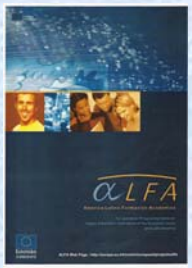
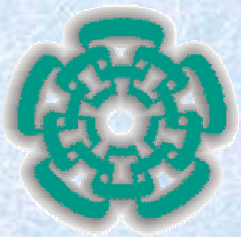
Determination of a mathematical indicator for human stability based on control criteria

(Falling Syndrome)

TRAMA PROJECT
Eladio Cardiel
Grant Holder
Pablo Rogelio Hernández
Full Partner
CINVESTAV MEXICO





One of the most important conquest of human being is to maintain himself in a standing position

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

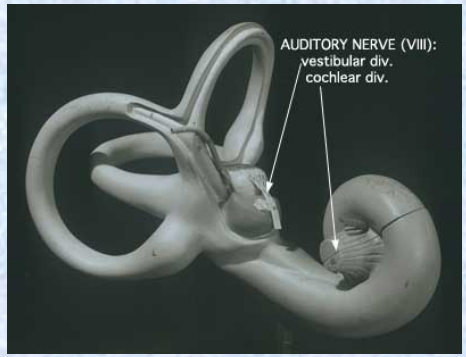
The effects of ageing on postural control and their consequences for functional dependence and the risk of fall have been documented by observing and analysing the capacity of the subject to stand up from a chair. This is an important indicator of elderly functional independence and also a predictor of falls.

BALANCE

VESTIBULAR, VISUAL AND PROPRIOCEPTIVE SYSTEMS

We are concern on :

The vestibular system is of particular importance because it provides information about movements and orientation in space. It is also involved in visual system development, auditory functioning, muscle tone and posture.



Methodology

45 Cases of study, covering three subjects at least per age decade.

The range of ages were from 6 to 84 years old.

Three different stimulli are considered

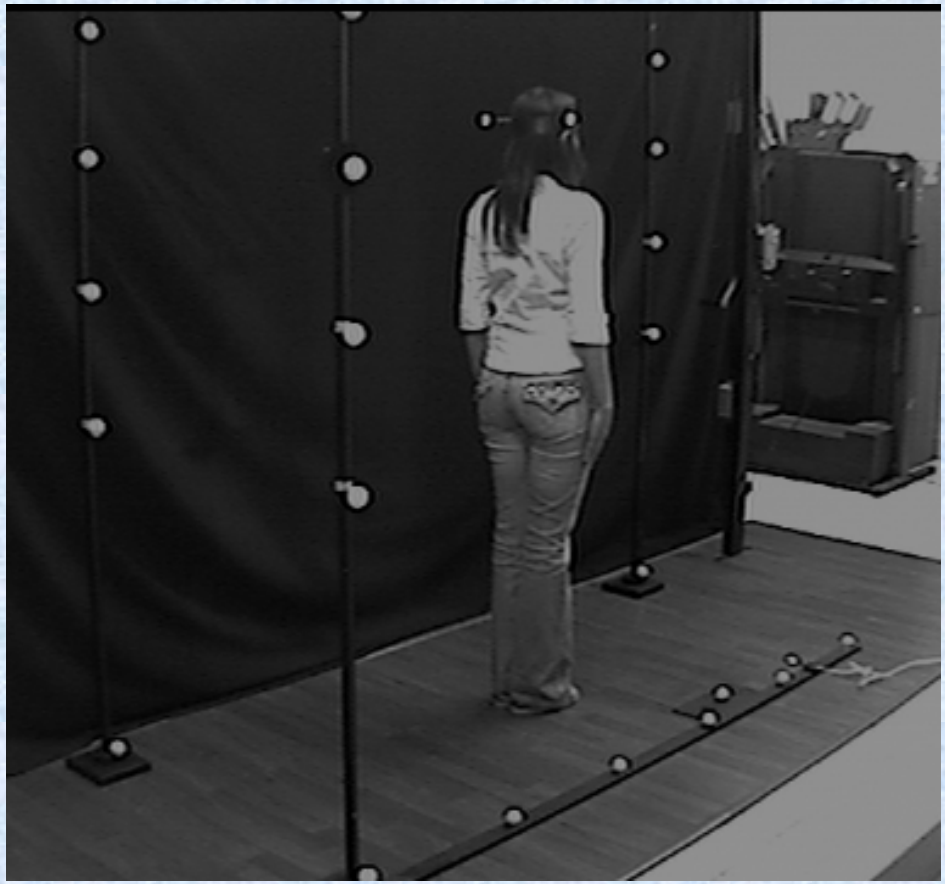
The subject was asked to maintain an erected position with his eyes opened during 5 seconds. After that, he was given the order to close his eyes for fifteen seconds and finally he had to stay with his eyes opened in an standing position for five more seconds. The idea is to observe how the vestibular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

We registered the position of two infrared markers located at the head of the subject by means of the APAS system.

