema EL.I.Te. (Elaborazione Immagini Televisive)

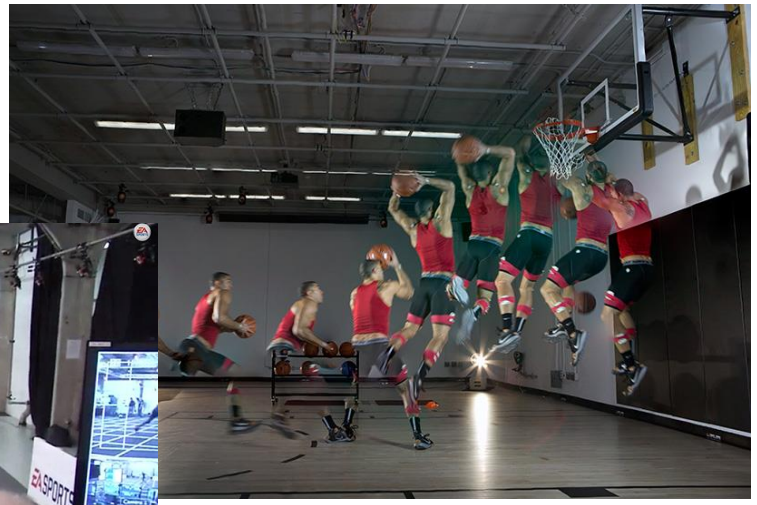




ARD Research LAB

Laboratorio di
Analisi del Movimento e Postura

è un laboratorio realizzato per offrire un servizio innovativo con tecnologia avanzata (MOTION CAPTURE) in diversi settori:
Cinema, Videogiochi, Medicina e Riabilitazione



ARD Research LAB

Bari 12 Aprile 2019


Rai 1 HD
Butterfly
Butterfly
Noth

Come studiare il movimento

Registrazione
Video

- ✓ Valutazione qualitativa del movimento
- ✓ Valutazione influenzata dalla soggettività dell'osservatore

- ✓ Valutazione del movimento su due piani
- ✓ Nessuna informazione sullo scambio di forze
- ✓ Nessuna informazione sulla forza muscolare

Come studiare il movimento

~~Analisi QUALITATIVA E SOGGETTIVA~~

Analisi QUANTITATIVA E OGGETTIVA

TECNOLOGIA AVANZATA PER GLI STRUMENTI DI MISURA

Come studiare il movimento

L'analisi del movimento quantitativa e oggettiva è sempre più richiesta da clinici, sport e nell'ambito della ricerca

Healthcare

Sport

Research

...in ambito clinico

In ambito clinico, in caso di pazienti con patologie motorie più o meno gravi, lo studio delle alterazioni motorie e posturali ci permette di ottenere informazioni molto importanti:

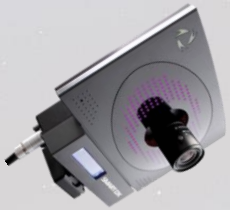
- conoscere il grado delle alterazioni funzionali
- monitorare nel tempo lo sviluppo di alterazioni motorie causate dalla patologia
- valutare l'efficacia di specifici protocolli di riabilitazione

Analisi cinematica con il sistema Smart Dx

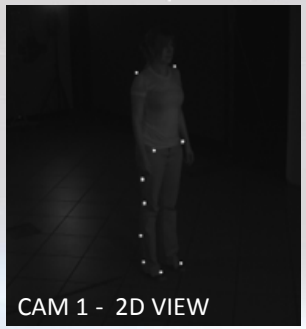
Analisi cinematica con il sistema Smart Dx

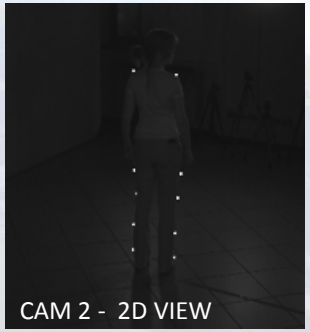
Marker sferici ed emisferici ricoperti con materiale catarinfrangente

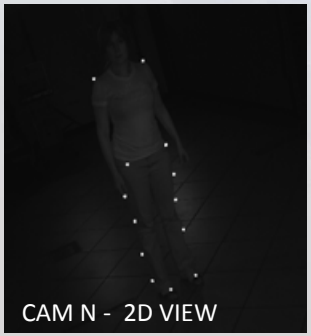
Analisi cinematica con il sistema Smart Dx



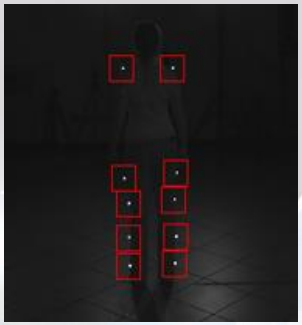
MARKER
RIFLETTENTI

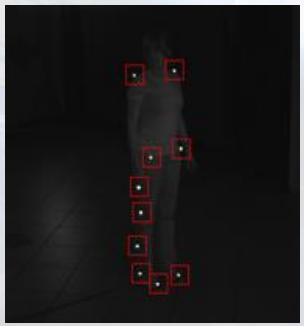




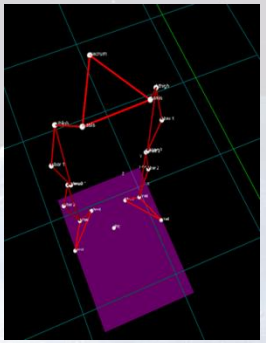


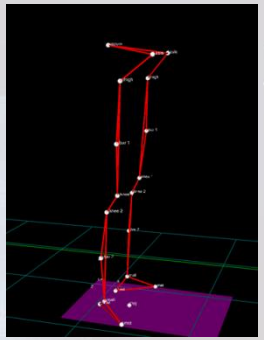
IDENTIFICAZIONE

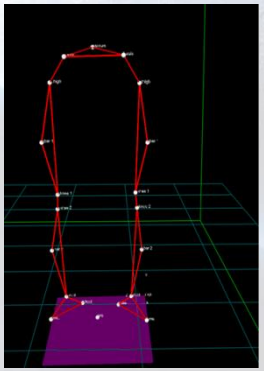




RICOSTRUZIONE 3D



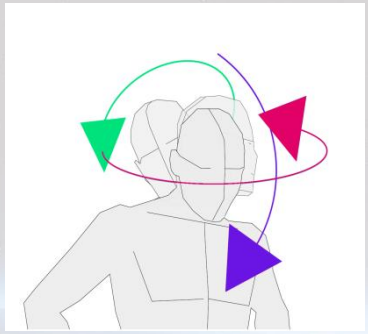




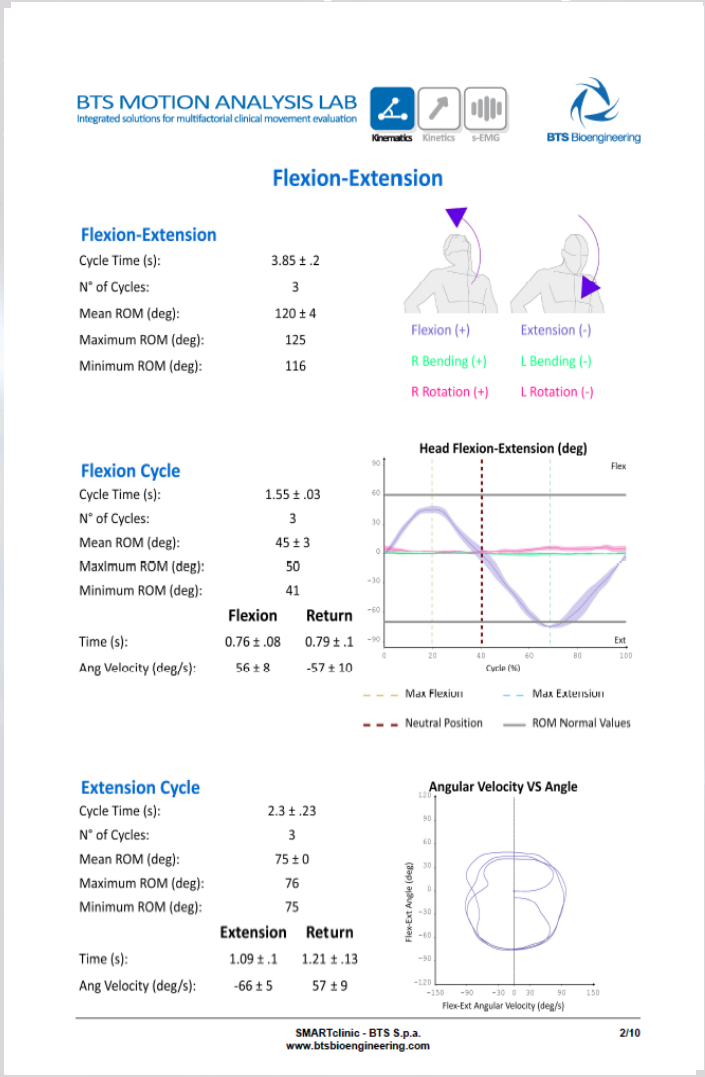
Ricostruzione 3D

Healthcare

Kinematic Analysis by BTS SMART-DX System



Cervical Spine Analysis

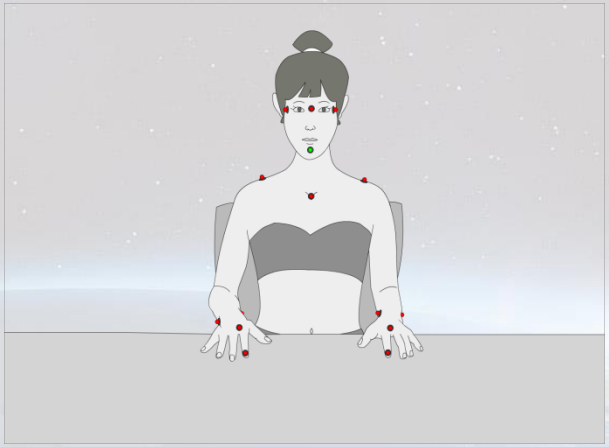


CEMES Clinic in Padova (Italy)

BTS Bioengineering

Healthcare

Kinematic Analysis by BTS SMART-DX System



BTS Bioengineering Lab in Milan (Italy)

Upper Limb Analysis

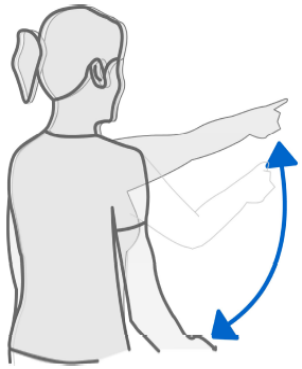
BTS MOTION ANALYSIS LAB
Integrated solutions for multifactorial clinical movement evaluation
Kinematics Kinetics s-EMG
BTS Bioengineering

UPPER LIMB EXAM - POINTING TASK

Final Clinical Report

Patient Details:

FIRST NAME:	UPPER LIMBS	**SESSION DATE:**	29/09/2014
LAST NAME:	RAB	**PATHOLOGY:**	NORMAL
BIRTHDAY:	26/9/1999	**PROTOCOL:**	Rab Pointing



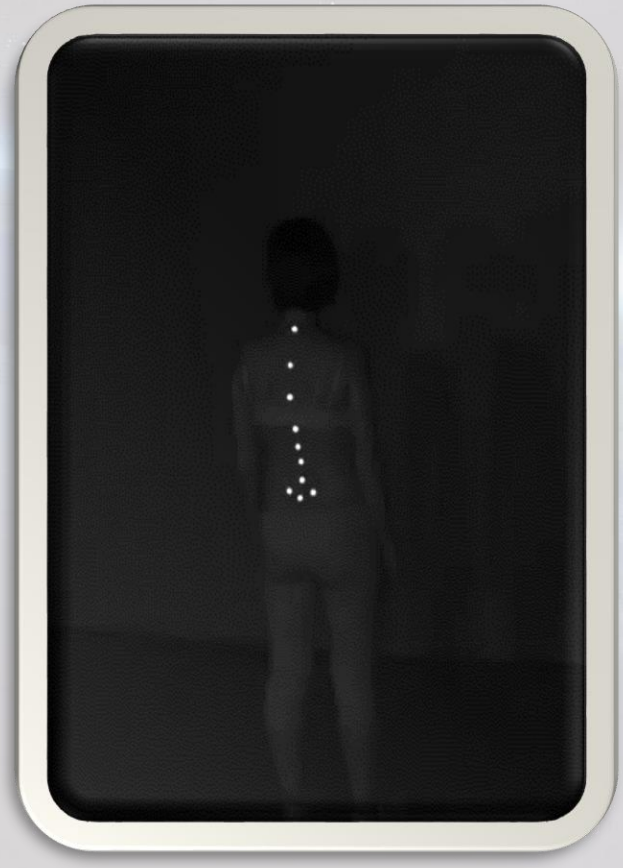
Case History:

