TRAMA
TRAining in Motion Analysis

Falling Risk in Elderly

TRAMA PROJECT
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Full Partner
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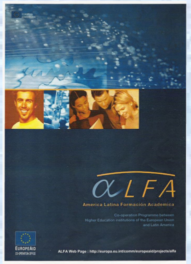

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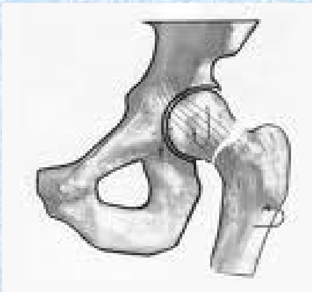
Thesis Index

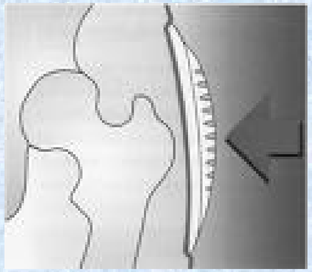
Normal ageing is associated with decreased ability to maintain postural stability when responding to some unexpected perturbations.

Fallings in elderly are a very serious medical, familiar and social problem, it is reported that more than 30% of the population from 60 years and older have suffered at least one fall per year.

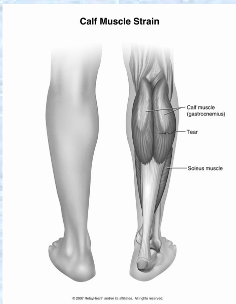
Falls represent one of the most serious and costly problems associated with elderly. Falls can mark the beginning of a decline in function and independence and are the leading cause of injury-related hospitalization in older people.

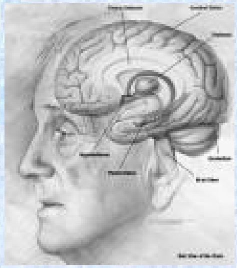
Hip fracture -long period of recovery





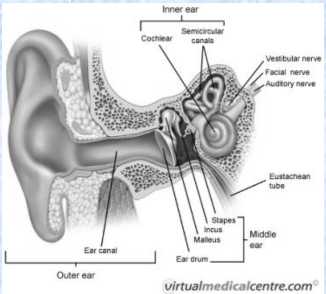
Postural Control and Balance in Human





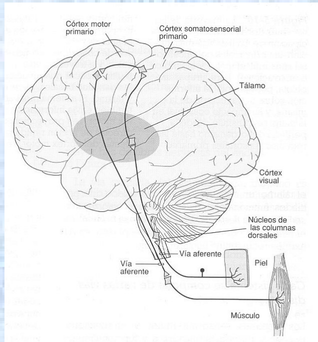
The postural control system receives information from receptors in the visual, vestibular and somatosensory systems.

Visual inputs are the primary back-ups when the somatosensory information becomes deficient.



reaction time

The vestibular system has both a sensory and a motor function:



Somatosensory inputs are the dominant sensory information for balance when the body is standing still on a fixed, firm surface

Common procedures for risk of falling evaluation

Observing and analysing the capacity of the subject to stand up from a chair. It is an important indicator of elderly functional independence.

Gait changes are common with increasing age, Spatiotemporal gait patterns has been analysed, specially time spent in double support phase, slower walking velocity(mainly slower first step length) and shorter step length as predictor of falls.

However decreased in Cognitive in elderly people is a serious disadvantage to folow instructions, shyness in our culture also represents a serious disadvantage to make movement analysis

The aim

To determine an objective indicator of falling risk in order to reduce the number of falls which result in serious injury in elderly people

Our hypothesis is based on a study of compensatory movements as the response to stimuli related with environmental changes to determine how far or close the regulation systems from stability are. The stimulus used was open-closed-open eyes action considering erect posture. Head was chosen for the study because of its lower integrated motion response compared with the center of mass.

Subjects

Eleven elderly subjects, four women and seven men (mean 71 years) and eight adult people(mean 35 years) for control were recruited from a group of volunteer patients who attended the invitation for research purposes. The tenets of the Declaration of Helsinki were observed, and the study gained approval from the CINVESTAV ethics committee. Informed consent was obtained by the volunteers after the nature of the study had been fully explained.

Methodology

The subject was asked to maintain an erected position with his eyes opened during 5 seconds. After that, he was given the order to close his eyes for fifteen seconds and finally he had to stay with his eyes opened in an standing position for five more seconds. The idea is to observe how the vestibular system but all over the visual system and stability at all recover the initial condition after a perturbating stimulus.

We registered the position of an infrared marker located at the head of the subject by means of the APAS system.

To perform the sway test, the subject was asked to stand on both feet on a baropodometric platform with eyes open and eyes closed to allow the study of visual and vestibular influences on sway parameters.
Anterior/Posterior and lateral/Lateral sway velocity of the center of pressure is given by the system

The subject was submitted to infrasound waves (1-10 Hz), while he was standing on both feet on a baropodometric platform with eyes open and eyes closed **to evaluate the sway parameters.**

Instrumentation

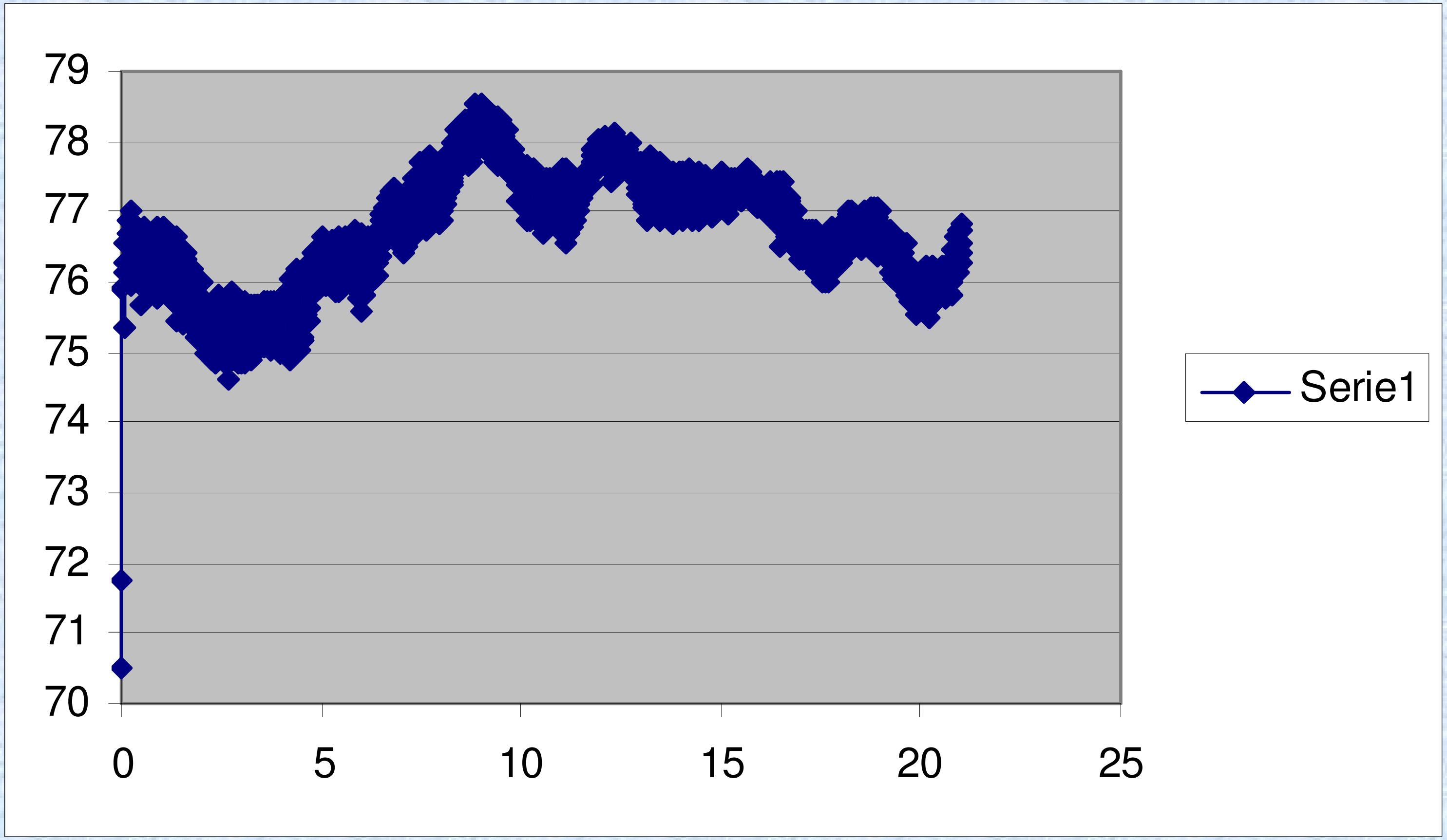
A digital optical system (Ariel Performance Analysis System, USA) was used for 3D measurements of head displacements. Sphere-shaped infrared reflexive markers (BTS Bioengineering, Italy), 15 mm diameter with a plastic extension were used. The system included four infrared cameras (Bristall, Mod. CAM817M, NTSC system, China), 3.6mm fixed focal length and IR radiation equipped. Volume for measurements was 2.7 m3 dimensioned as 1.8 m high, 0.82 m wide and 1.9 m long. Image capture and processing was performed by using the 4-channel 133 MHz Picolo Tetra card (Euresys Company, USA) and a generic PC implemented with a hard disk Sata type 160GB and 2GB in RAM, respectively. Configuration of the optical system included: 30 f/s frame ratio and five-order polynomial filtering at 0.4Hz 3dB cutoff frequency. Frame 44synchronization was done by the use of a lamp whose light temporally labeled the frames from all the cameras as a reference.