The subject was submitted to infrasound waves (1-10 Hz), while he was standing on a baropodometric platform to evaluate the sway.

Ages from 6 to 84 years old are involved in the protocol

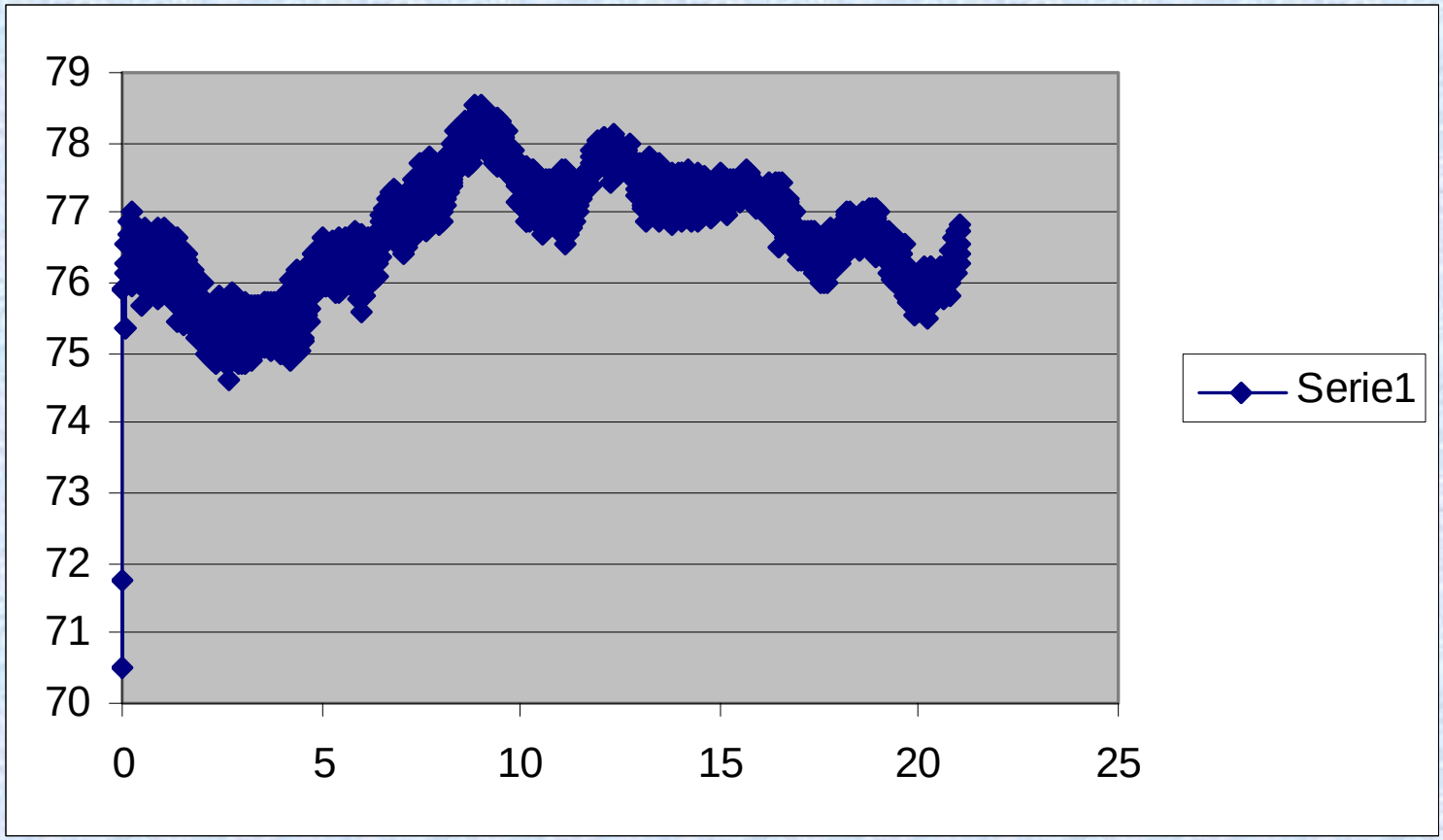