SMARTanalyzer - BTS S.p.a.
www.btsbioengineering.com
1/7

BTS Bioengineering

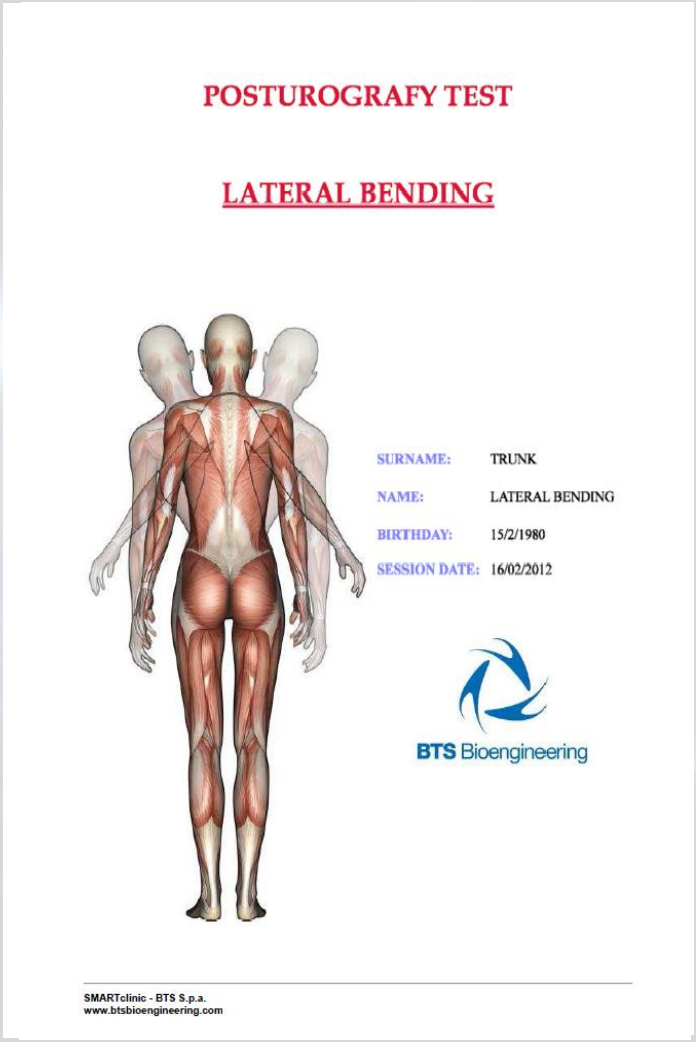
Healthcare

Kinematic Analysis by BTS SMART-DX System



BTS Bioengineering Lab in Milan (Italy)

Trunk Analysis

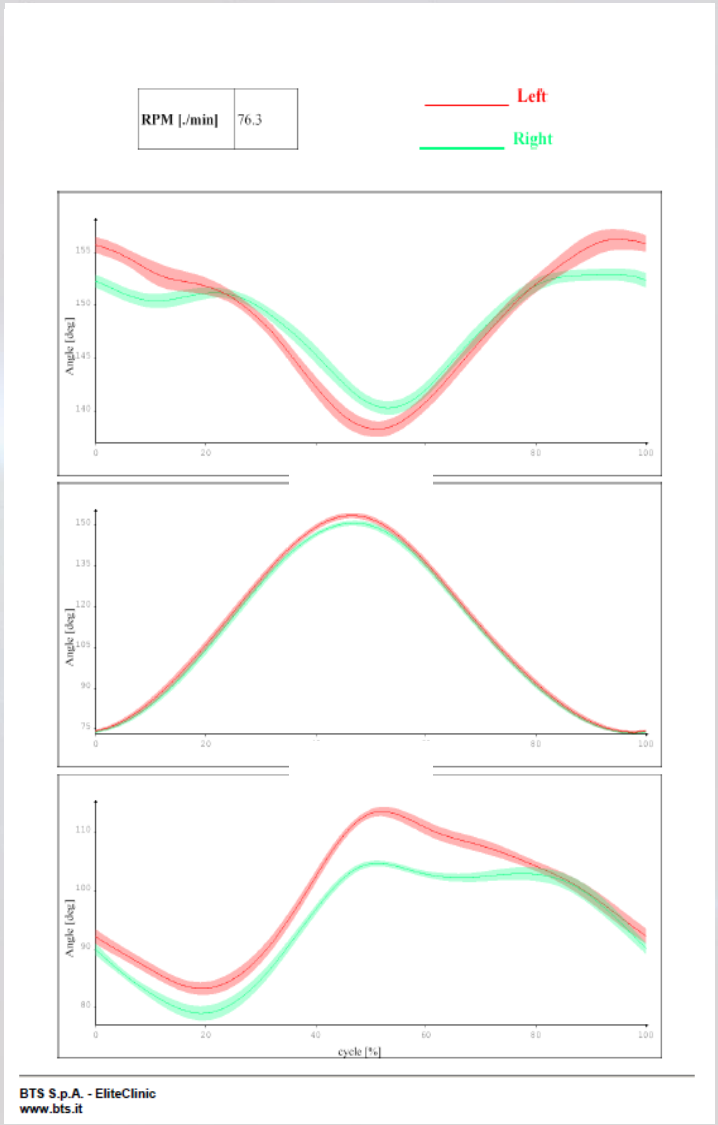


Sport

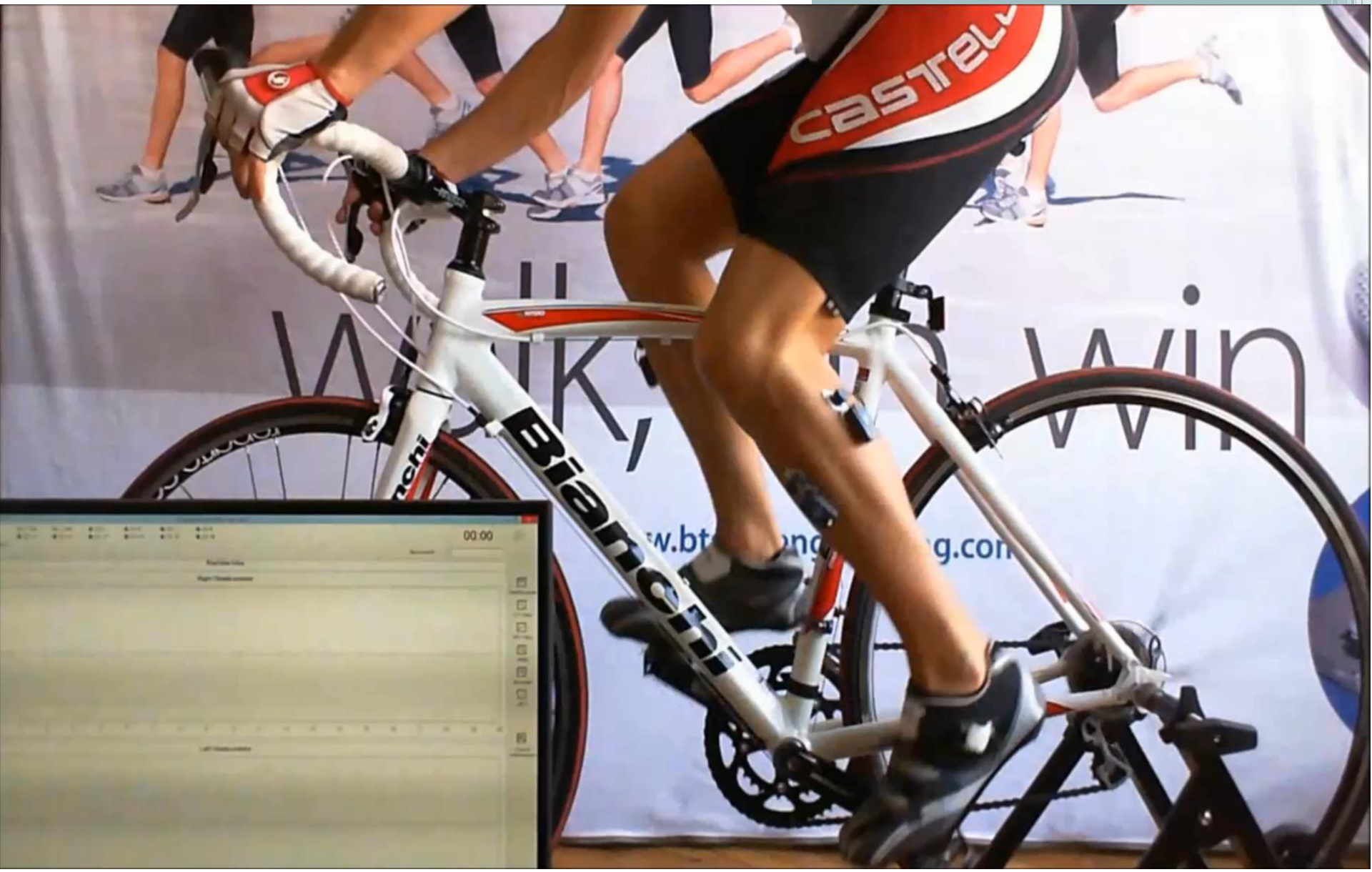
Kinematic Analysis by BTS SMART-DX System

Bicycle Analysis

MAPEI Lab in Castellanza (Italy)



BTS Bioengineering


castelli
Bianchi
win

Sport

Kinematic Analysis by BTS SMART-DX System

Ballet Analysis

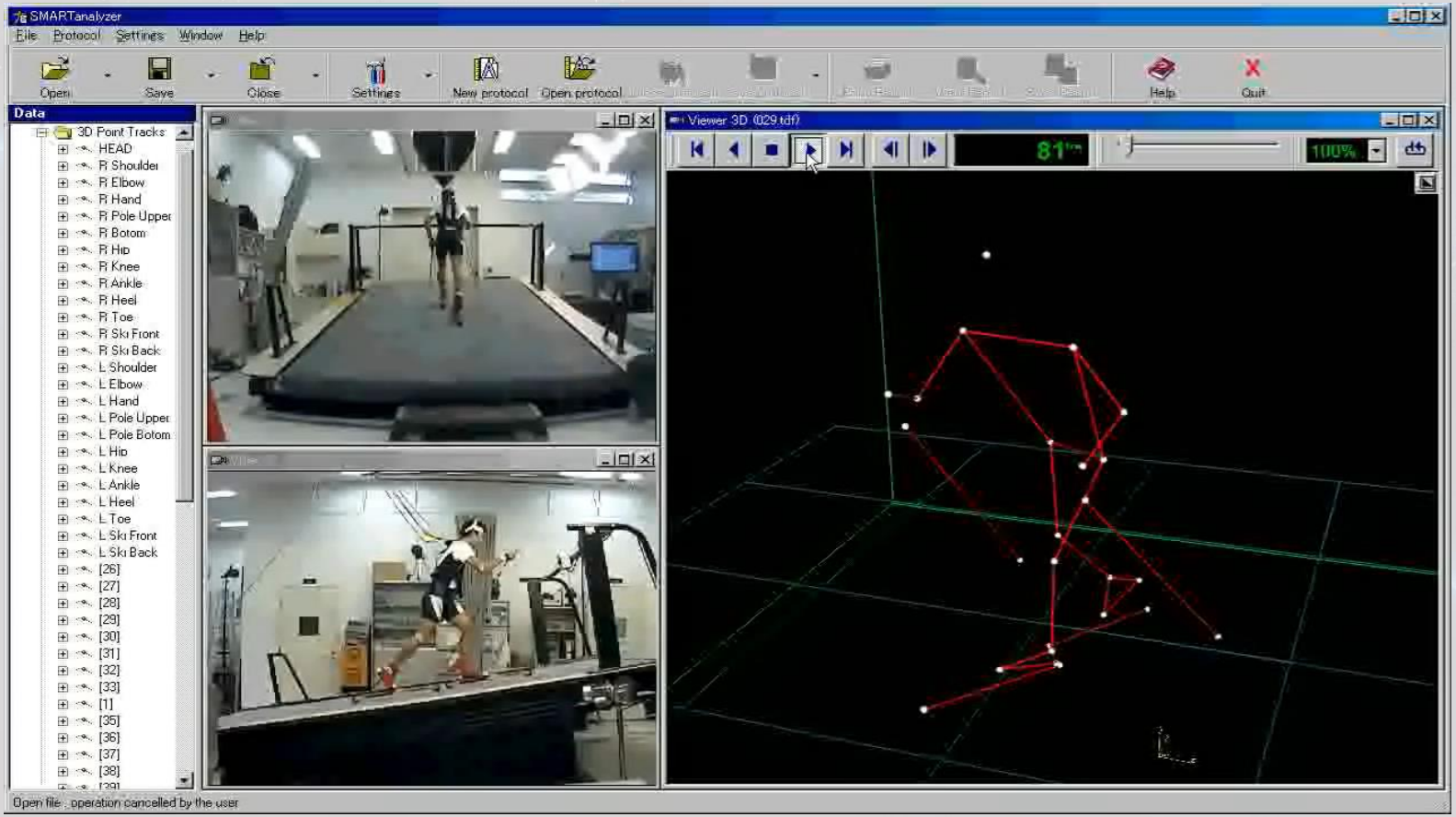
Ballet of SCALA Theatre in Milan (Italy)

BTS Bioengineering

Sport

Kinematic Analysis by BTS SMART-DX System

Ski Analysis



Federal Medical Biophysical Centre in Mosca (Russia)

BTS Bioengineering

Sport

Kinematic Analysis by BTS SMART-DX System

Roller Skate Analysis

Motor Science Lab in Bologna (Italy)

BTS Bioengineering

Sport

Kinematic Analysis by BTS SMART-DX System

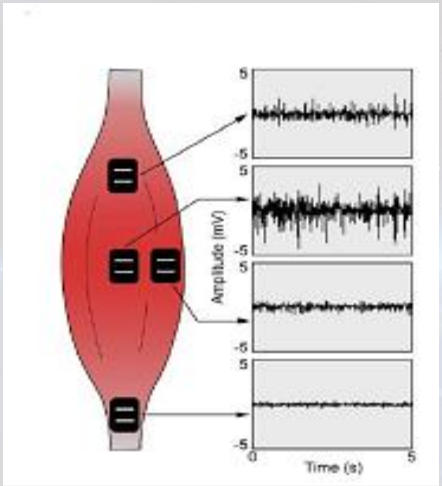
Artistic Gymnastics Analysis

Motor Science Lab in Bologna (Italy)