70 YEARS OLD SUBJECT

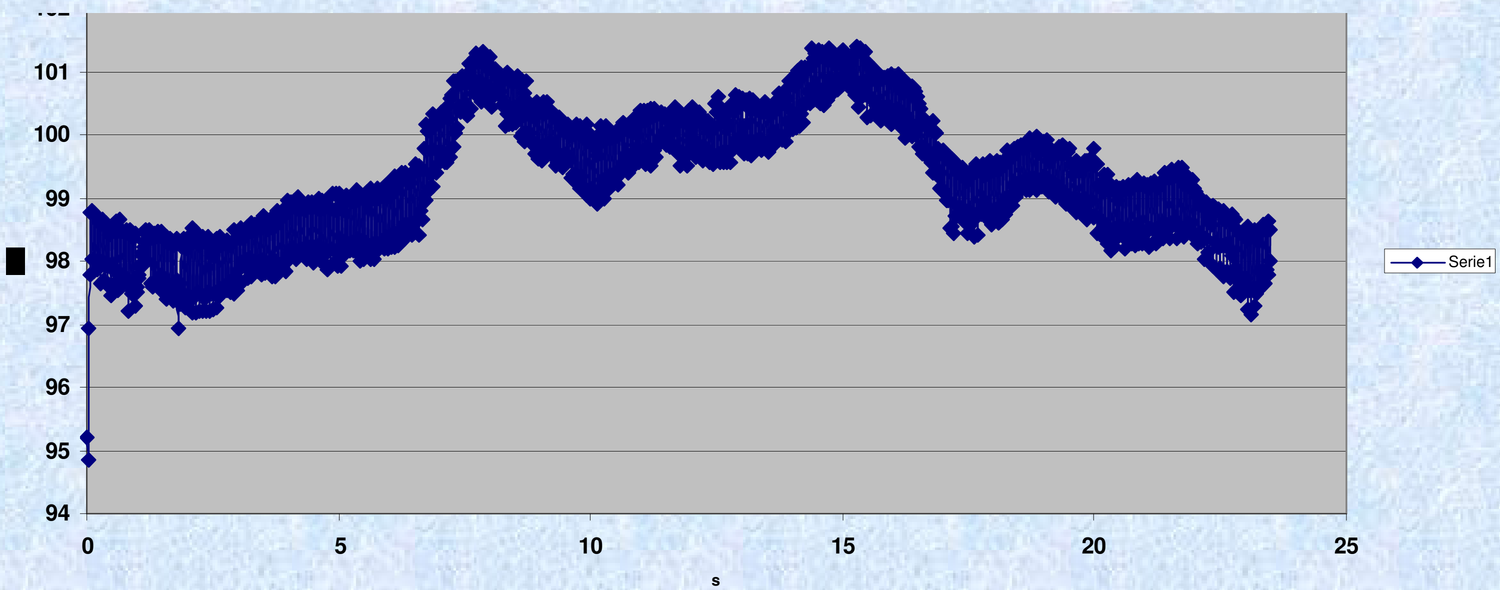
84 YEARS

MARKER DATA COLLECTED

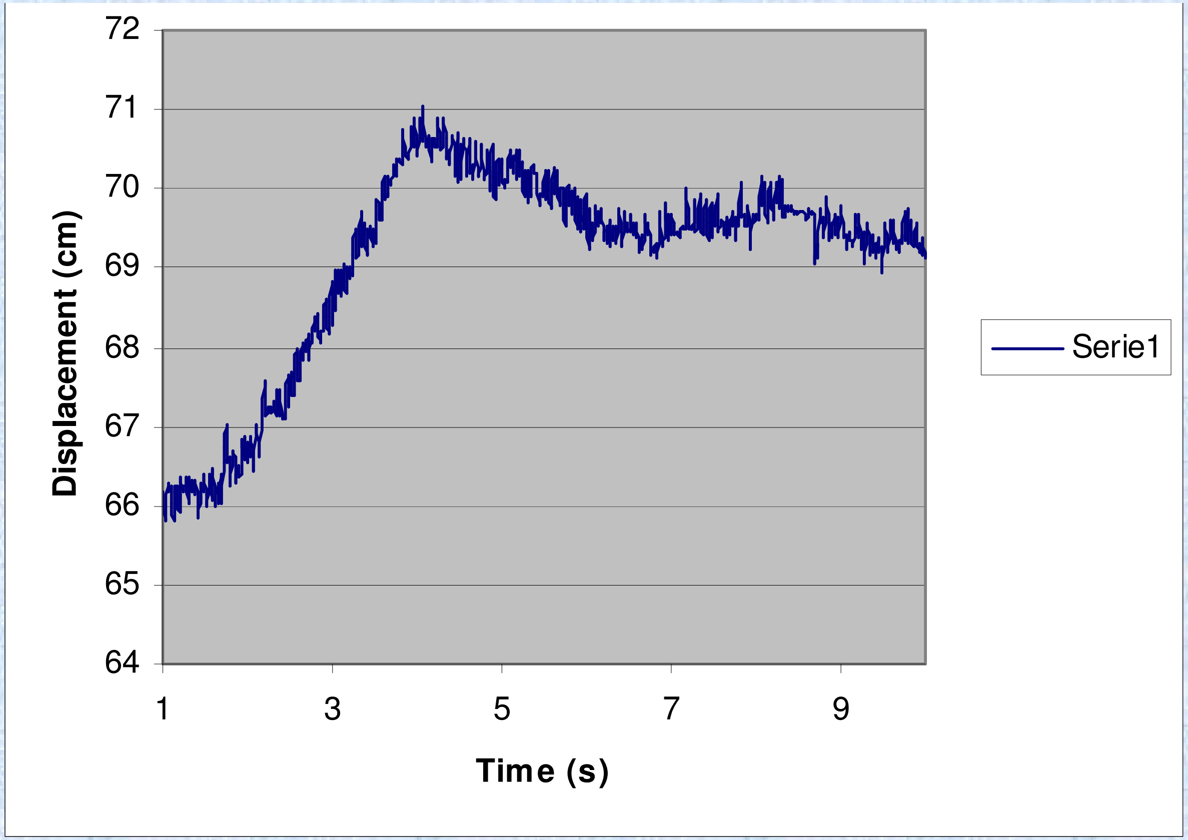
SUBJECT. 1



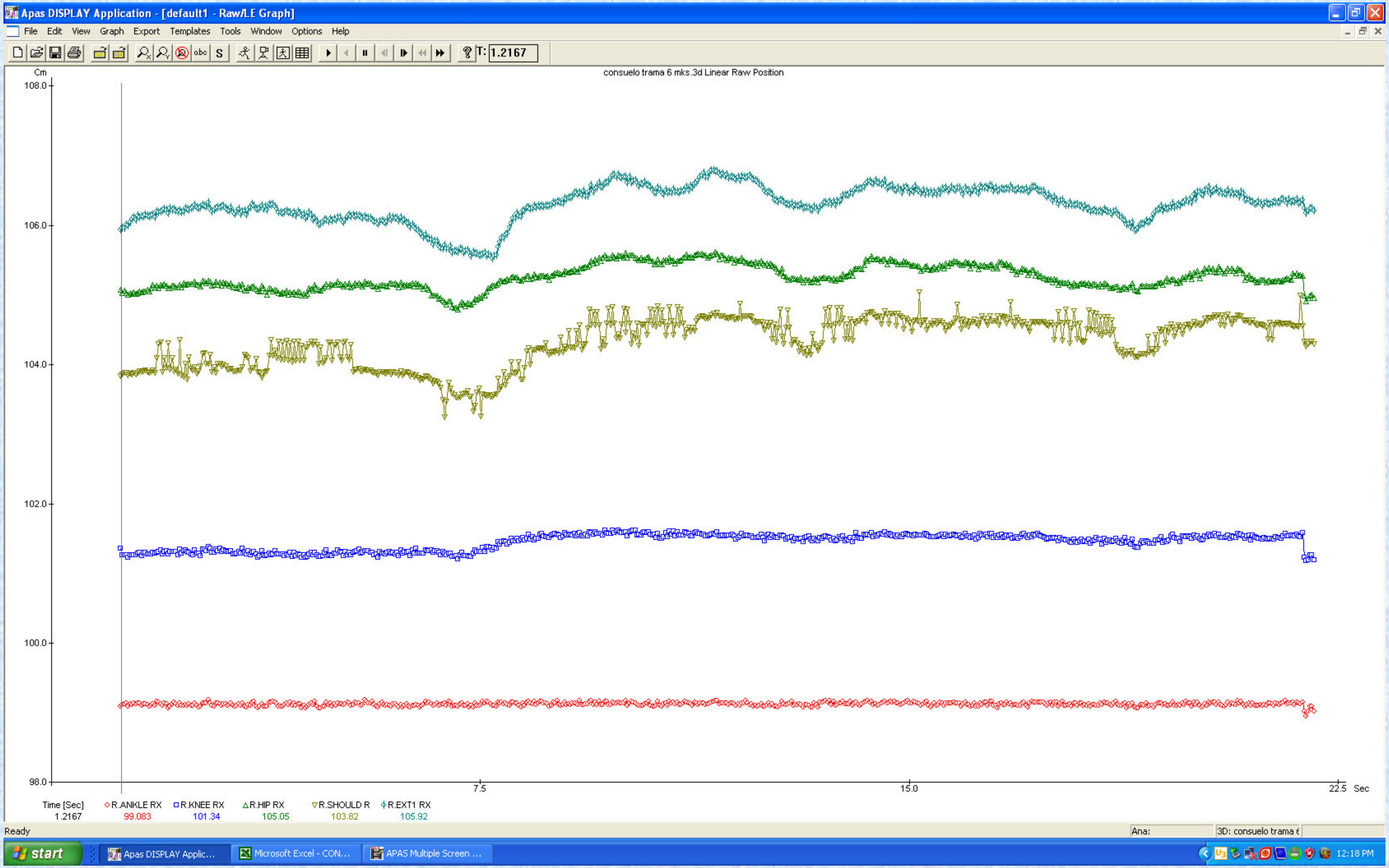
SUBJTECT.2



SUBJTECT.3

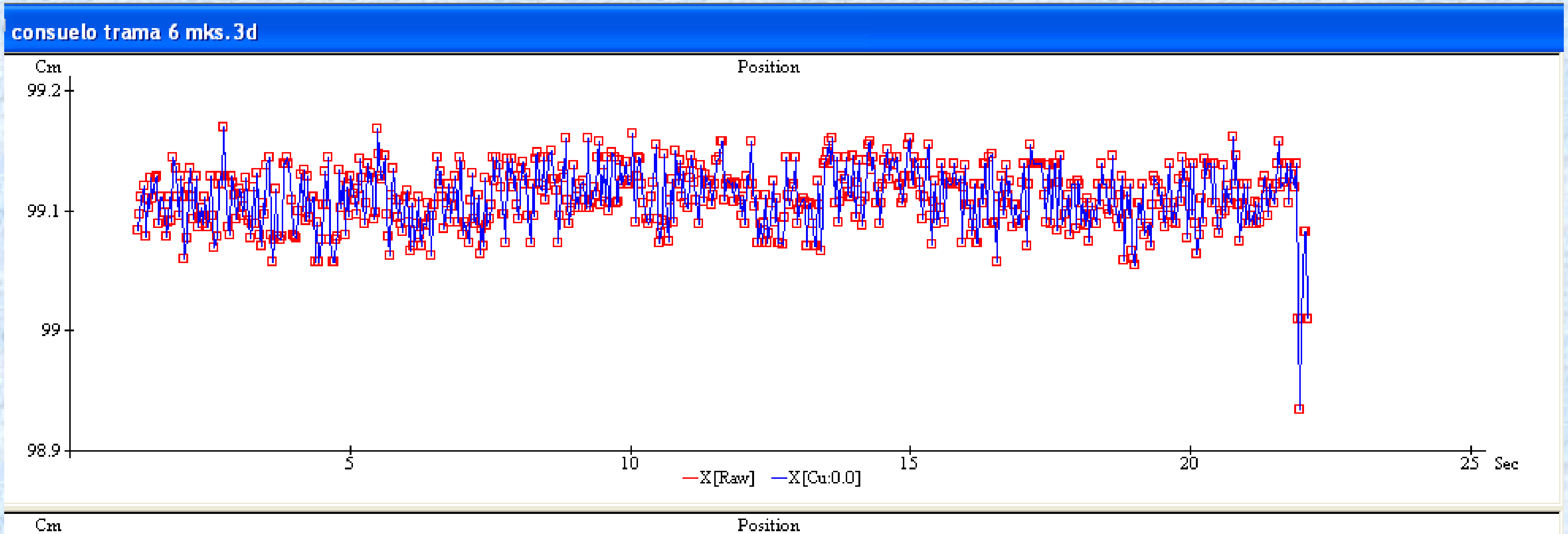


Subject 4, ankle, knee, hip, shoulder and head raw data marker

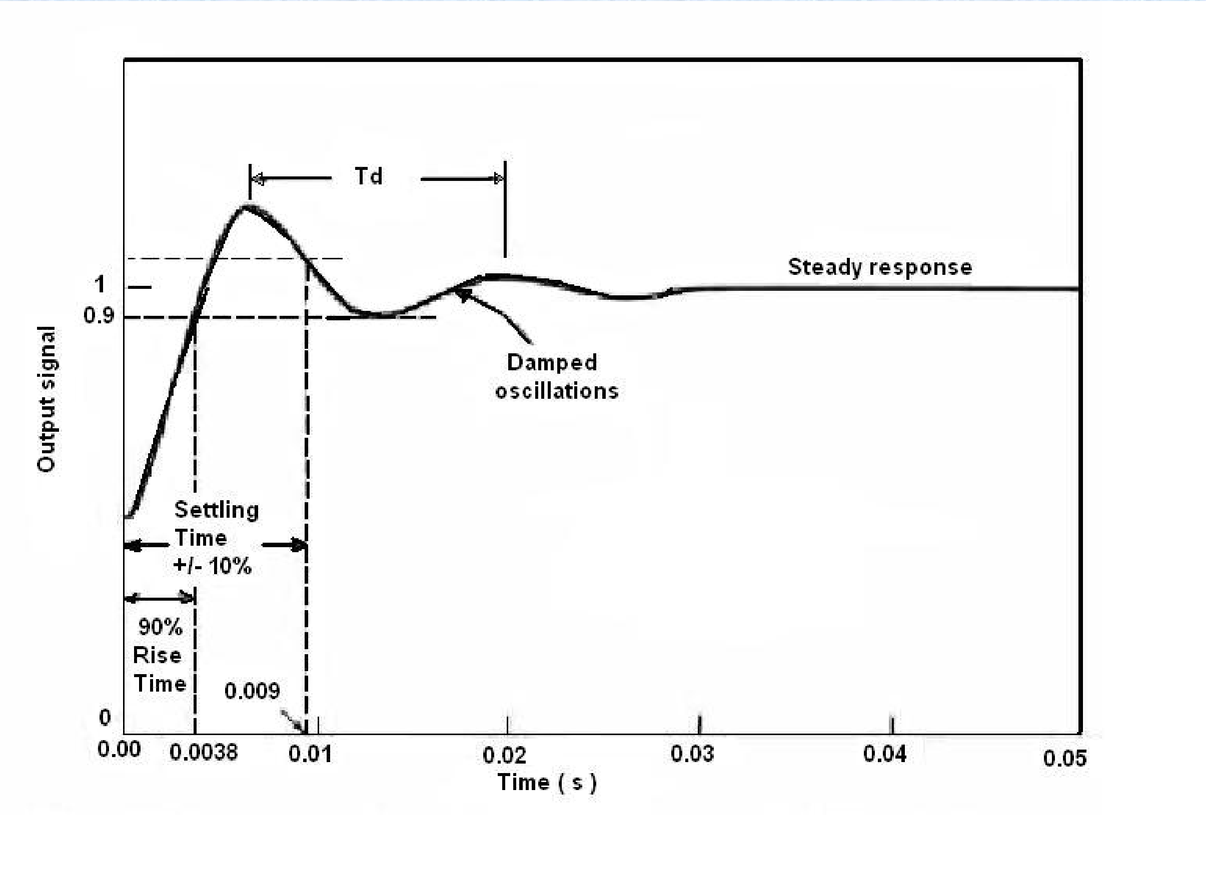


Subject 4 Ankle

Very poor significant changes in ankle raw data



Typical answer of a Second order control function



Second order system

$$\frac{d^2y}{dx^2} + 2\zeta\omega_n\frac{dy}{dx} + 2\omega_n^2 y = 2\omega_n^2 x$$

$$Y(s) = \left[\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}\right] X(s)$$

Poles $\quad s = -\zeta\omega_n \pm j\,\omega_n\sqrt{1-\zeta^2}$

Let $\dfrac{1}{\alpha} = \dfrac{1}{\zeta\omega_n}$ = time constant... &... $\omega_d = \omega_n\sqrt{1-\zeta^2}$

Then $\quad s = -\alpha \pm j\,\omega_d$

Second order system