BTS Bioengineering

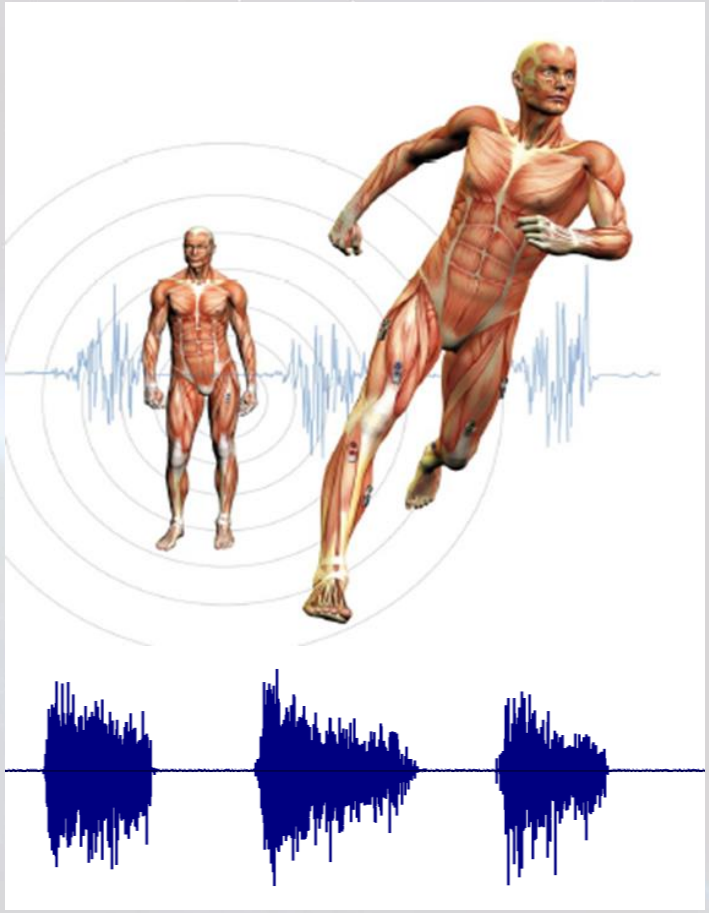
Strumenti di misura

Elettromiografia di superficie



Analisi EMG

«Electromyography…
*"..is **the study of muscle function** through the analysis of the electrical signal the muscles emanate." Basmajian & DeLuca*

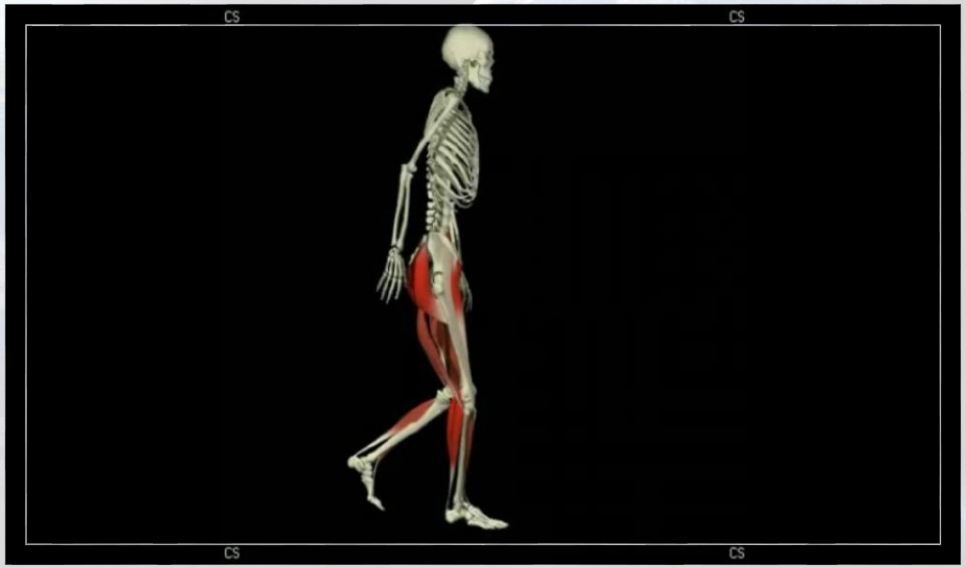


Il sistema EMG è una tecnica assolutamente non-invasiva usata per registrare e analizzare il segnale elettromiografico.

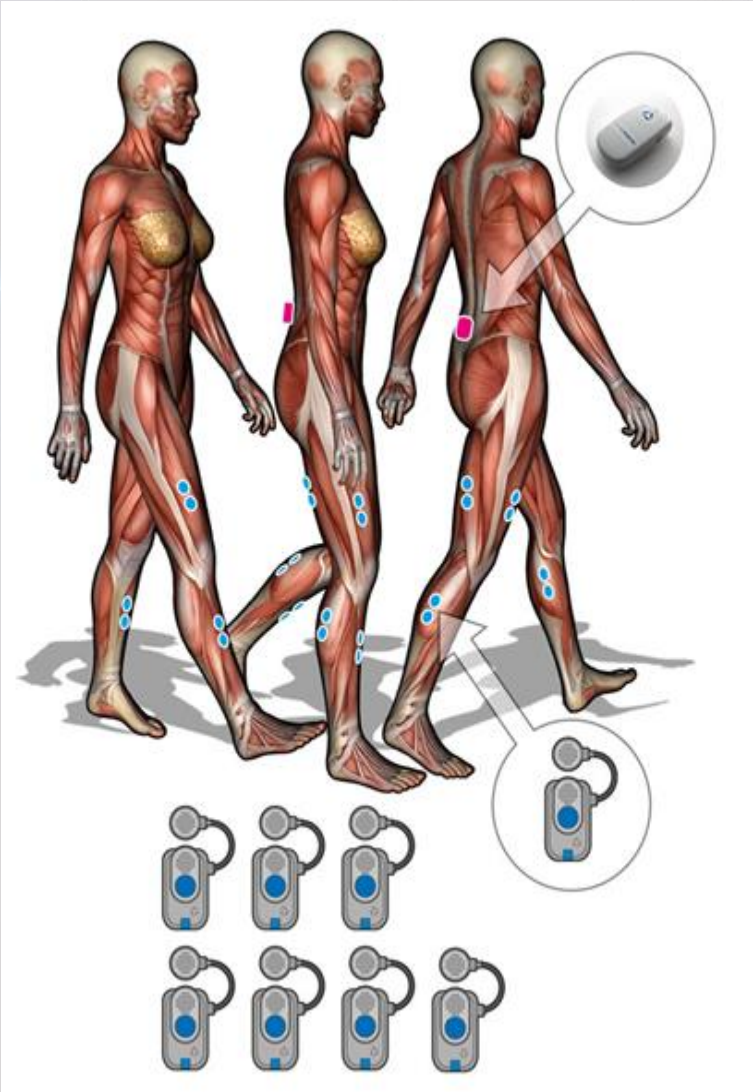
Permette una valutazione funzionale dell'attività funzionale fornendo informazioni su:

- **Tempo**
- **Durata**
- **Ampiezza**
- **Fatica**

Alcuni esempi di analisi EMG…



Analisi EMG



WALKING Analysis

TRUNK Analysis

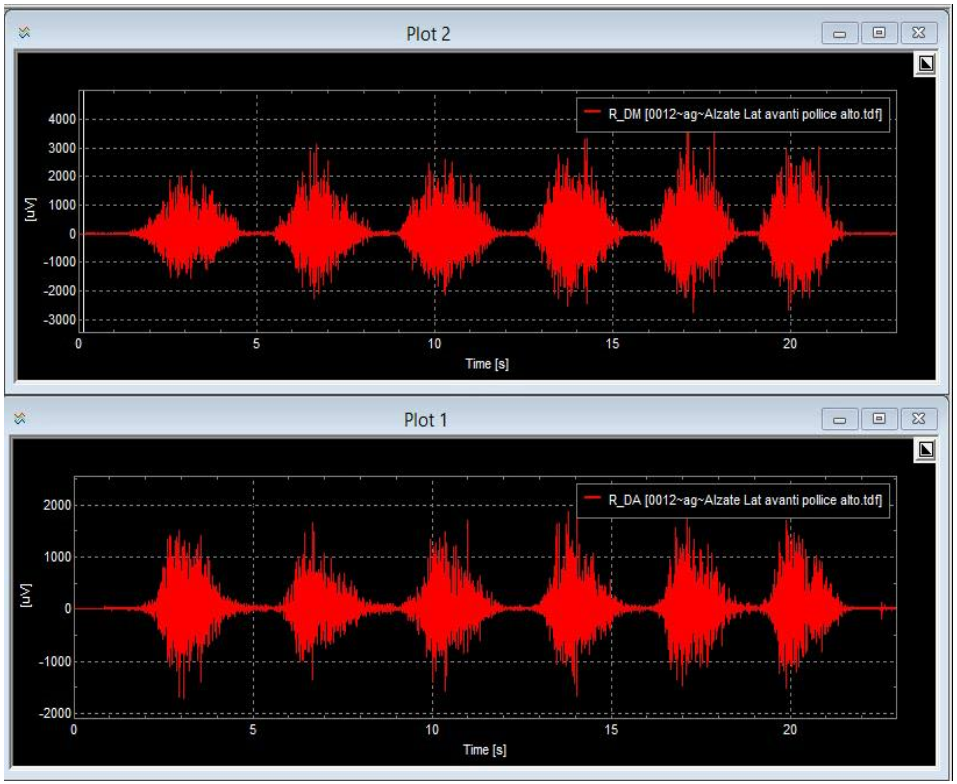
LUMBAR MUSCLE PAIN PREVENTION

Analisi OCCLUSIONE DENTALE

…. sEMG in SPORTING GESTURE ANALYSIS

«Understanding the muscle strategies to be more selective»

Deltoid muscle TRAINING

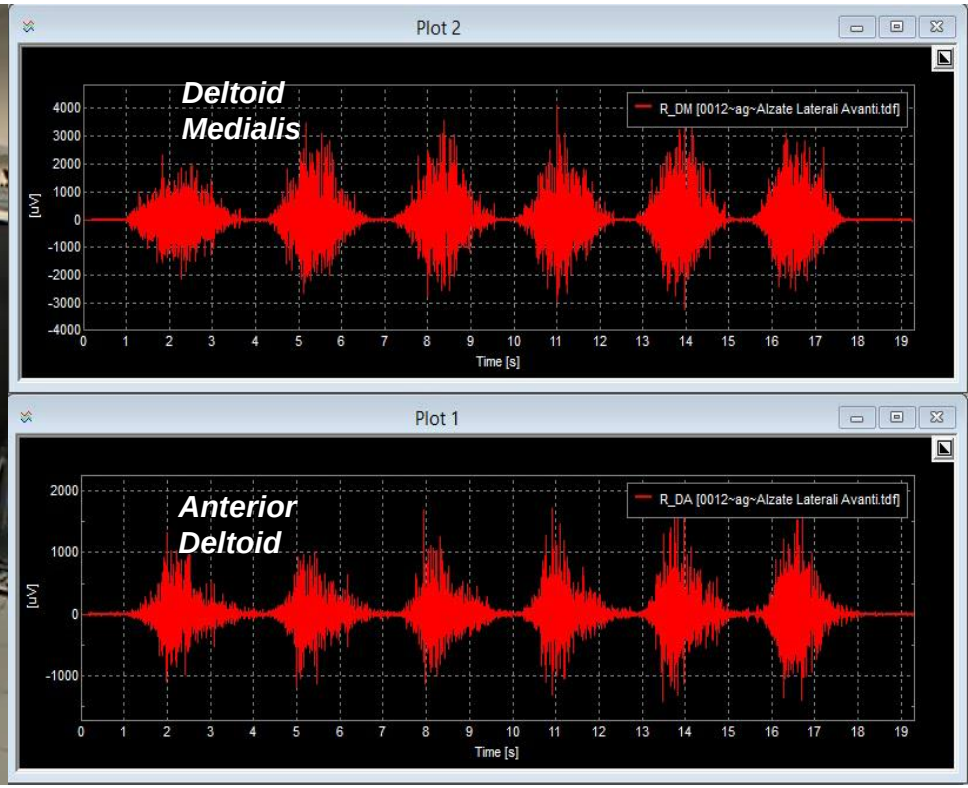


[Condition 1 – With thumb up]

…. sEMG in SPORTING GESTURE ANALYSIS

«Understanding the muscle strategies to be more selective»

Deltoid muscle TRAINING



[Condition 2 – With thumb dw]

Sport

EMG Analysis by BTS FREEEMG

sEMG… also for muscle training reducing the workload

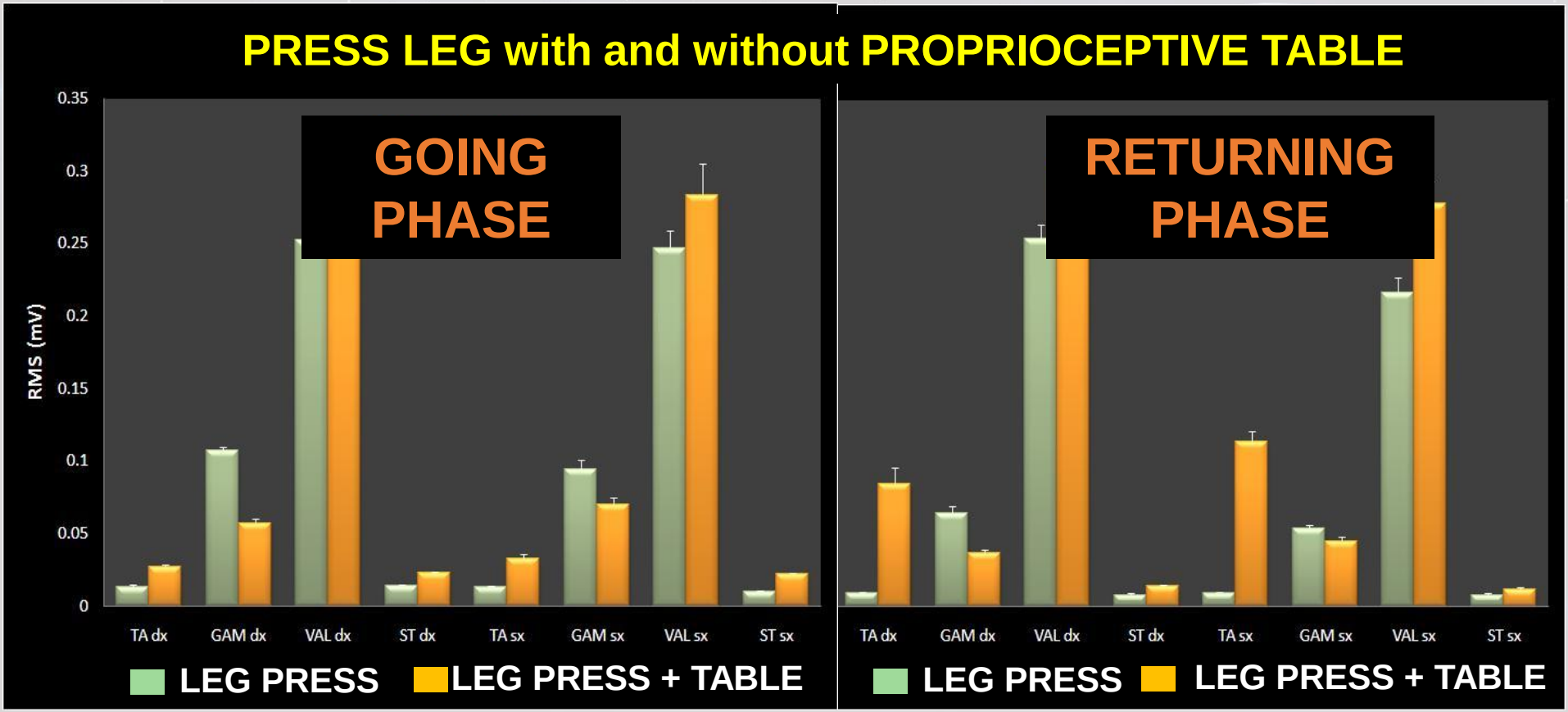
[Press Leg]
Load = 160 kg

[Press Leg + proprioceptive table]
Load = 120 kg

Biomechanical Lab at AC MILAN (Italian Football Team)