where ω_n is the natural frequency and ζ (zeta) is the damping ratio.

$\omega_n = \sqrt{\frac{k}{m}}$ = natural frequency of the system

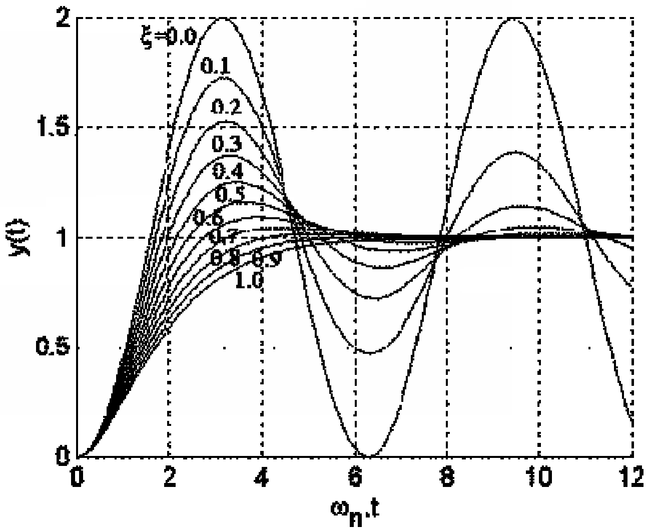
$\zeta = \frac{c}{2\sqrt{km}}$ = damping ratio of the system

Second order system

Depending on the value of ζ, three forms of the homogeneous solution are possible:

$0 < \zeta < 1$ (under damped system solution)

$\zeta = 1$ (critically damped system solution)



$\zeta > 1$ (over damped system solution)

For underdamped systems, the output oscillates at the frequency ω_d

$$T_d = \frac{2\pi}{\omega_d} = \frac{1}{f_d}$$

$$\omega_d = \omega_n \sqrt{1 - \zeta^2}$$

Remember $f = \omega/2\pi$

Results on movement analysis

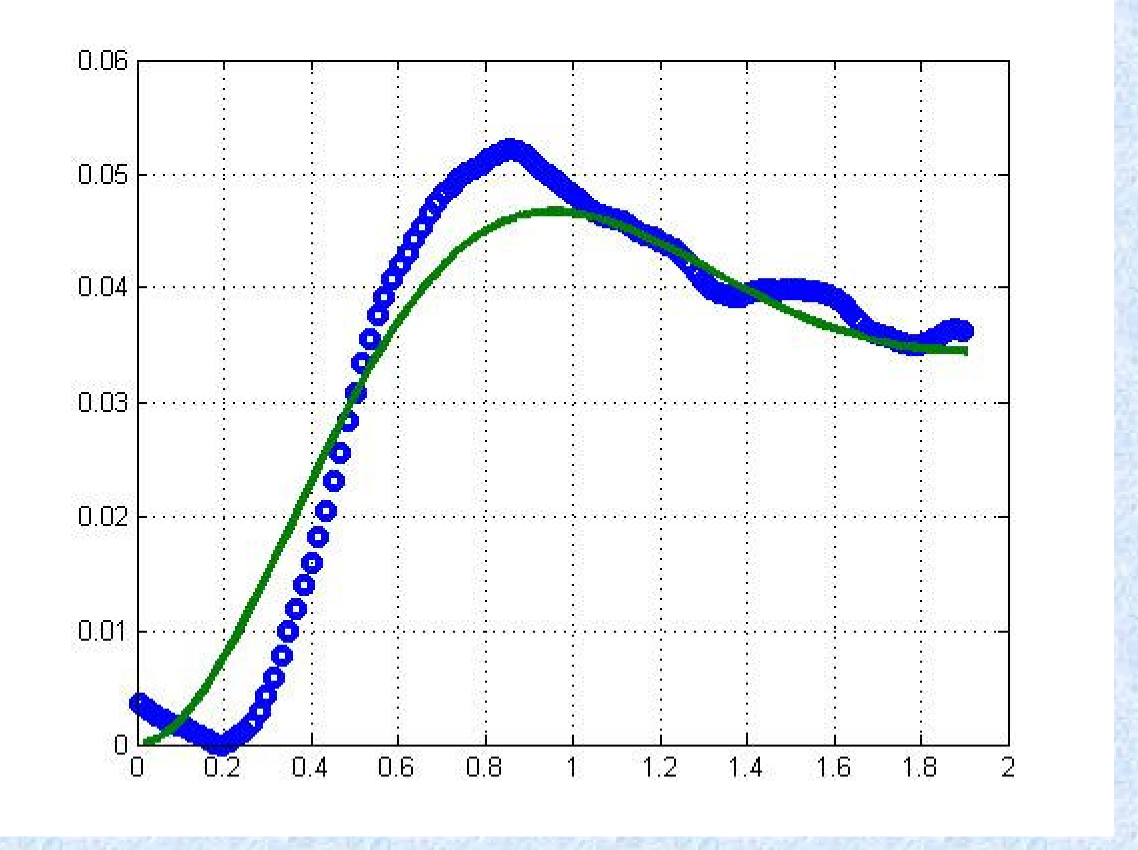
Mathematical procedures

A 60 Hz low-pass filter was employed to smooth the aquisition rercordings
A working space in the aquisition rercordings was defined in order to normalize all the data.