BTS Bioengineering

sEMG… anche per allenamenti muscolaro riducendo il carico di lavoro



Walking Analysis

BTS GAITLAB

Laboratorio de Biomecanica in San Juan (PORTORICO)

BTS Bioengineering

Jump Analysis

BTS SPORTLAB

Counter Movement Jump

Squat Jump

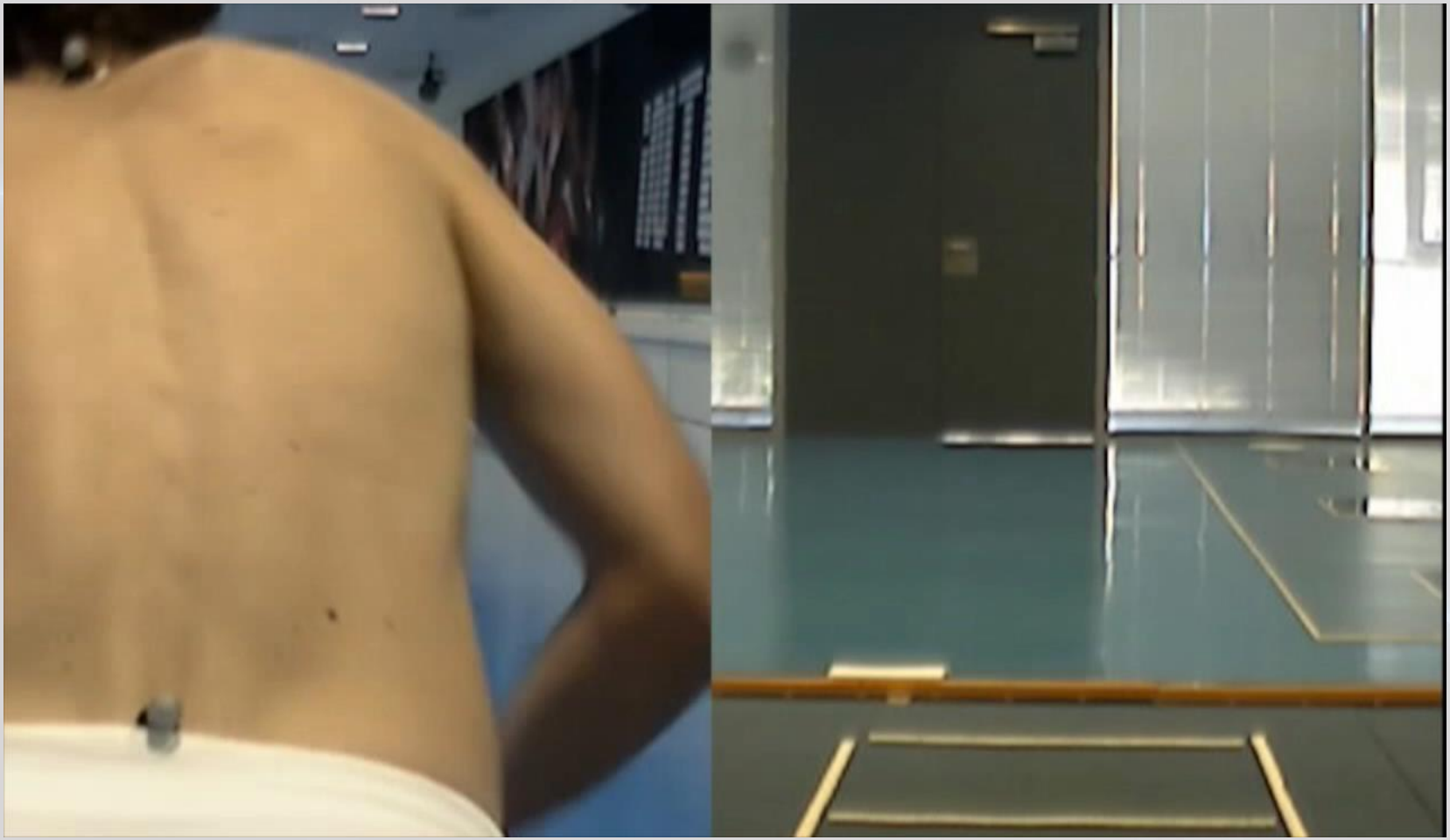
Dynamo Lab in Lodz (Poland)

Galliera Motor Science Lab in Genova (Italy)

BTS Bioengineering

Running Analysis

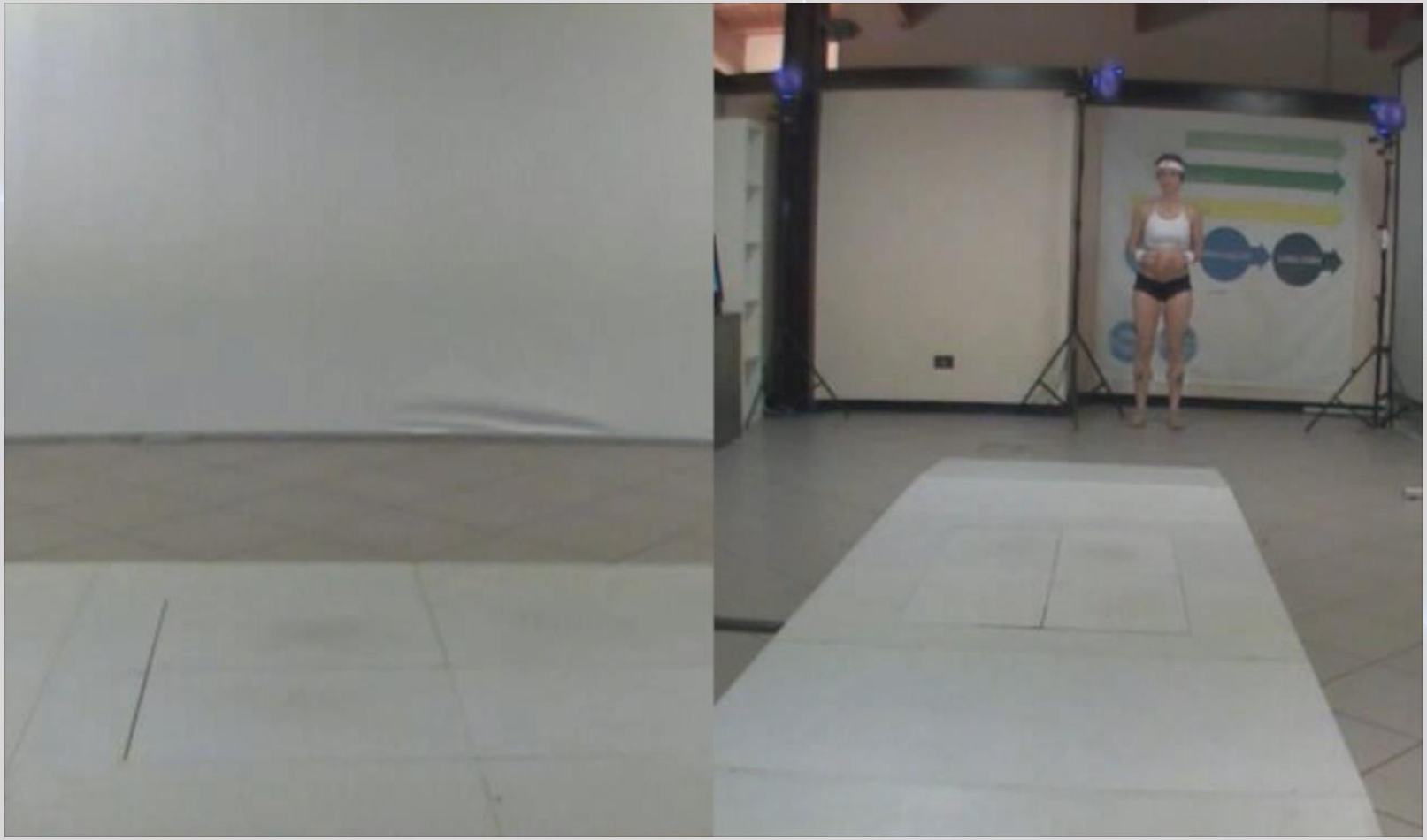
BTS SPORTLAB



Real Madrid Football Club in Madrid (Spain)

Change Direction Analysis

BTS SPORTLAB

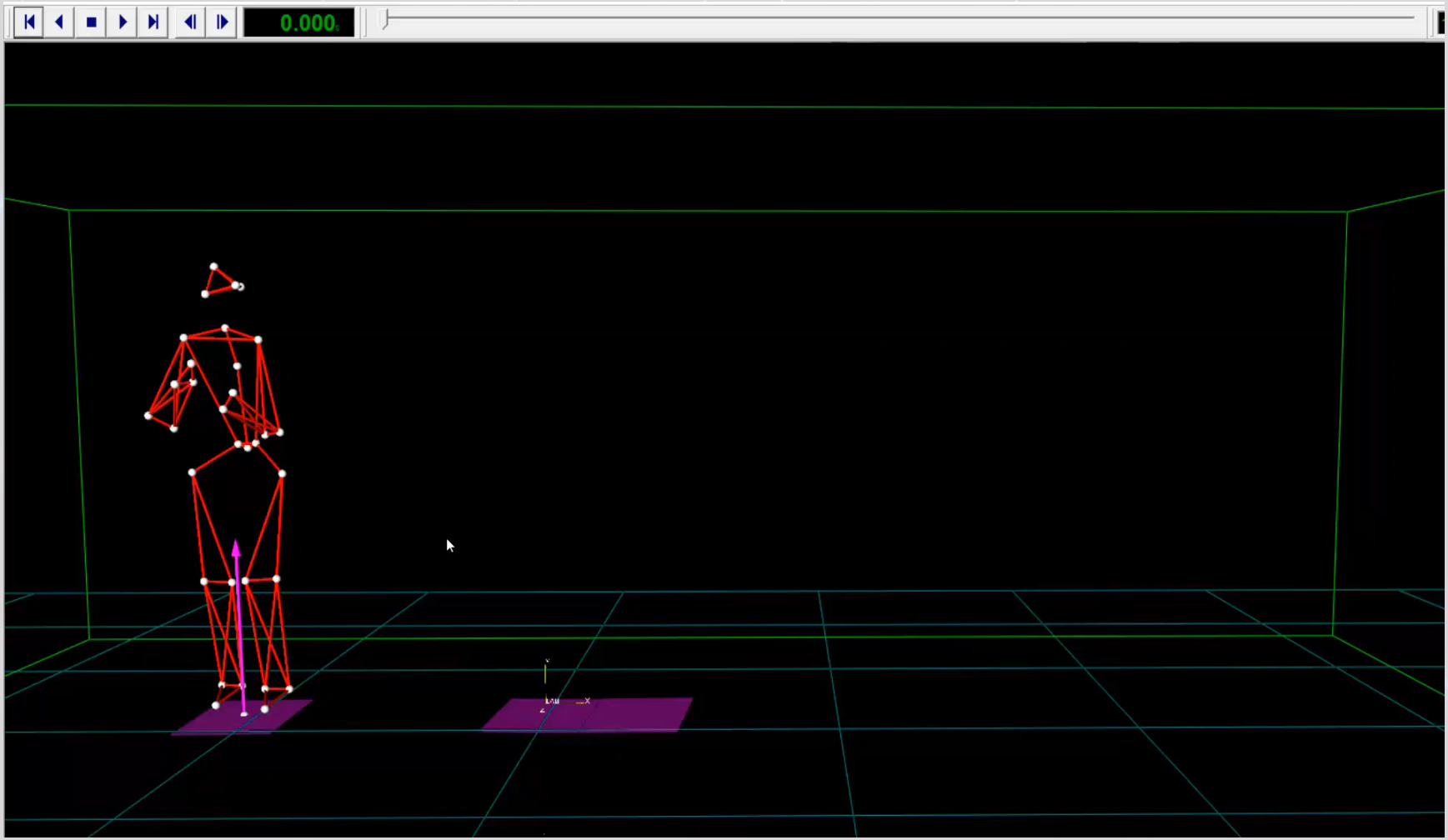


BTS Bioengineering Lab in Milan (Italy)

BTS Bioengineering

Baseball Analysis

BTS SPORTLAB

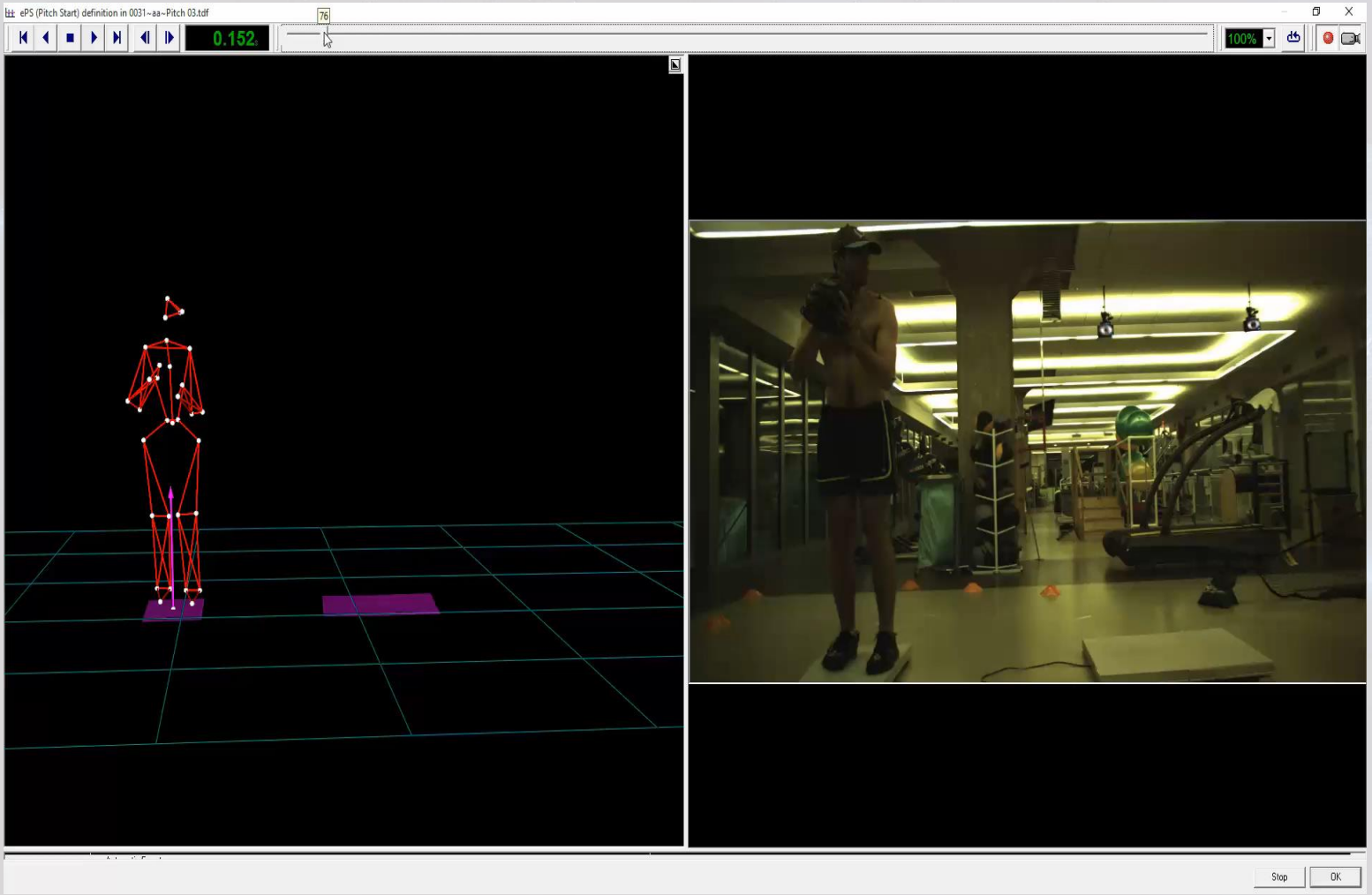


New York University (United States)

BTS Bioengineering

Baseball Analysis

BTS SPORTLAB



New York University (United States)

BTS Bioengineering

Fasi di un esame di gait analysis

- Calibrazione
- Misure antropometriche
- Posizionamento marker
- Standing
- Prove di cammino

Misure antropometriche

Larghezza Pelvi – distanza tra le asis

Altezza Pelvi

Misure antropometriche

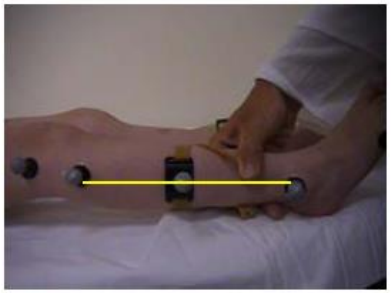
Diametro ginocchio

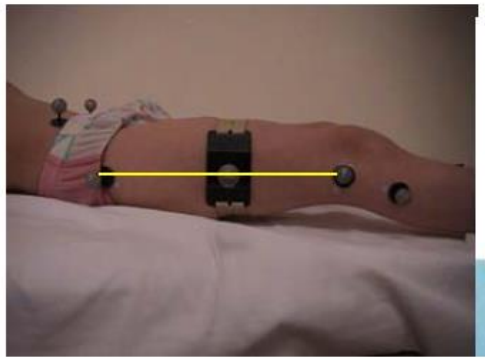
Diametro caviglia

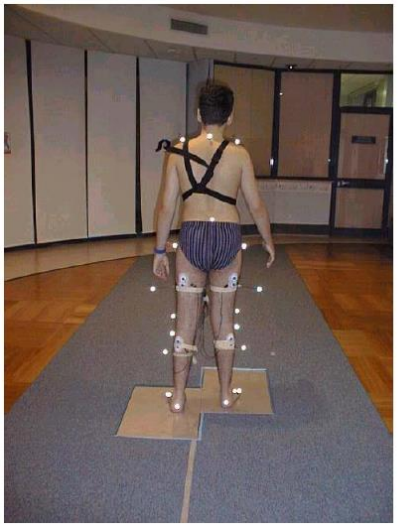
Misure antropometriche

Lunghezza gamba

Posizionamento marker







Analisi dello studio svolto

Lo studio proposto riguarda l'analisi del passo in condizioni estreme, in assenza totale della percezione sensoriale degli arti inferiori ed in assenza totale o parziale dell' attività muscolare.

I pazienti valutati, sono soggetti affetti da lesioni spinale dorso-lombare, pertanto paraplegici.

Analisi dello studio svolto

Metodo:

Numero Pazienti	Sesso	Età	Data evento	Prima valutazione (dall'ospedalizzazione)	Seconda valutazione (dall'ospedalizzazione)
22 (12 IP 10 CP)	M	$20 < x < 44$	> 6 mesi	$v < 21$ (t0)	$80 < v < 90$ (t90)

IP = Paraplegia incompleta CP = Paraplegia completa

I pazienti hanno svolto un training riabilitativo seguendo un protocollo standardizzato.

ARD Research LAB

Analisi dello studio svolto

Le acquisizioni di gait analysis (t0, t90) includono :

- standing
- cammino
- elettromiografia di superficie

La fase di acquisizione ha previsto delle prove locomotorie che consistono nel fare eseguire al paziente un certo numero di passaggi su un percorso prestabilito e nella registrazione delle grandezze temporali, cinematiche, dinamiche ed elettromiografiche.

LABORATORIO di ANALISI del MOVIMENTO
BTS

REPORT CLINICO

COGNOME:

NOME:

DATA di NASCITA:

PATOLOGIA: Davis

DATA SESSIONE: 25/07/2018

PROTOCOLLO: Davis

PARAMETRI TEMPORALI

	DX	SX	NORMALITA' DX	NORMALITA' SX
FASE di APPOGGIO (%)	64.1 ± 0	59.5 ± 0	59.6 ± 1.2	59.3 ± 1.8
FASE di VOLO (%)	35.9 ± 0	40.5 ± 0	40.4 ± 1.2	40.7 ± 1.8
FASE di DOPPIO SUPP. (%)	13.3 ± 0	9.2 ± 0	13.4 ± 1.1	12.5 ± 1.1
FASE di APPOGGIO (s)	0.82 ± 0	0.78 ± 0	0.63 ± .02	0.63 ± .04
FASE di VOLO (s)	0.46 ± 0	0.53 ± 0	0.43 ± .02	0.43 ± .02
TEMPO del CICLO (s)	1.28 ± 0	1.31 ± 0	1.06 ± .03	1.05 ± .05
CADENZA (step/min)	92.4 ± 0		113.844 ± 4.302	

PARAMETRI SPAZIALI

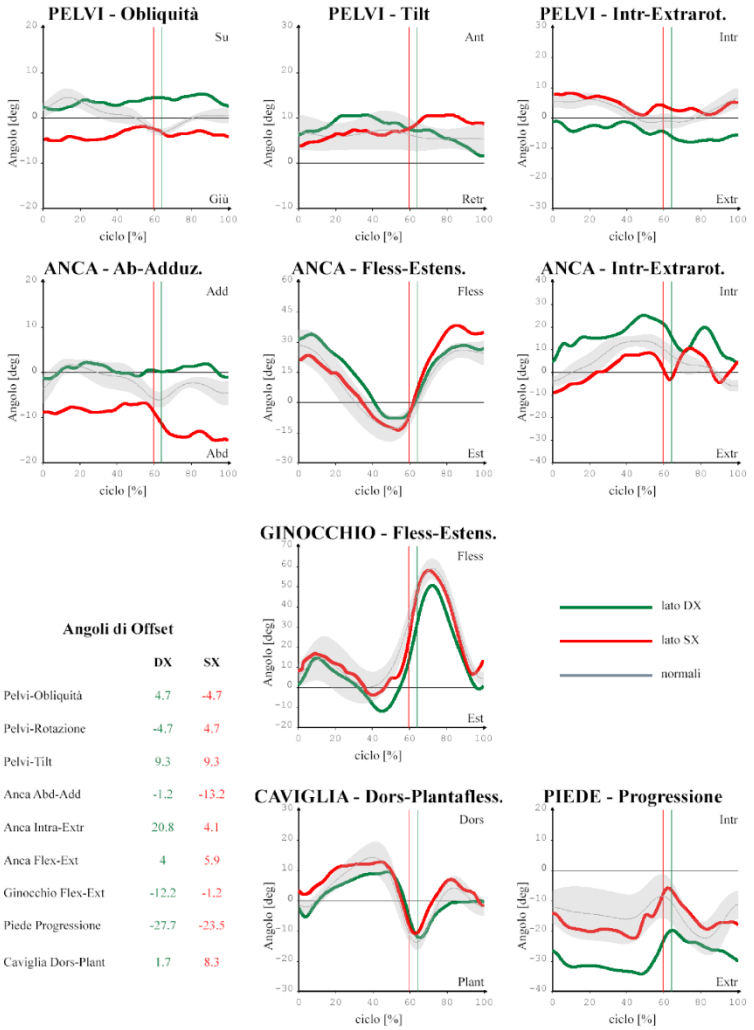
	DX	SX	NORMALITA' DX	NORMALITA' SX
LUNGHEZZA del PASSO (m)	0.6 ± 0	0.56 ± 0	0.73 ± .02	0.74 ± .02
VELOCITA' (m/s)	0.94 ± 0	0.95 ± 0	1.39 ± .06	1.39 ± .07
VELOCITA' di VOLO (m/s)	2.33 ± 0	2.17 ± 0	3.3 ± .14	3.27 ± .18
LUNGHEZZA del CICLO (m)	1.2 ± 0	1.24 ± 0	1.47 ± .08	1.47 ± .06
LARGHEZZA del PASSO (m)	0.17 ± 0	0.17 ± 0	0.11 ± .03	0.13 ± .01
VELOCITA' MEDIA (m/s)	0.6 ± 0		1.39 ± .06	

SMARTclinic - BTS S.p.a.
www.btsbioengineering.com

ARD Research LAB

Bari 02 Aprile 2019

Cinematica MEDIA: DX vs SX



Angoli di Offset

	DX	SX
Pelvi-Obliquità	4.7	-4.7
Pelvi-Rotazione	-4.7	4.7
Pelvi-Tilt	9.3	9.3
Anca Abd-Add	-1.2	-13.2
Anca Intra-Extr	20.8	4.1
Anca Flex-Ext	4	5.9
Ginocchio Flex-Ext	-12.2	-1.2
Piede Progressione	-27.7	-23.5
Caviglia Dors-Plant	1.7	8.3

Analisi dello studio svolto

Metodi:

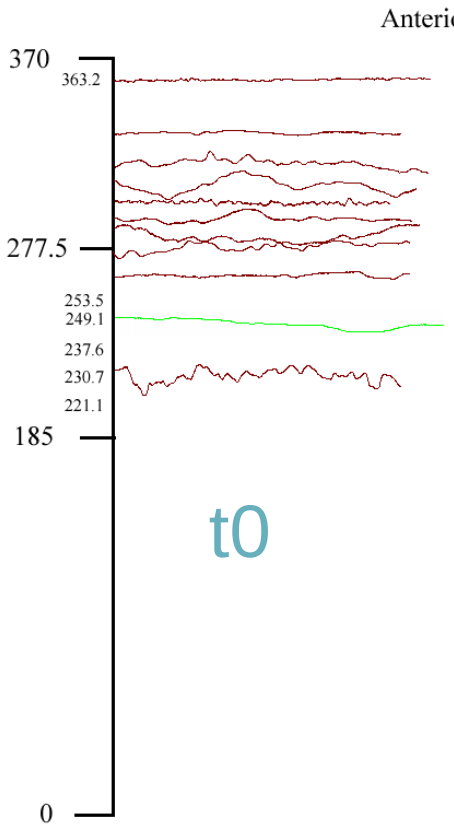
La mappatura dei muscoli analizzati con l'elettromiografo di superficie ad otto canali è la seguente:

1° canale: quadricipite destro
2° canale: quadricipite sinistro
3° canale: Ischio crurali destro
4° canale: Ischio crurali sinistro
5° canale: Grandorsale destro
6° canale: Grandorsale sinistro

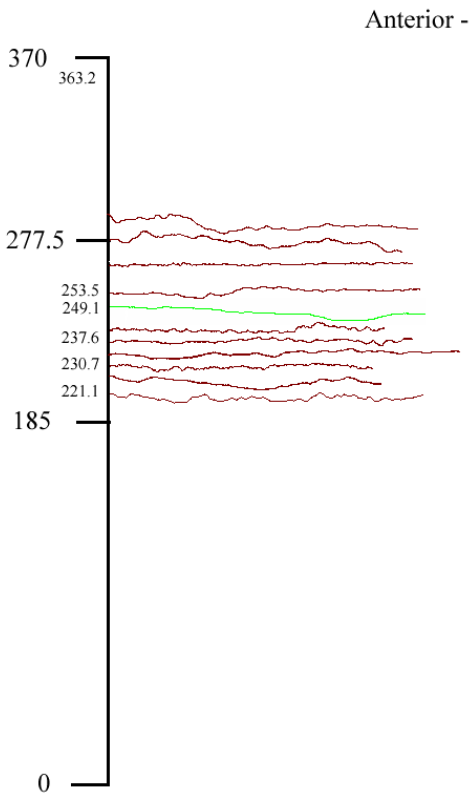
ARD Research LAB

Risultati

Paraplegia completa

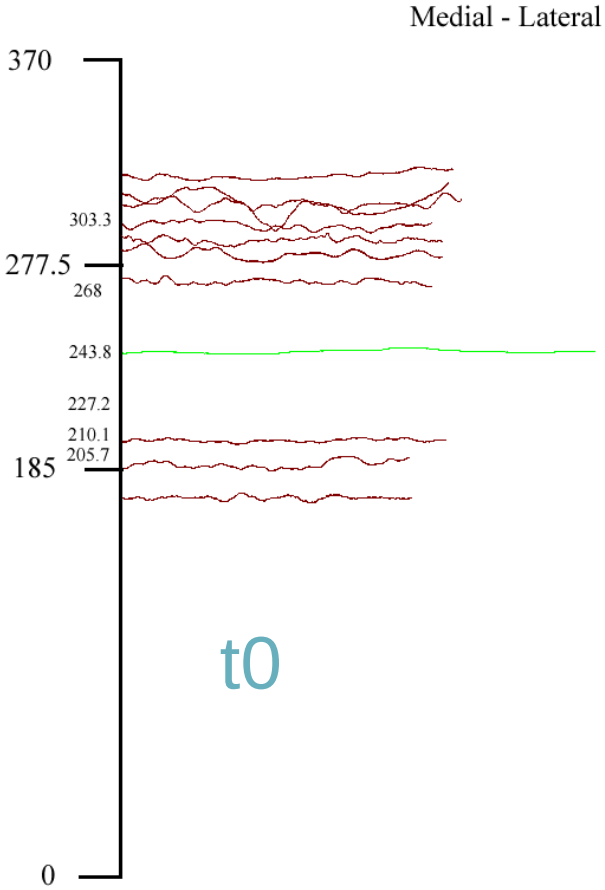


t0

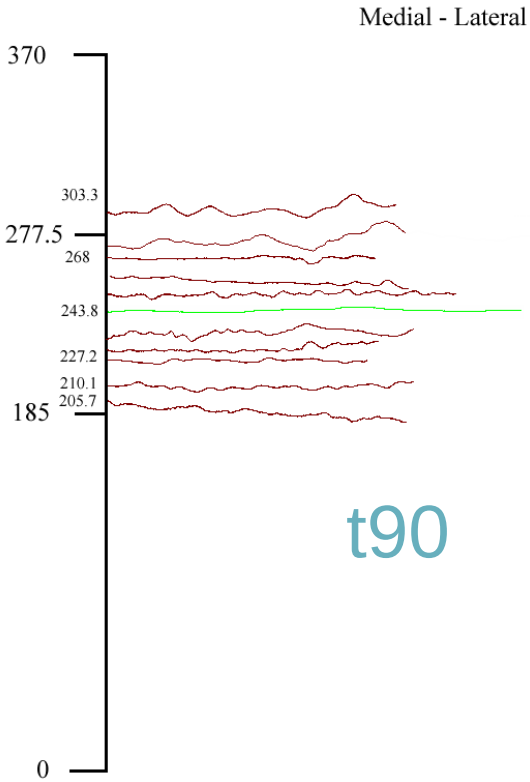


t90

Risultati



t0



t90

Paraplegia completa

ARD Research LAB

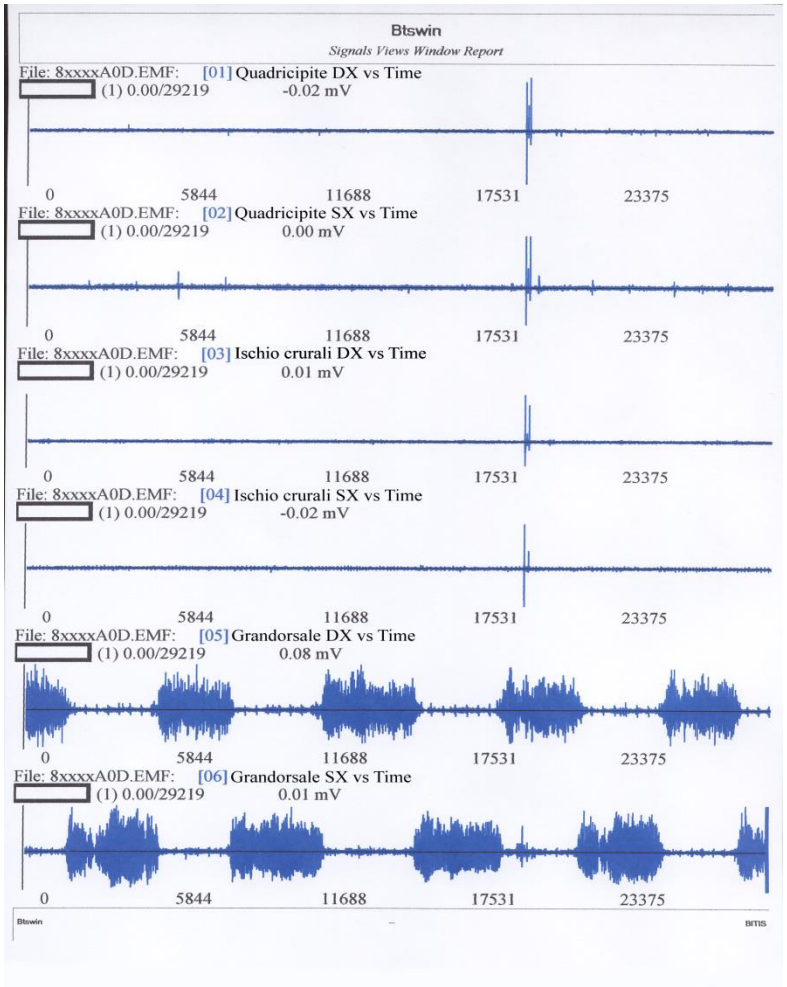
Risultati

Paraplegia completa

Valutazione nella fase t90 del paziente GR

Temporal Parameters	RT	LT	NORMAL VAL. RT	NORMAL VAL. LT
Stance time [msec]	5200	5580	393 - 777	405 - 715
Swing time [msec]	1520	1290	343 - 462	308 - 534
Stance time [% stride]	78	81	53 - 65	52 - 63
Swing time [% stride]	22	19	35 - 47	37 - 48
Stride time [msec]	6720	6870	763 - 1212	740 - 1222
Cadence [step/min]	18		98 - 149	98 - 149
	R-Fw	L-Fw	R-Fw	L-Fw
Double supp. time [msec]	2020	1920	- 114	- 220
Double supp. [% stride]	30	28	2 - 9	1 - 19

Distance Parameters	RT	LT	RT	LT
Anterior step length [mm]	182.86	82.64	469.27 - 679.23	410.30 - 725.83
Velocity [m/sec]	0.04	0.04	0.89 - 1.54	0.90 - 1.56
Swing velocity [m/sec]	0.19	0.19	2.26 - 3.71	1.94 - 3.83
Stride length [mm]	275.44	244.86	858.78 - 1513.51	912.39 - 1487.98
Step width [mm]	238.09		70.52 - 146.56	70.52 - 146.56
Mean velocity [m/sec]	0.04		0.91 - 1.54	0.91 - 1.54



ARD Research LAB

Risultati

Paraplegia completa

Valutazione nella fase t90 del paziente GR

	RT	LT
Stance	5200	5580
Swing	1520	1290
% Stance	78	81
% Swing	22	19

Risultati

Paraplegia completa

Altra Valutazione (CL) nella fase t90

Temporal Parameters	RT	LT	NORMAL VAL. RT	NORMAL VAL. LT
Stance time [msec]	4340	5040	393 - 777	405 - 715
Swing time [msec]	1320	1120	343 - 452	308 - 534
Stance time [% stride]	77	82	53 - 65	52 - 63
Swing time [% stride]	23	18	35 - 47	37 - 48
Stride time [msec]	5660	6160	753 - 1212	740 - 1222
Cadence [step/min]	20		98 - 149	98 - 149
	R-Fw	L-Fw	R-Fw	L-Fw
Double supp. time [msec]	1860	1360	- 114	- 220
Double supp. [% stride]	33	24	2 - 9	1 - 19

Distance Parameters	RT	LT	RT	LT
Anterior step length [mm]	42.95	120.64	469.27 - 679.23	410.30 - 725.83
Velocity [m/sec]	0.03	0.02	0.89 - 1.54	0.90 - 1.56
Swing velocity [m/sec]	0.14	0.13	2.26 - 3.71	1.94 - 3.83
Stride length [mm]	184.27	142.51	858.78 - 1513.51	912.39 - 1487.98
Step width [mm]	182.32		70.52 - 146.56	70.52 - 146.56
Mean velocity [m/sec]	0.03		0.91 - 1.54	0.91 - 1.54

ARD Research LAB

Risultati

Paraplegia completa

Altra Valutazione (DC) nella fase t90

Temporal Parameters	RT	LT	NORMAL VAL. RT	NORMAL VAL. LT
Stance time [msec]	4440	4490	393 - 777	405 - 715
Swing time [msec]	1180	850	343 - 452	308 - 534
Stance time [% stride]	79	84	53 - 65	52 - 63
Swing time [% stride]	21	16	35 - 47	37 - 48
Stride time [msec]	5620	5340	753 - 1212	740 - 1222
Cadence [step/min]	22		98 - 149	98 - 149
	R-Fw	L-Fw	R-Fw	L-Fw
Double supp. time [msec]	1780	1520	- 114	- 220
Double supp. [% stride]	32	27	2 - 9	1 - 19

Distance Parameters	RT	LT	RT	LT
Anterior step length [mm]	91.24	147.90	469.27 - 679.23	410.30 - 725.83
Velocity [m/sec]	0.04	0.04	0.89 - 1.54	0.90 - 1.56
Swing velocity [m/sec]	0.20	0.28	2.26 - 3.71	1.94 - 3.83
Stride length [mm]	235.16	218.70	858.78 - 1513.51	912.39 - 1487.98
Step width [mm]	163.34		70.52 - 146.56	70.52 - 146.56
Mean velocity [m/sec]	0.04		0.91 - 1.54	0.91 - 1.54

ARD Research LAB

Risultati

Paraplegia completa

Altra Valutazione (N) nella fase t90

Temporal Parameters	RT	LT	NORMAL VAL. RT	NORMAL VAL. LT
Stance time [msec]	6200	6060	393 - 777	405 - 715
Swing time [msec]	1440	1500	343 - 452	308 - 534
Stance time [% stride]	81	80	53 - 65	52 - 63
Swing time [% stride]	19	20	35 - 47	37 - 48
Stride time [msec]	7640	7560	753 - 1212	740 - 1222
Cadence [step/min]	16		98 - 149	98 - 149
	R-Fw	L-Fw	R-Fw	L-Fw
Double supp. time [msec]			- 114	- 220
Double supp. [% stride]			2 - 9	1 - 19

Distance Parameters	RT	LT	RT	LT
Anterior step length [mm]	142.36	137.96	469.27 - 679.23	410.30 - 725.83
Velocity [m/sec]	0.03	0.02	0.89 - 1.54	0.90 - 1.56
Swing velocity [m/sec]	0.16	0.12	2.26 - 3.71	1.94 - 3.83
Stride length [mm]	234.33	175.65	858.78 - 1513.51	912.39 - 1487.98
Step width [mm]	226.13		70.52 - 146.56	70.52 - 146.56
Mean velocity [m/sec]	0.03		0.91 - 1.54	0.91 - 1.54