Second order polinomial functions were generated
Iterative processes as Identification algorithm were developed, this measures the degree of association between two variables

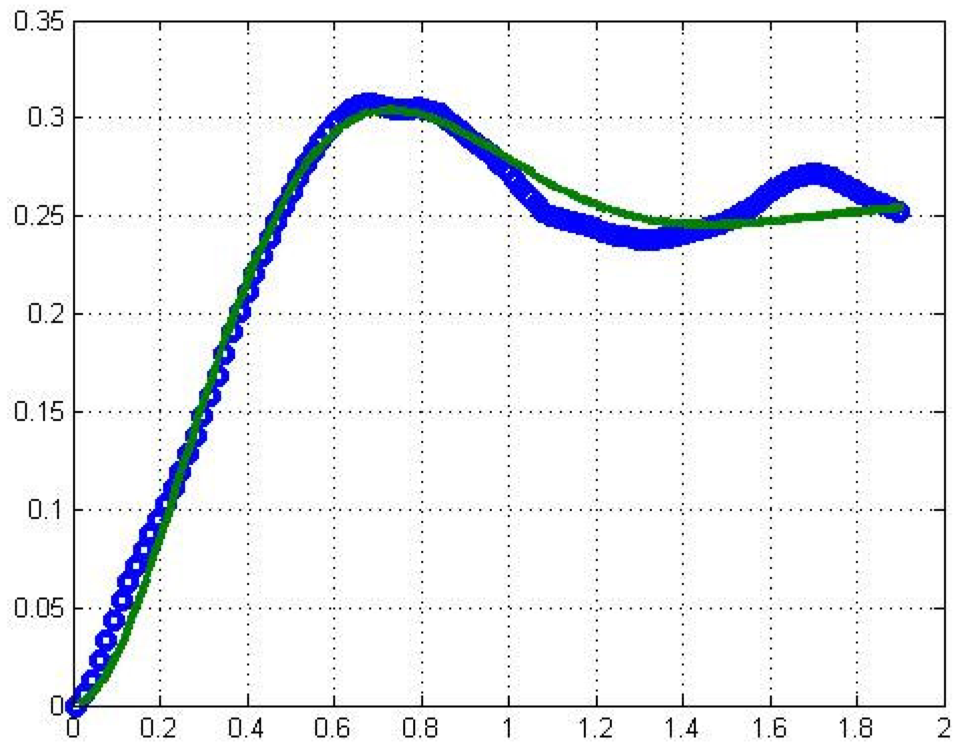
Subject 4 knee

Working space :6.4 s – 8.3s



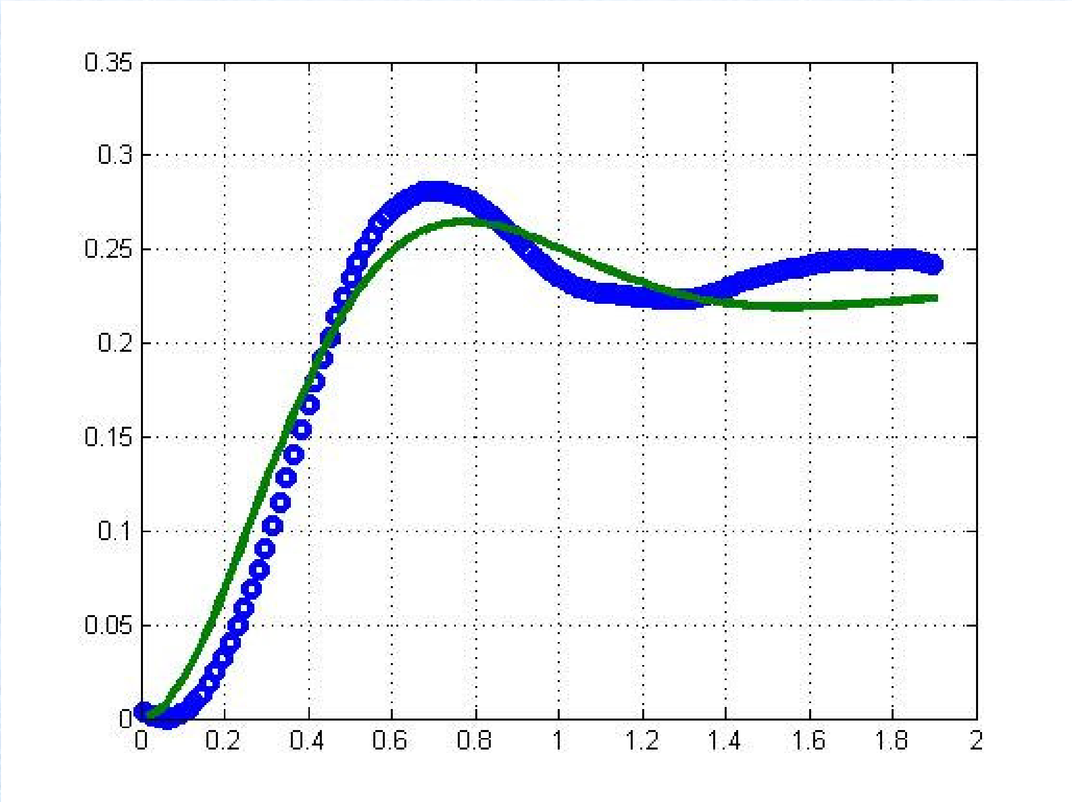
Subject 4 Hip

Working space :6.4 s – 8.3s



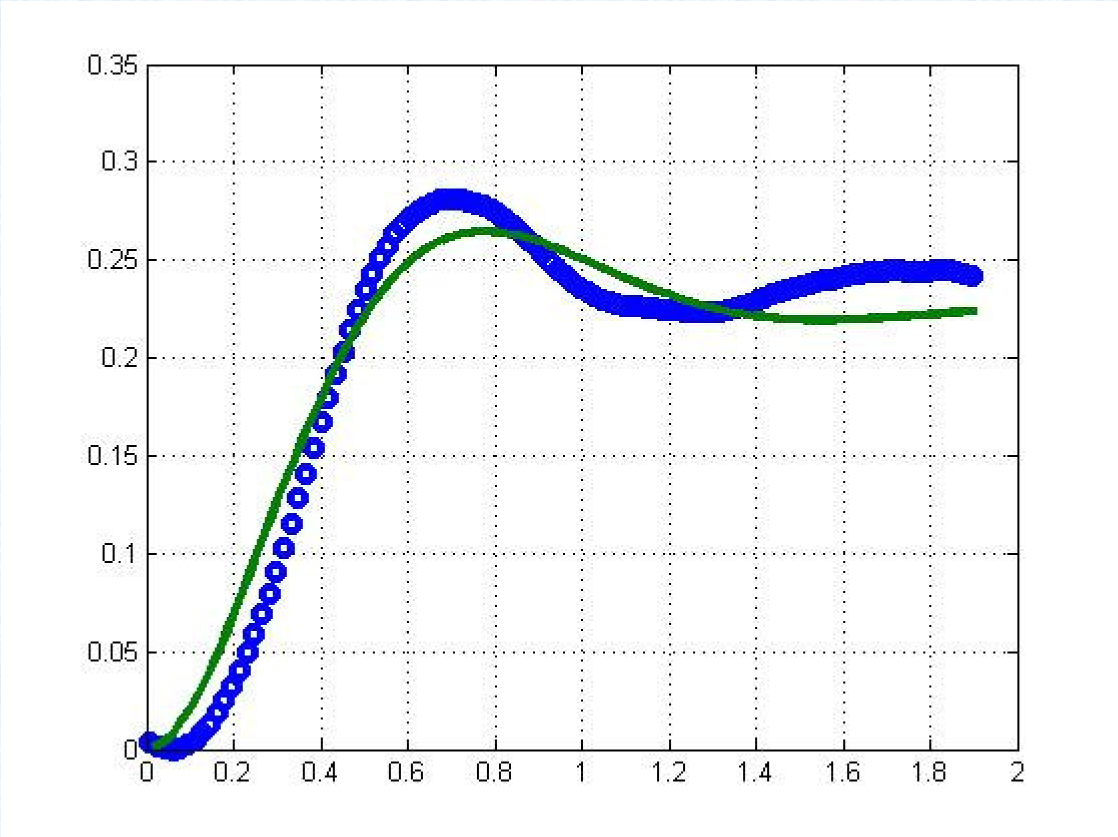
Subject 4 Shoulder

Working space :6.4 s – 8.3s

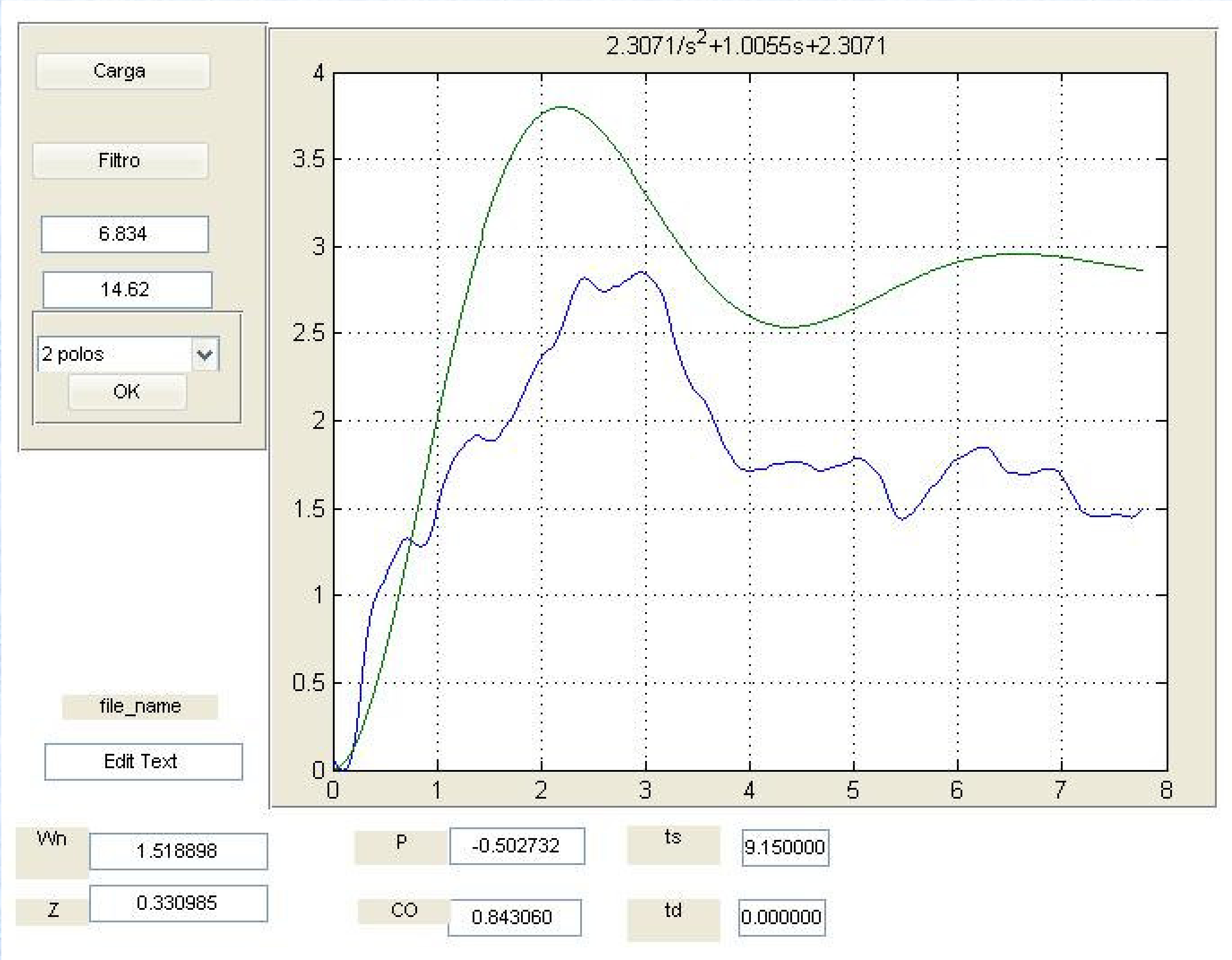


Subject 4 Head

Working space :6.2 s – 8.1s

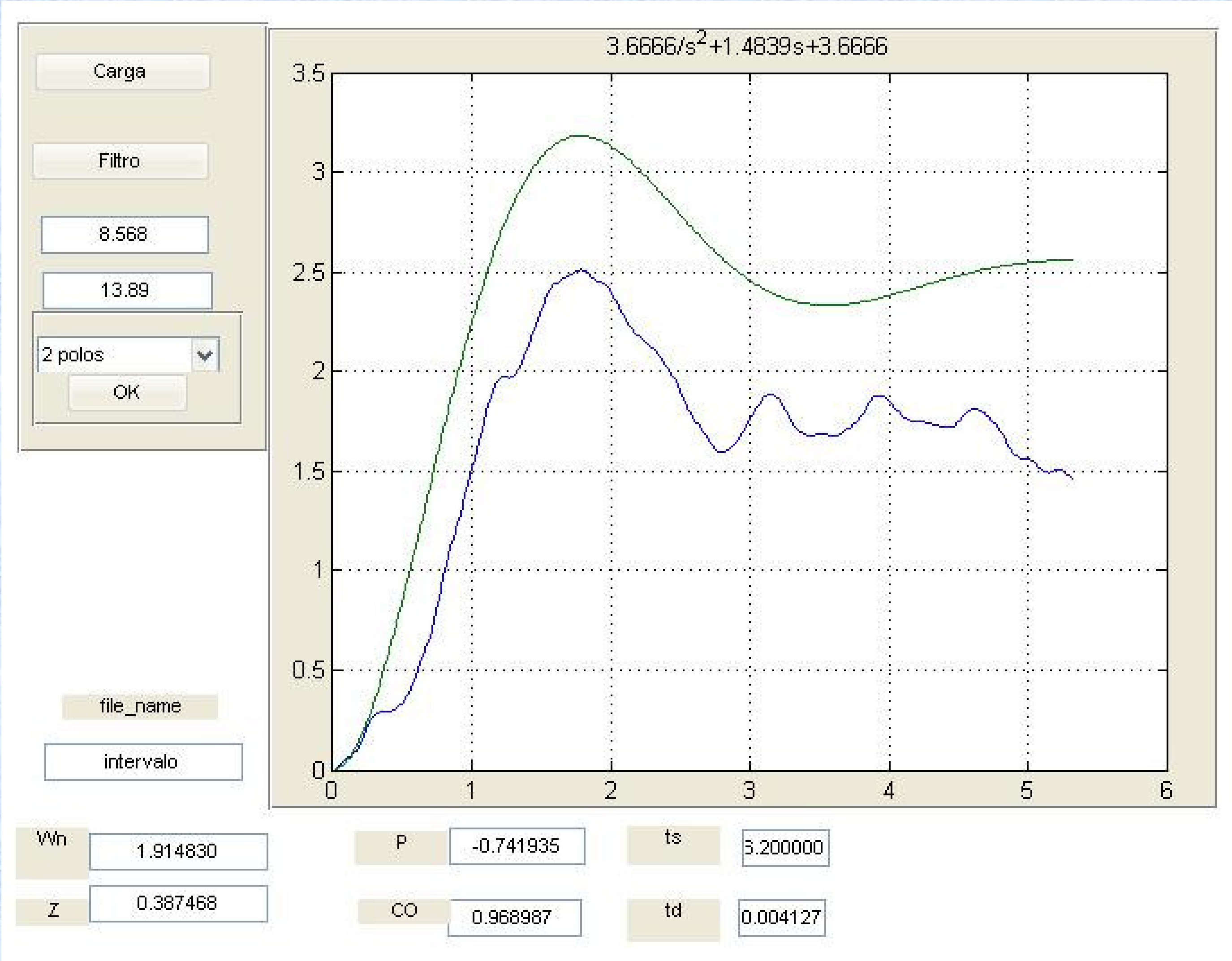


Subject 1



Carga
Filtro
6.834
14.62
2 polos
OK
2.3071/s2+1.0055s+2.3071
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
file_name
Edit Text
Wn
1.518898
Z
0.330985
P
-0.502732
CO
0.843060
ts
9.150000
td
0.000000

Subject 2



Carga
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8.568
13.89
2 polos
OK
file_name
intervalo
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3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Wn
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CO
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ts
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td
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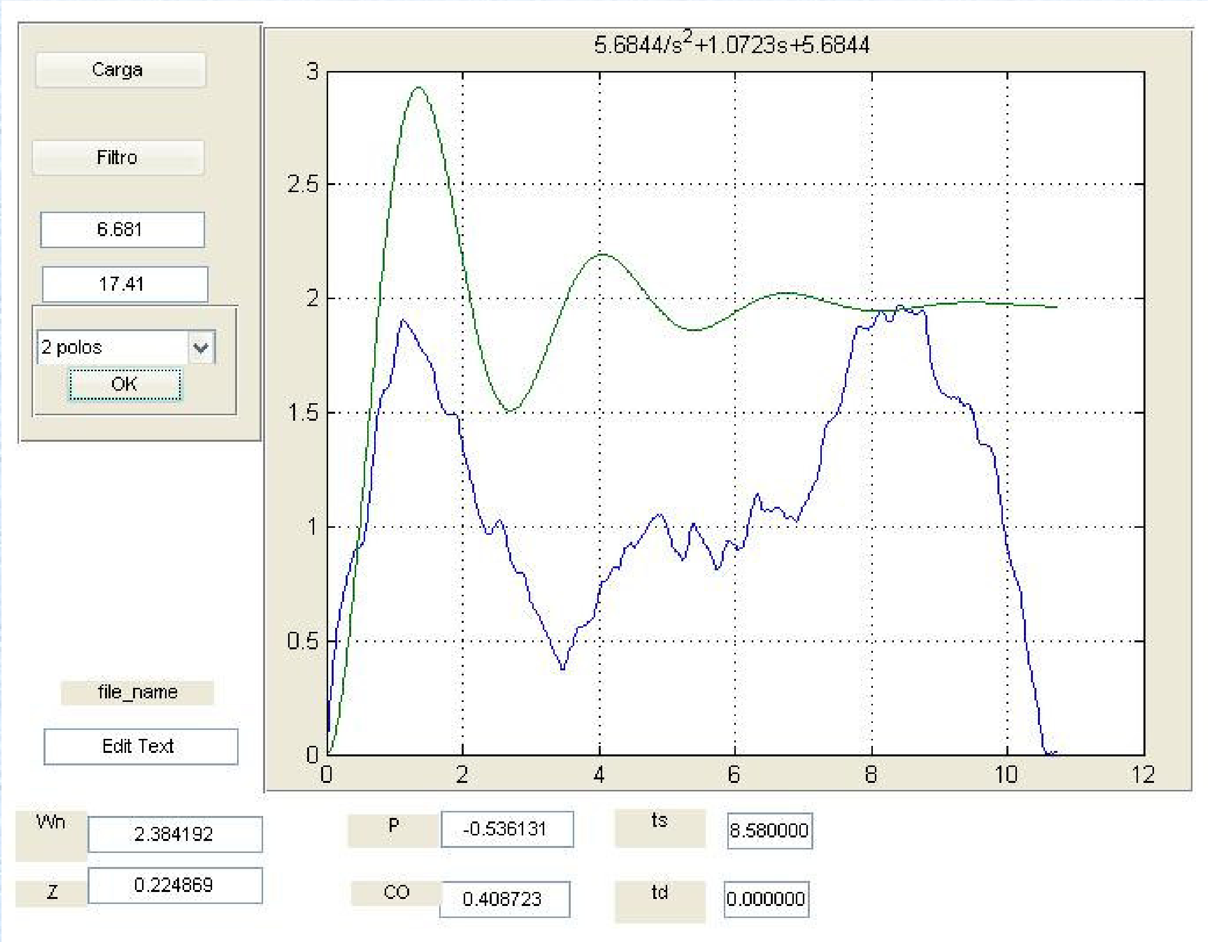
Subject 3



Carga
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17.41
2 polos
OK
file_name
Edit Text
5.6844/s^2+1.0723s+5.6844
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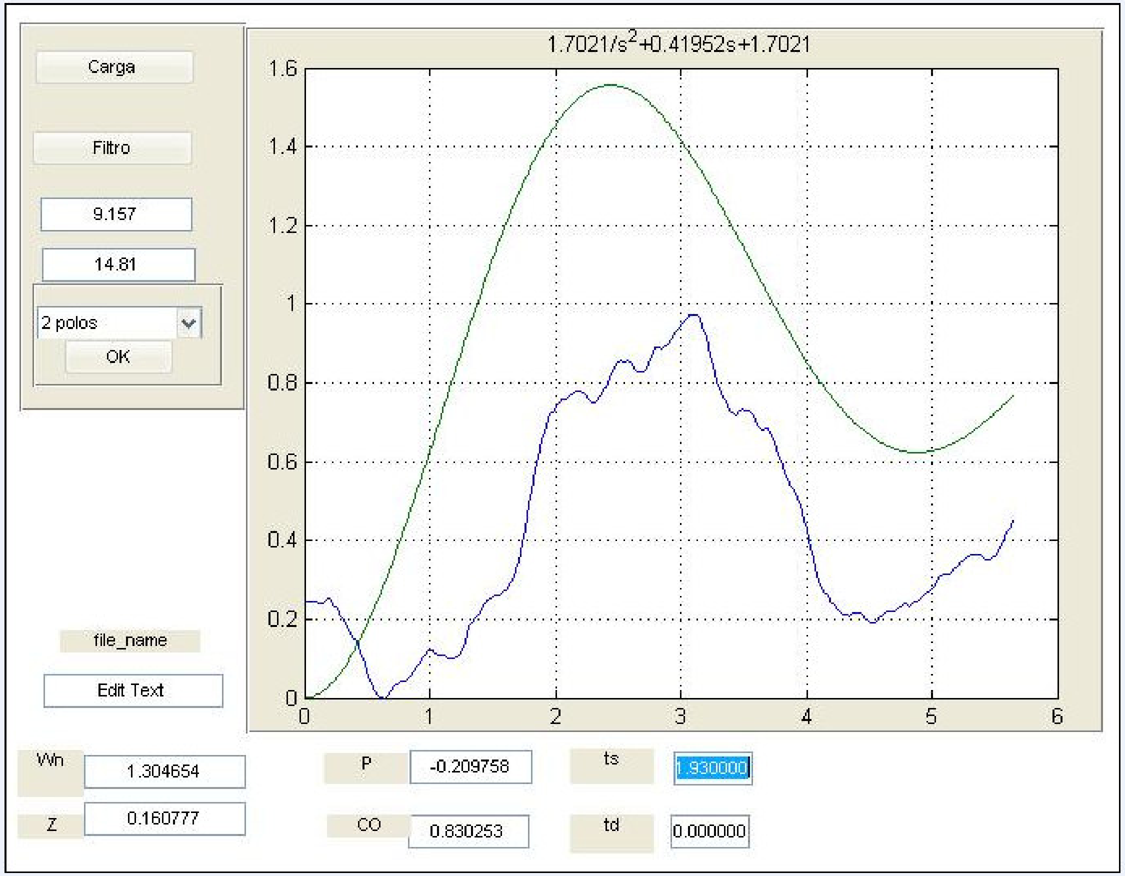
ts
8.580000
td
0.000000