ARD Research LAB

Stance RT

Paraplegia incompleta

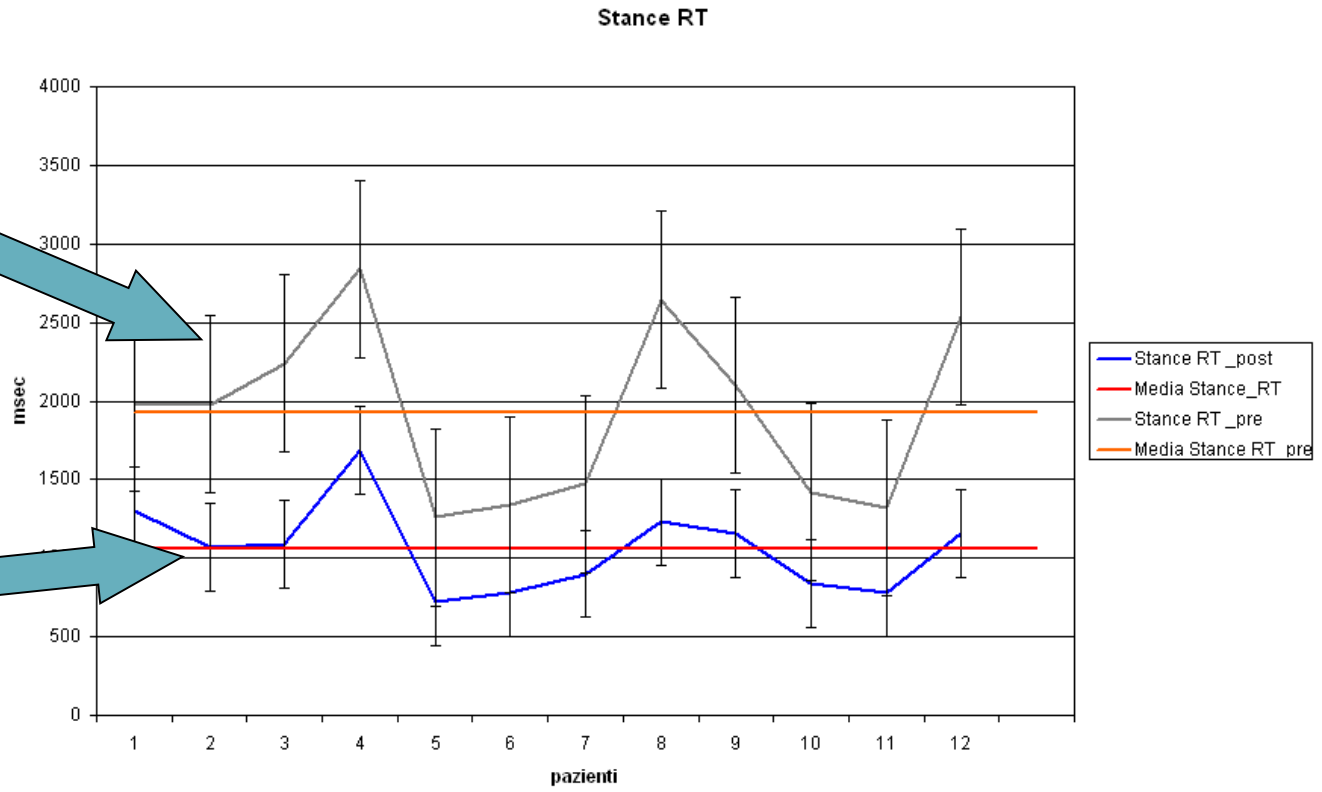
t0

t0 = 1928.1

p <0.01

t90

t90 = 1059.75



ARD Research LAB

Stance LT

Paraplegia incompleta

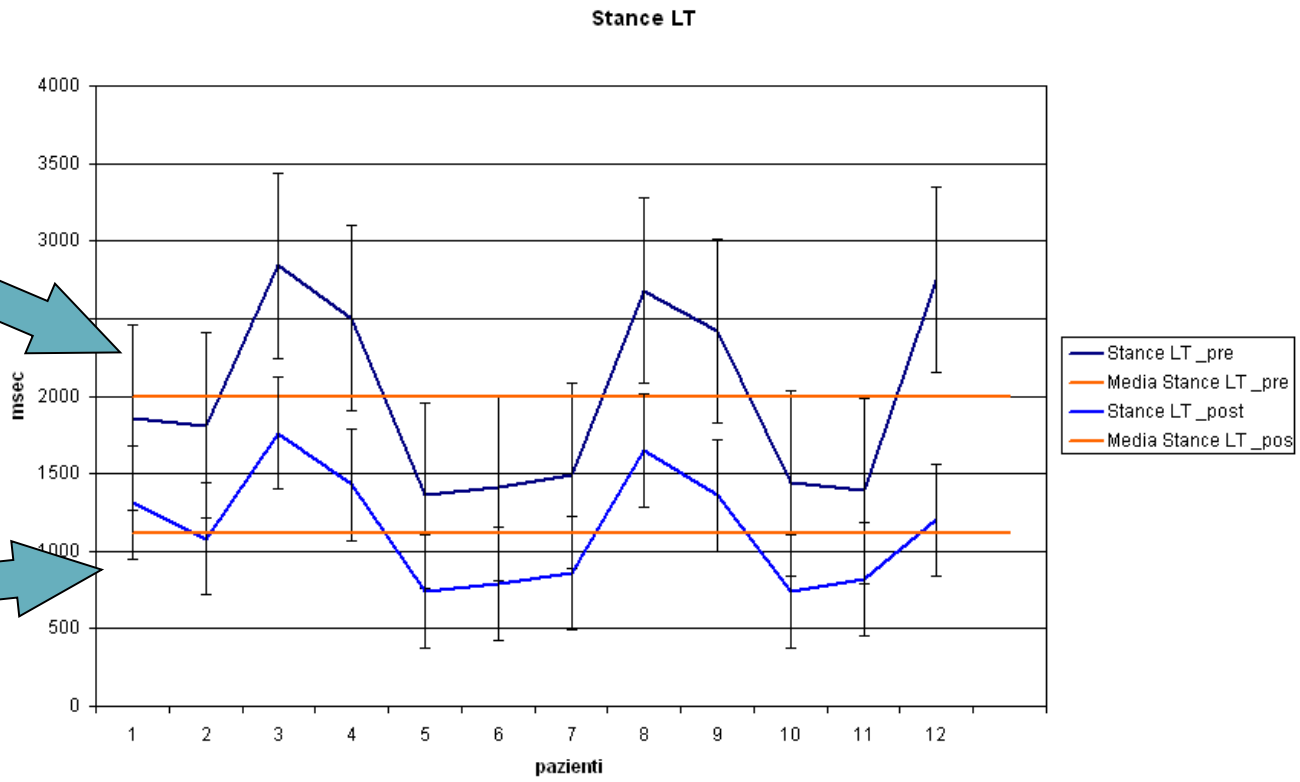
t0

t0 = 1995.6

p <0.01

t90

t90 = 1145.25



ARD Research LAB

SWING RT

Paraplegia incompleta

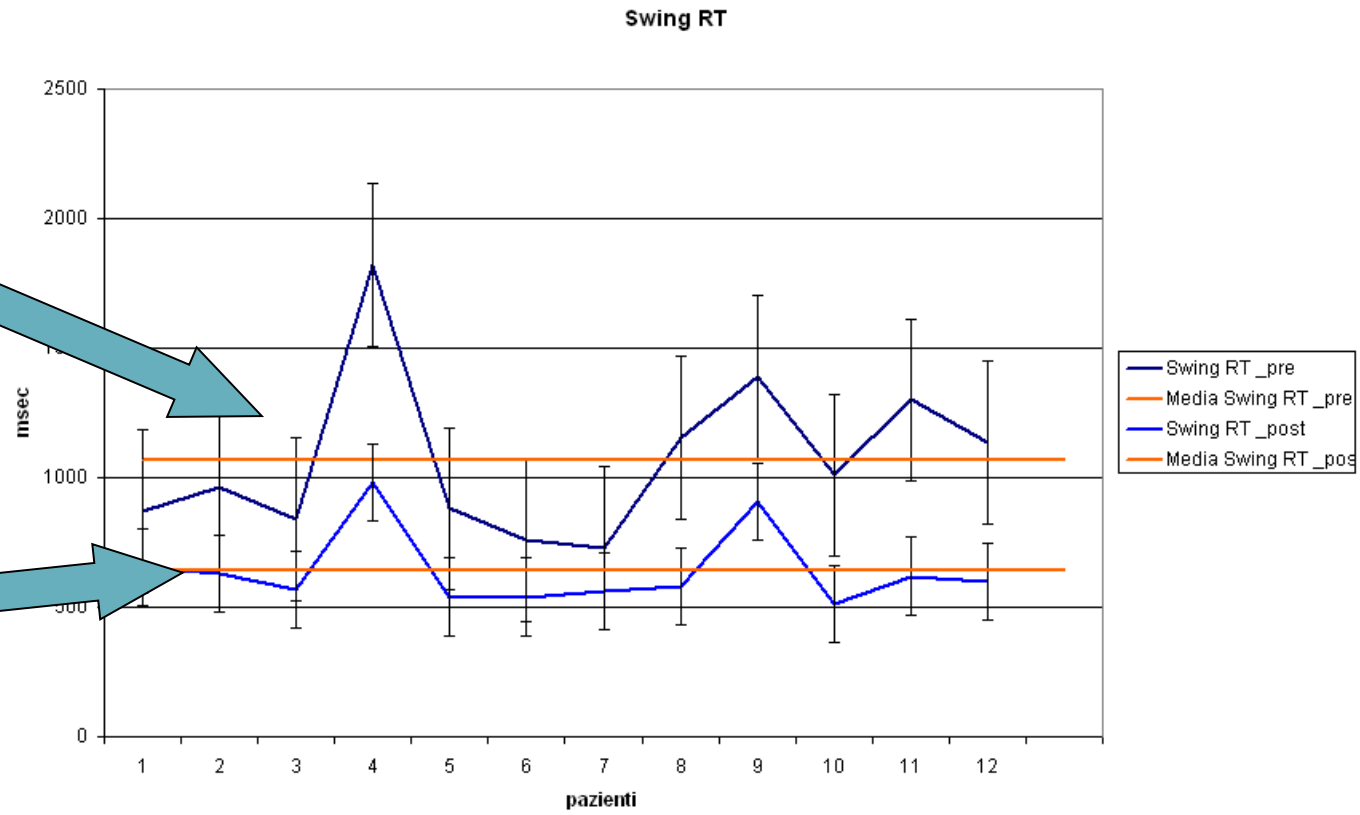
t0

t0 = 640.8

p <0.01

t90

t90 = 1070.7



Swing LT

Paraplegia incompleta

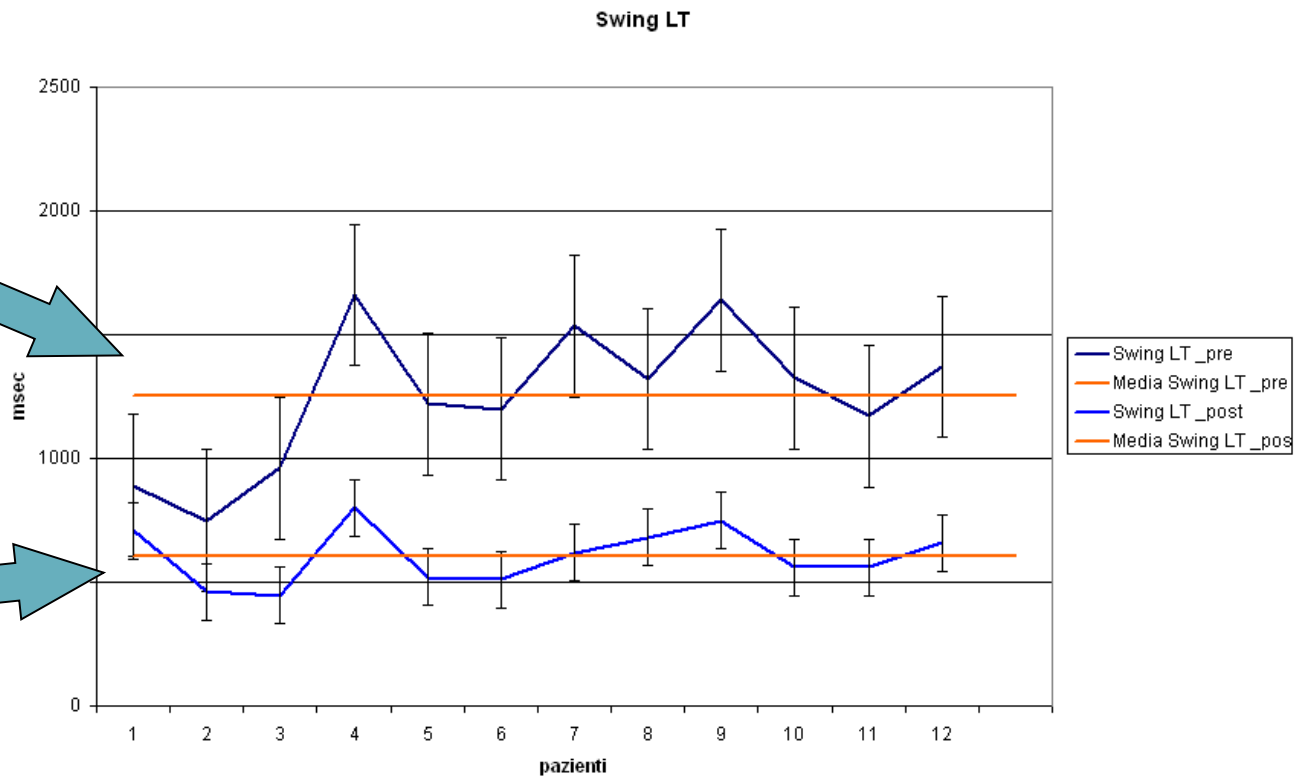
t0

t0 = 1253.4

p <0.01

t90

t90 = 606.2



ARD Research LAB

t0

Pa

Stance e swing

a t0 e a t90

Temporal Parameters	RT	LT	NORMAL VAL. RT	NORMAL VAL. LT
Stance time [msec]	2100	2420	393 - 777	405 - 715
Swing time [msec]	740	640	343 - 452	308 - 534
Stance time [% stride]	74	79	53 - 65	52 - 63
Swing time [% stride]	26	21	35 - 47	37 - 48
Stride time [msec]	2840	3060	753 - 1212	740 - 1222
Cadence [step/min]	41		98 - 149	98 - 149
	R-Fw	L-Fw	R-Fw	L-Fw
Double supp. time [msec]	1080	400	- 114	- 220
Double supp. [% stride]	38	14	2 - 9	1 - 19

Distance Parameters	RT	LT	RT
Anterior step length [mm]	345.60	345.55	469.27 - 67
V	0.24	0.24	0.89 - 1.
Swing velocity [m/sec]	0.94	1.14	2.26 - 3.
Stride length [mm]	694.35	726.77	858.78 - 15
Step width [mm]	190.72		70.52 - 14
Mean velocity [m/sec]	0.24		0.91 - 1.