Subject 4



Carga
Filtro
9.157
14.81
2 polos
OK
file_name
Edit Text
1.7021/s^2+0.41952s+1.7021
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
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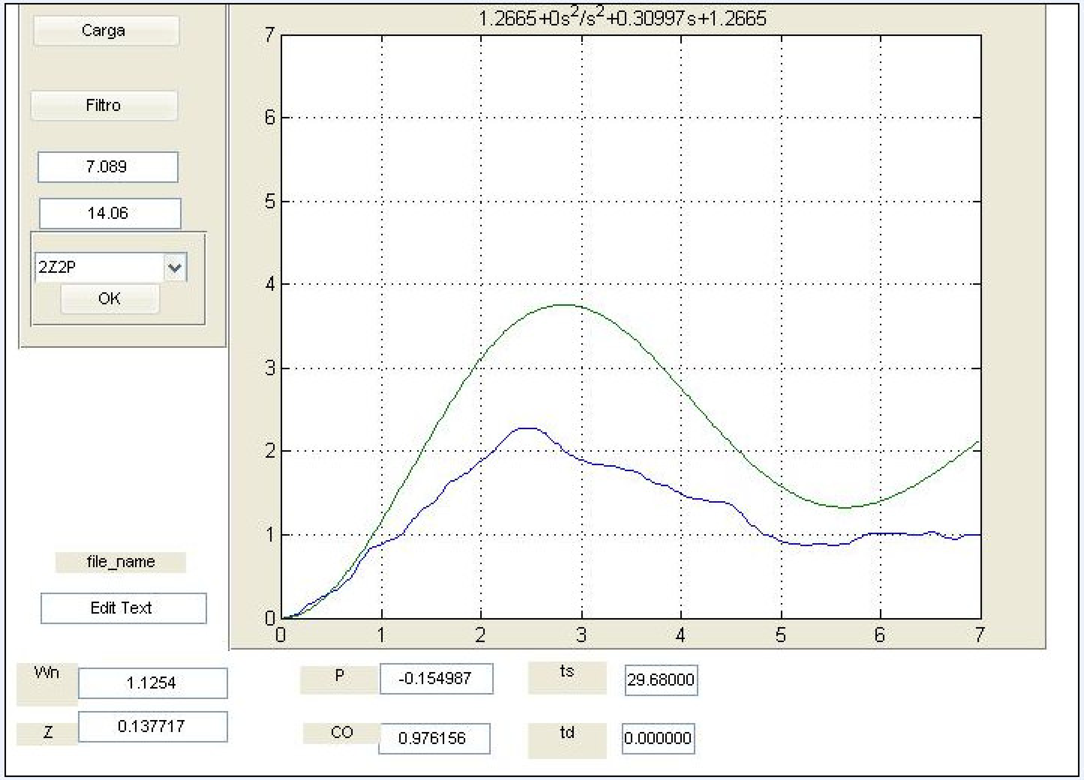
td
0.000000

Subject 5



Carga
Filtro
7.089
14.06
2Z2P
OK
file_name
Edit Text
1.2665+0s^2/s^2+0.30997s+1.2665
Wn
1.1254
Z
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P
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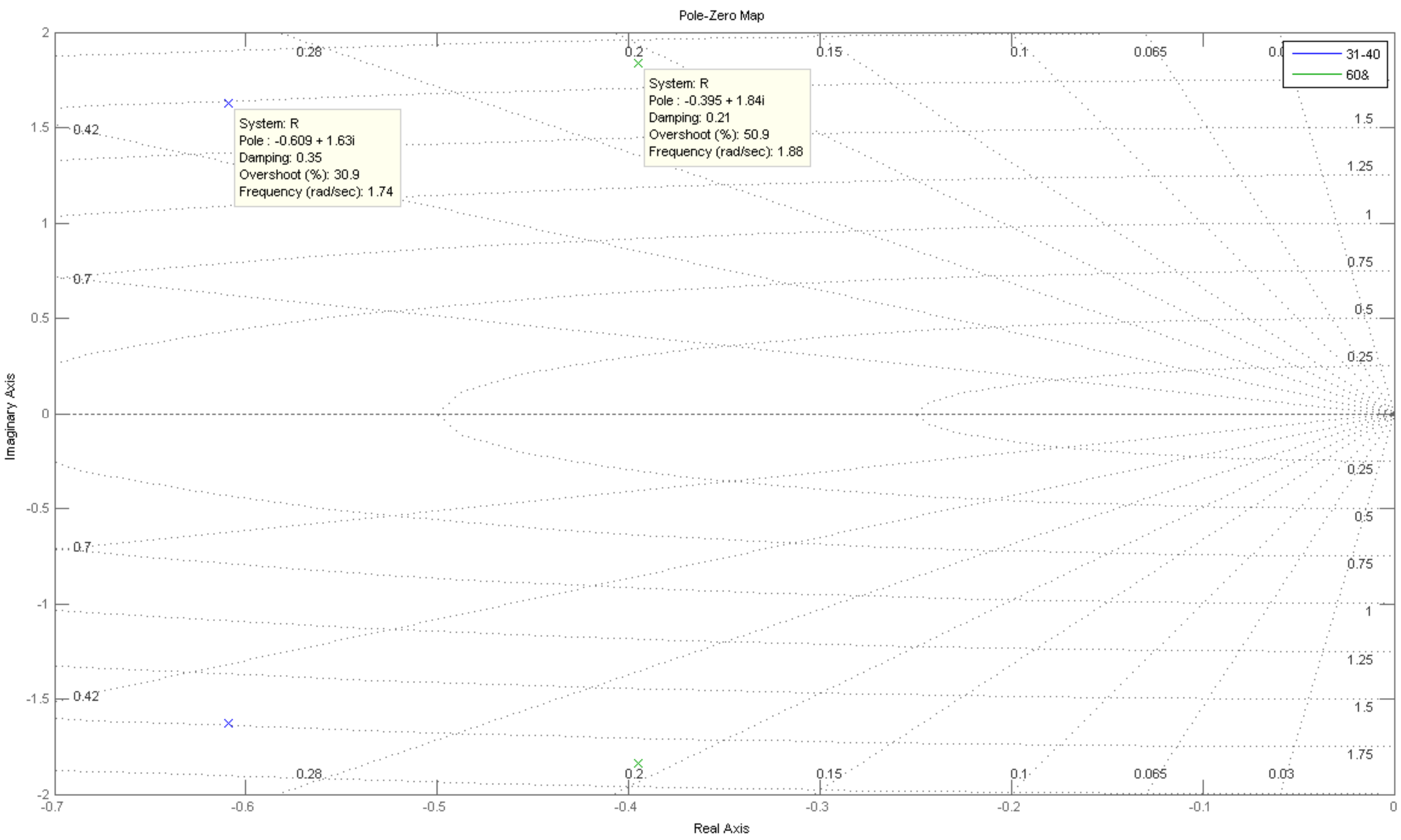
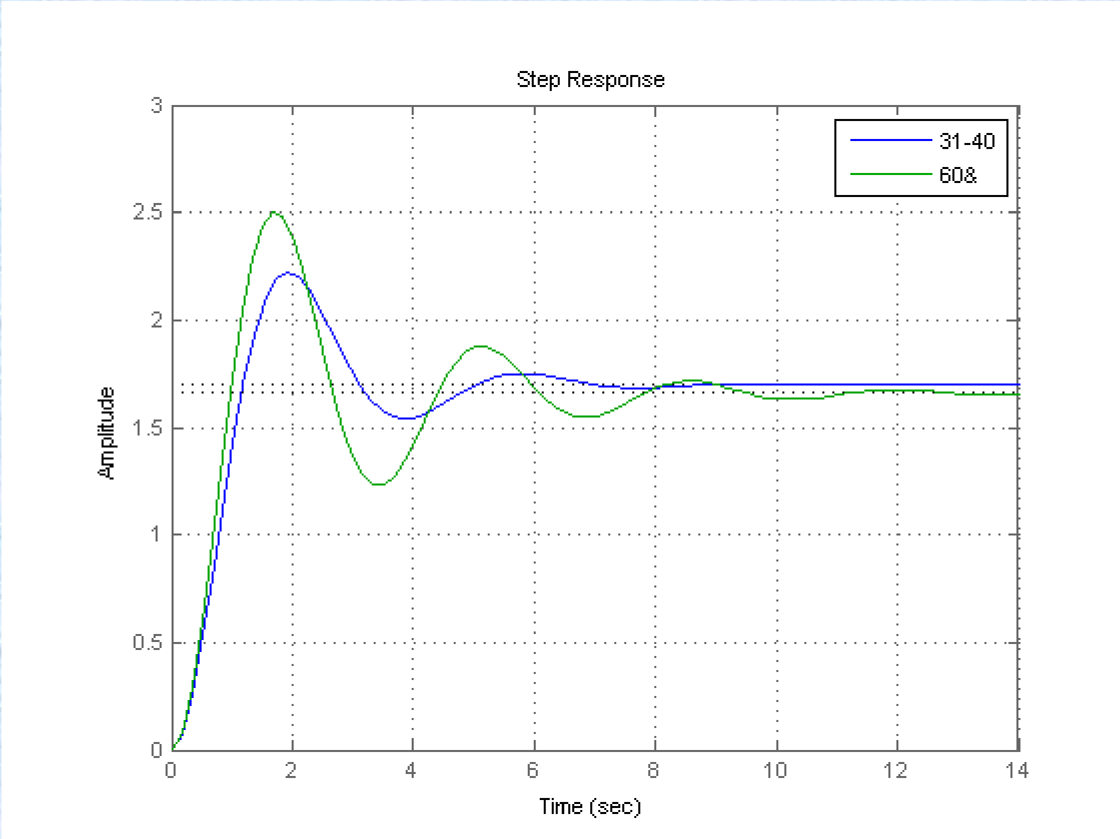
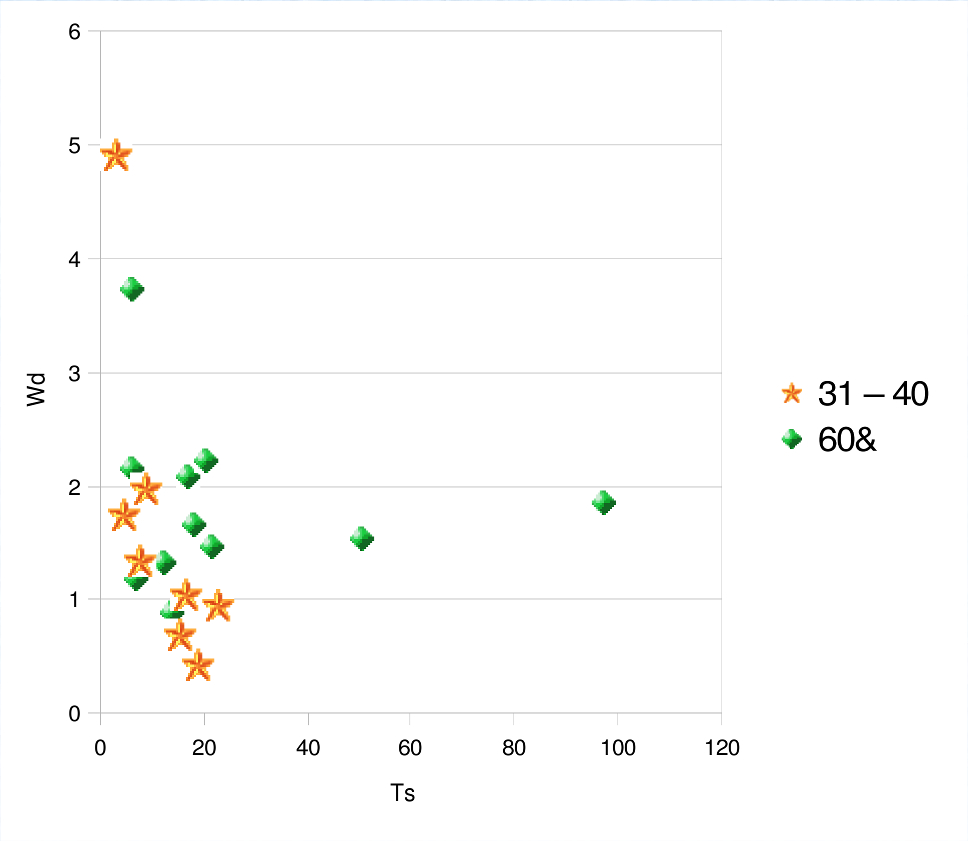
CO
0.976156
ts
29.68000
td
0.000000

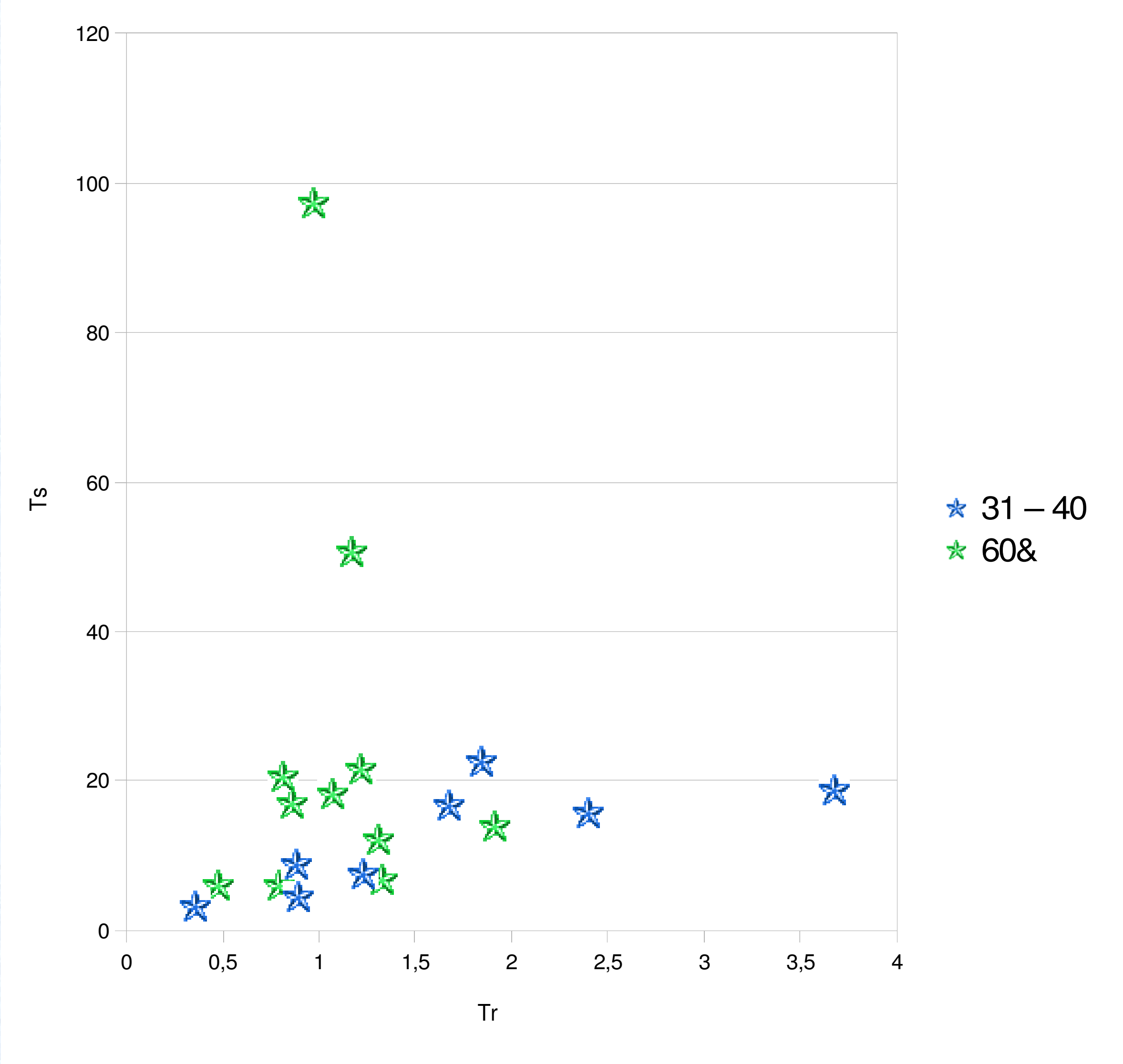
Stability criterium based on pole zero map





Step Response
31-40
60&
Amplitude
Time (sec)
0
0.5
1
1.5
2
2.5
3
0
2
4
6
8
10
12
14


6
5
4
3
2
1
0
Wd
0
20
40
60
80
100
120
Ts
31 – 40
60&



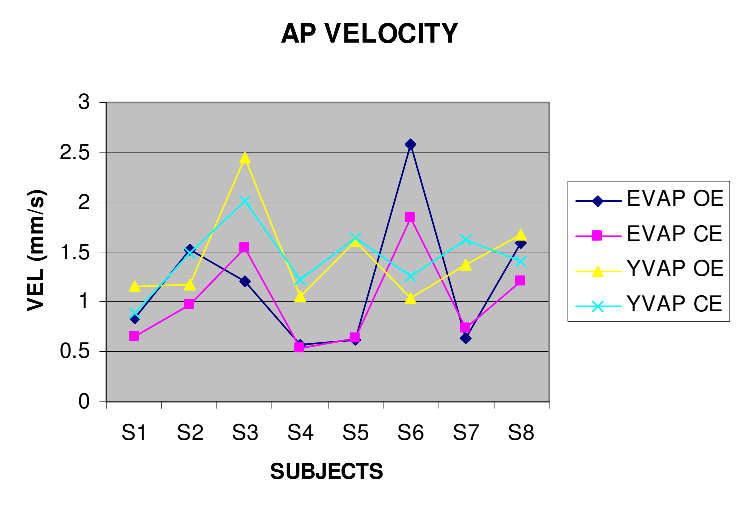
120
100
80
60
40
20
0
Ts
0
0,5
1
1,5
2
2,5
3
3,5
4
Tr
31 – 40
60&

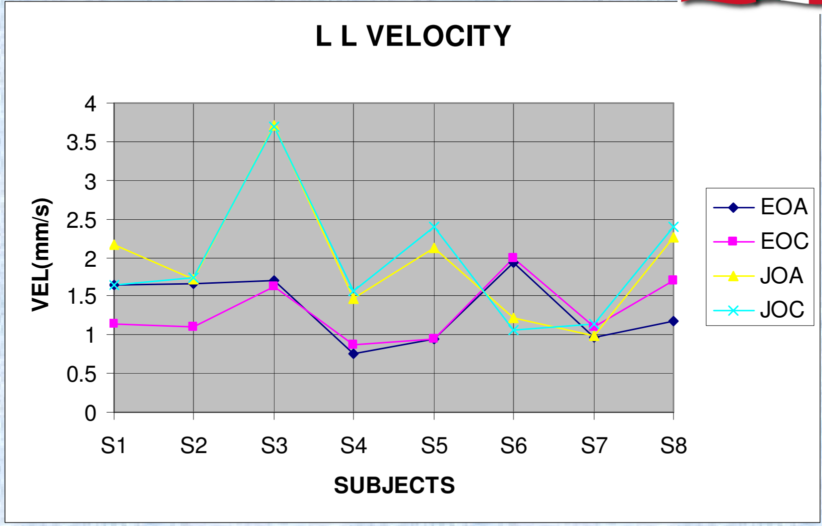
ELECTRONIC BAROPODOMETER

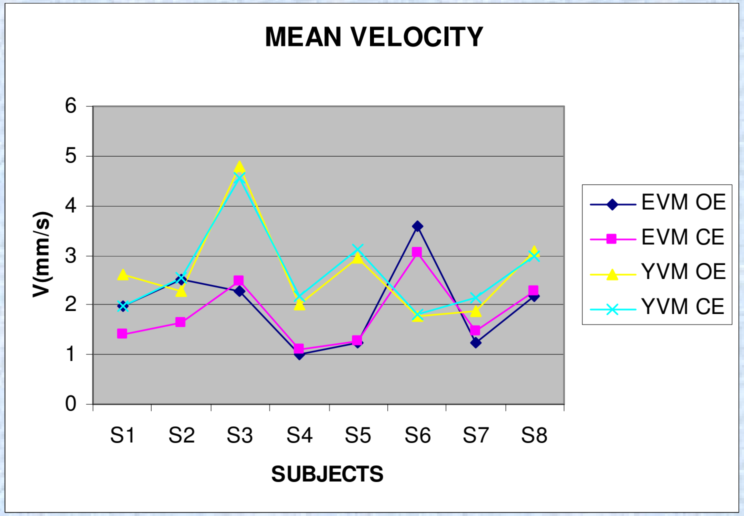
Sway Test, performed with eyes open and eyes closed while standing on both feet to allow the study of visual and vestibular influences. Anterior/Posterior and lateral/Lateral sway velocity of the center of pressure is given by the system