Il rapporto fisiologico di stance e swing rispetto al passo completo è rispettivamente di 60% e 40%

t90

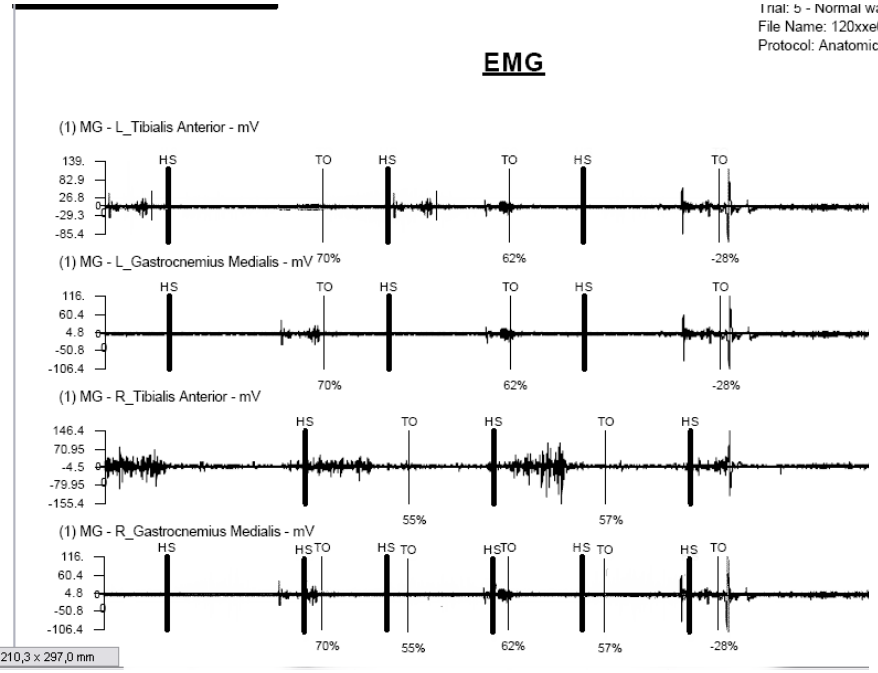
Temporal Parameters	RT	LT	RT
Stance time [msec]	1160	1480	393 - 7
Swing time [msec]	910	750	343 - 4
Stance time [% stride]	56	66	53 - 6
Swing time [% stride]	44	34	35 - 4
Stride time [msec]	2070	2230	753 - 12
Cadence [step/min]	56		98 - 14
	R-Fw	L-Fw	R-Fw
Double supp. time [msec]	190	220	- 114
Double supp. [% stride]	9	11	2 - 9

Distance Parameters	RT	LT	RT	LT
Anterior step length [mm]	474.74	466.20	469.27 - 679.23	410.30 - 725.83
Velocity [m/sec]	0.45	0.42	0.89 - 1.54	0.90 - 1.56
Swing velocity [m/sec]	1.01	1.26	2.26 - 3.71	1.94 - 3.83
Stride length [mm]	921.45	940.91	858.78 - 1513.51	912.39 - 1487.98
Step width [mm]	123.31		70.52 - 146.56	70.52 - 146.56
Mean velocity [m/sec]	0.43		0.91 - 1.54	0.91 - 1.54

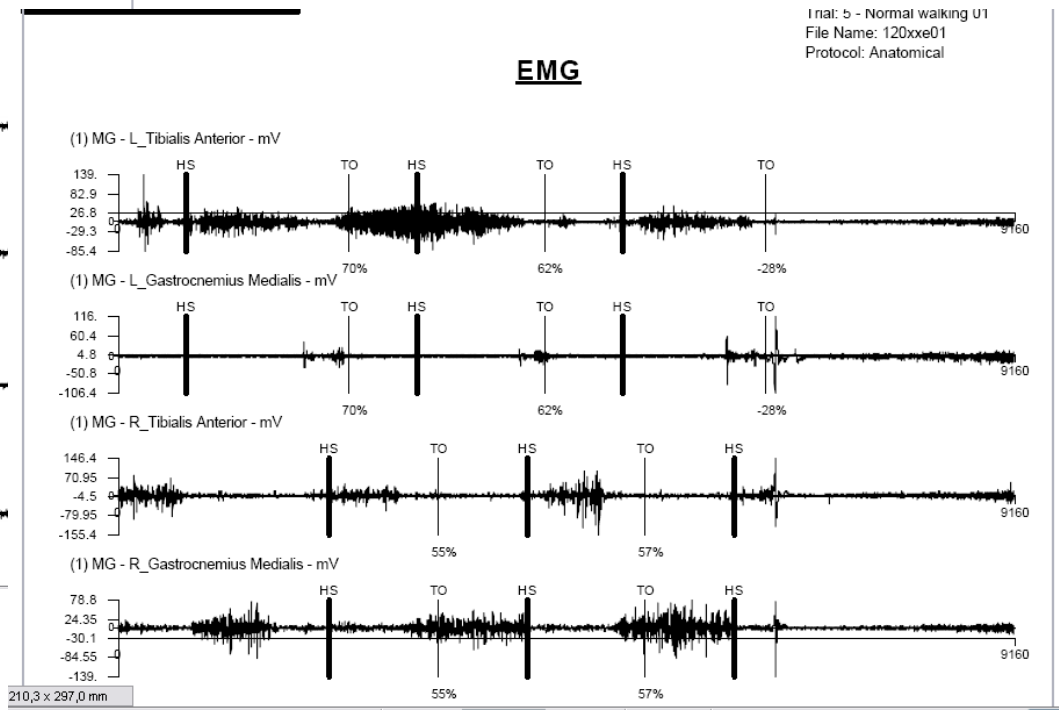
ARD Research LAB

EMG

Paraplegia incompleta



t0



t90

Cadenza

Paraplegia incompleta

Risultati

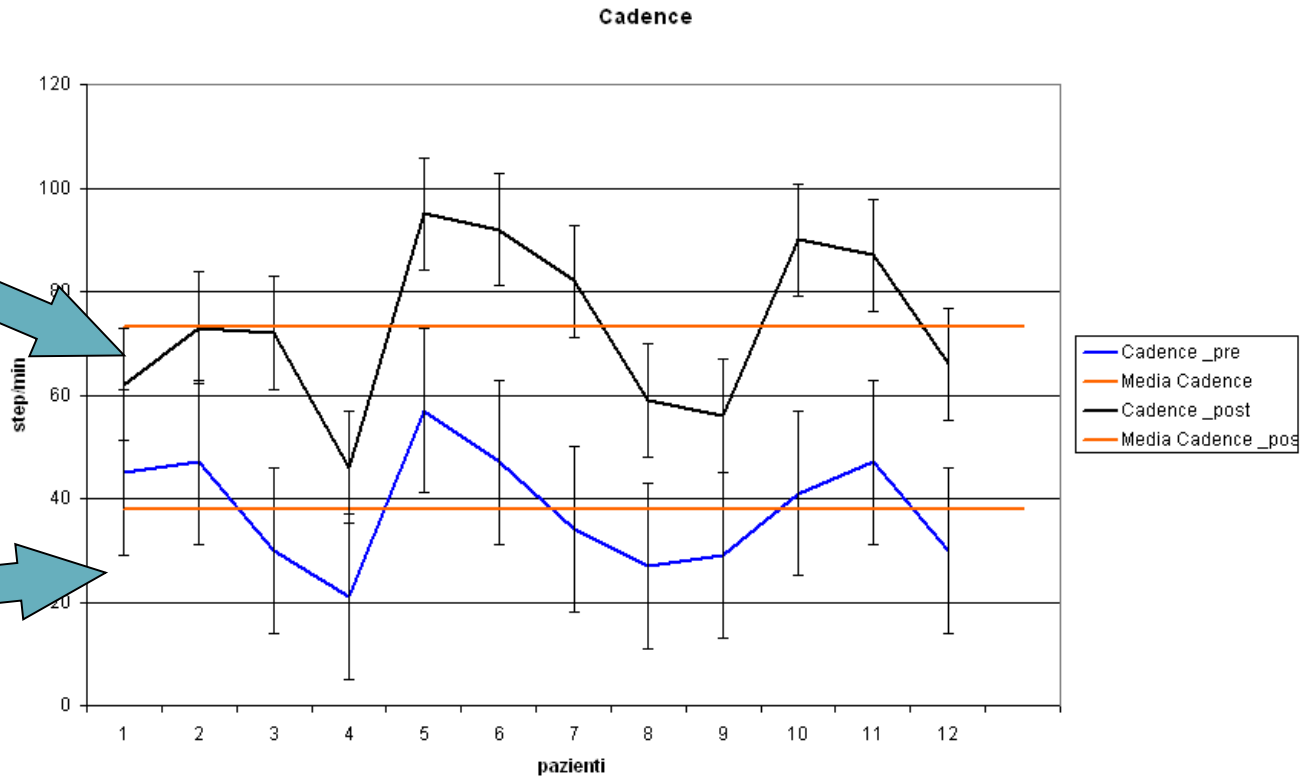
t90

t90 = 73.3

p <0.01

t0

t0 = 37.9



Velocità media

Paraplegia incompleta

Risultati

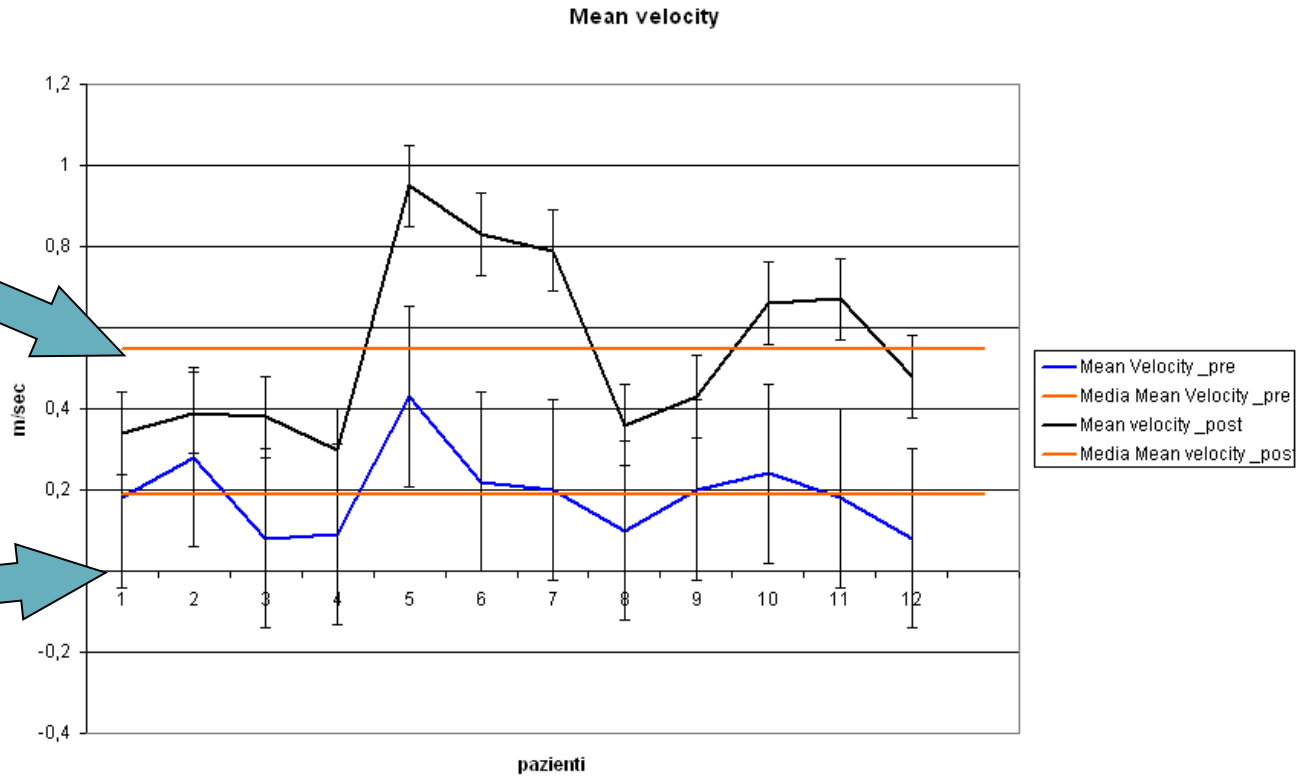
t90

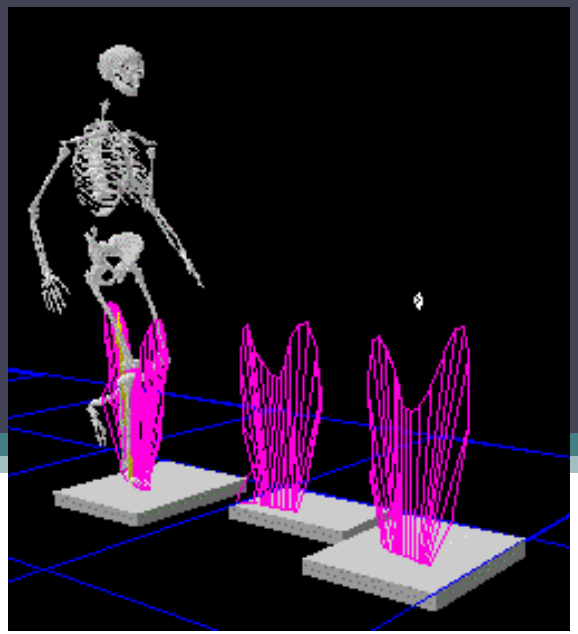
t90 = 0.55

p <0.02

t0

t0 = 0.19





Grazie

Andrea Di Candia
andrea_dicandia@yahoo.it

ARD Research LAB