TRAMA TRAining in Motion Analysis

SWAY DATA COLLECTED

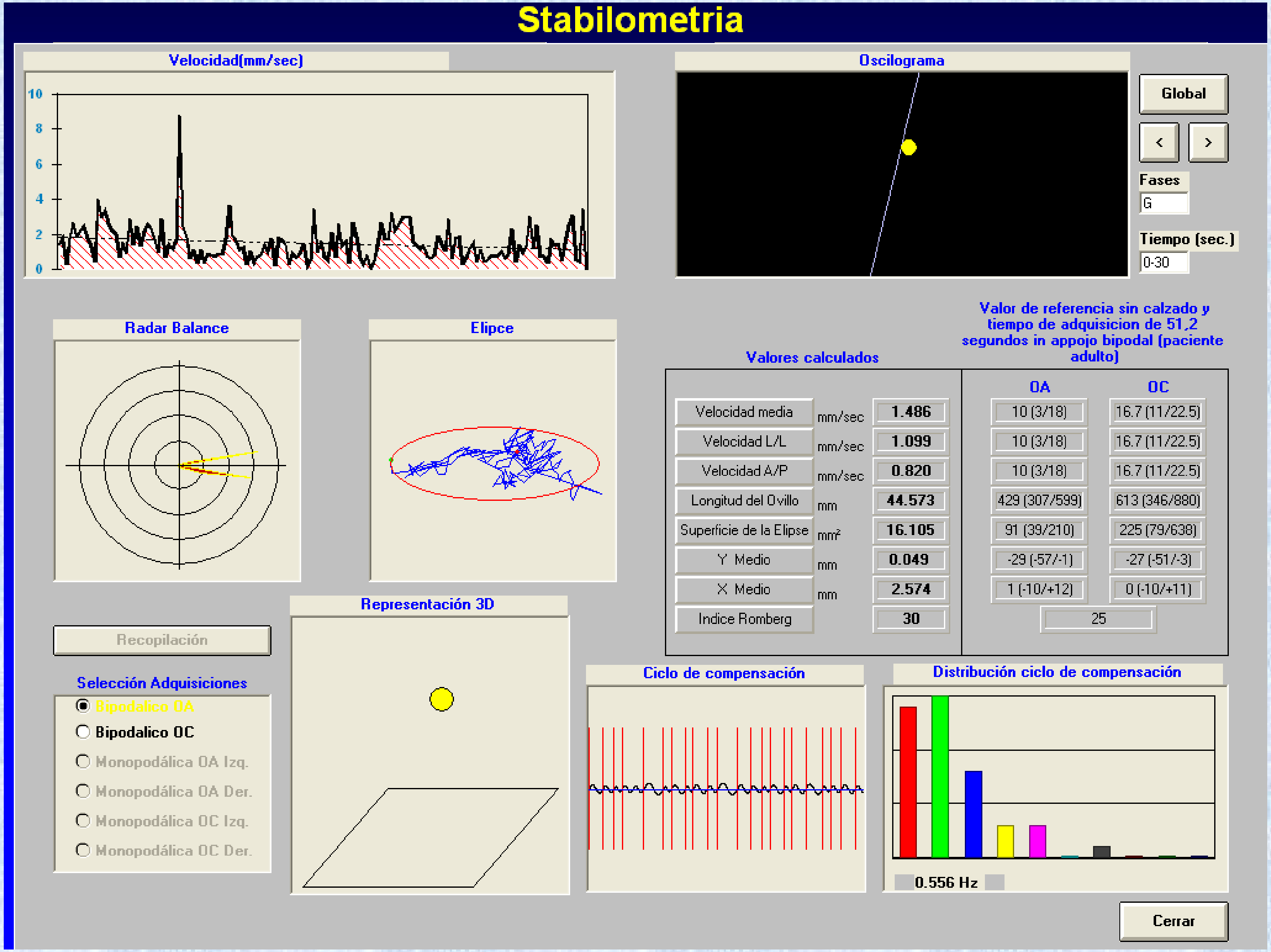




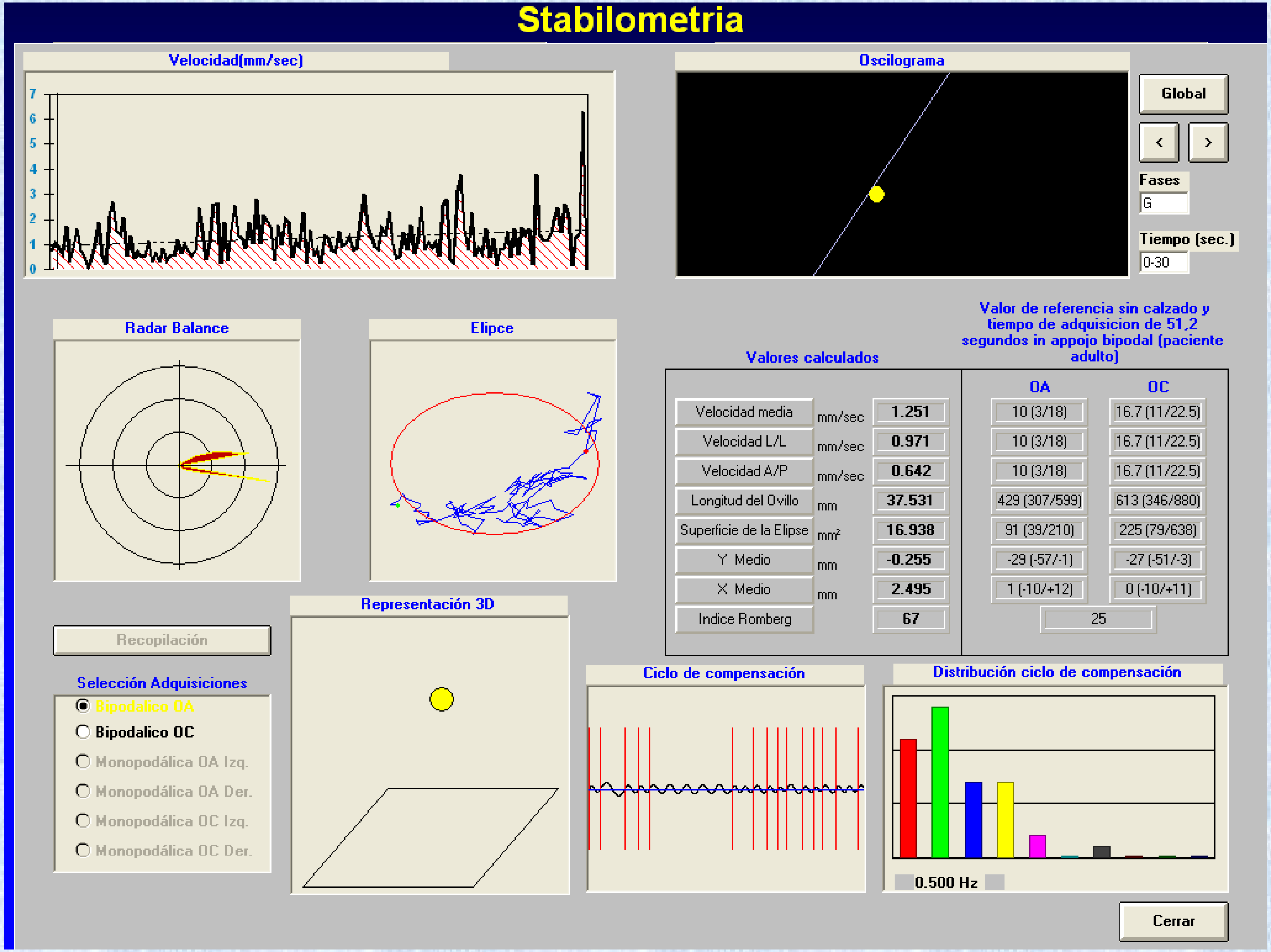


Infrasound stimulus - Somatosensory induced sway

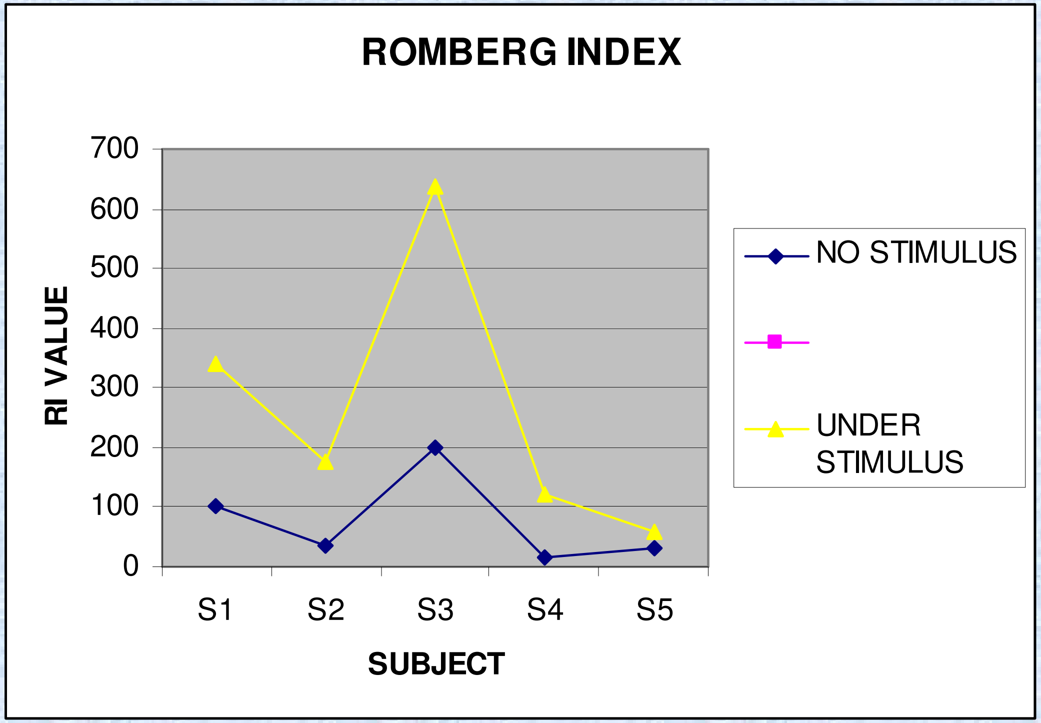
Subject without Stimulous



DAC 58 YEARS UNDER ST.



INFRASOUND STIMULI DATA COLLECTED



Staff in our Motion Lab. Analysis

Chief

Dr. Pablo Rogelio Hernández Rodríguez

Technical Responsable

Ing. Eladio Cardiel Pérez

Influence of TRAMA PROJECT in our Motin Lab.

TRAMA PROJECT led the activities in our lab. in a formal way as a motion analysis lab. at CINVESTAV.

Besides our project, some other people has worked in the lab. By analysing upper limb and lower limb for prosthesis developement and validation.

Use of the motion lab. for sports phisiology teaching

Conclusions

The convergence of the correlated data aquired with the typical answer of second order control system is encouraging to find a good indicator of risk of falling in elderly.

Stimulation with infrasound waves give us information about proprioceptive sensors ,it is important to cuantify the amount of pressure generated for the mechanical waves in order to correlate the risk of falling with some mechanical artifacts that we cannot hear but are present around us.

A novel and objective method has been developed to detect the risk of falling in elderly based on the movements of the head when subjects are submitted to the visual stimulus-response technique. The method is comfortable, fast, and not invasive.

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THANK YOU