24 YEARS



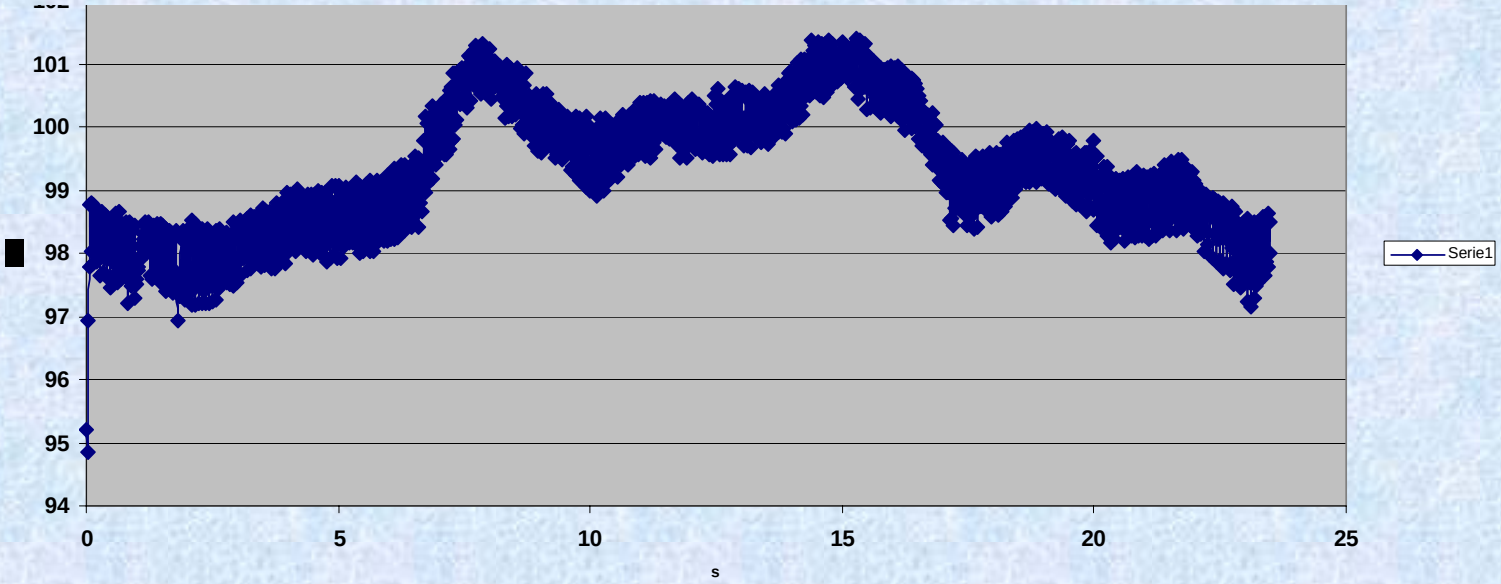
69 YEARS

84 YEARS

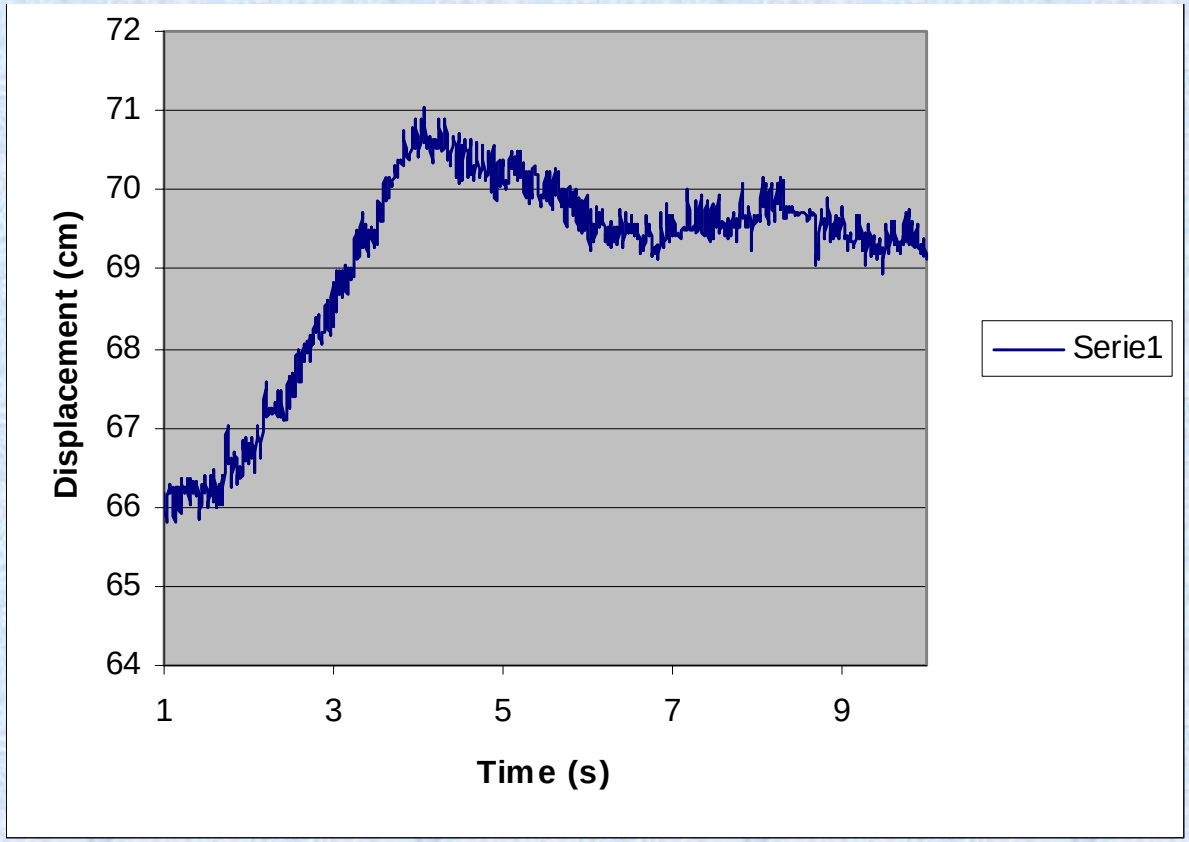
SUBJECT. 1



SUBJTECT.2

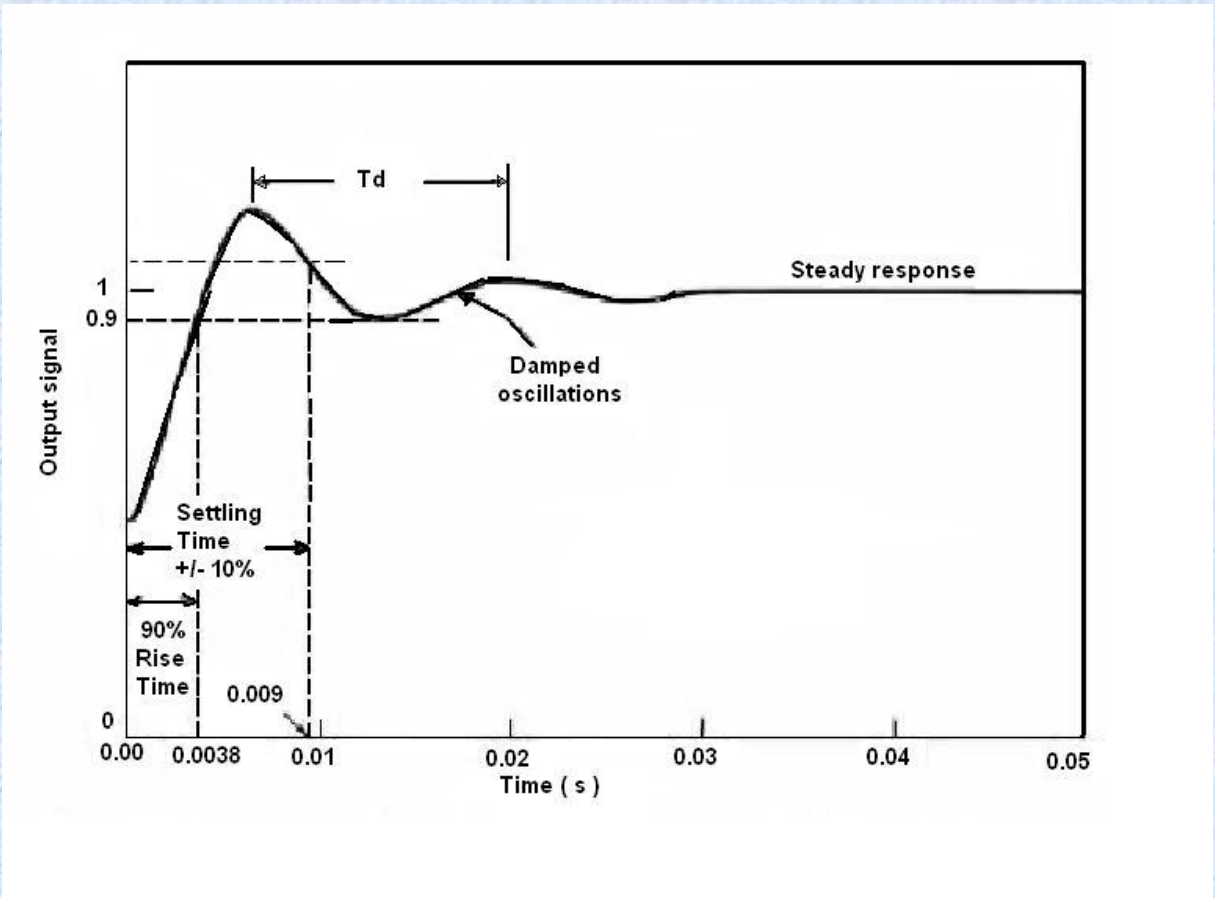


SUBJTECT.3



Model based on Multiple regression algorithm

Typical answer of a Second order 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 $\frac{1}{\alpha} = \frac{1}{\zeta\omega_n}$ = 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

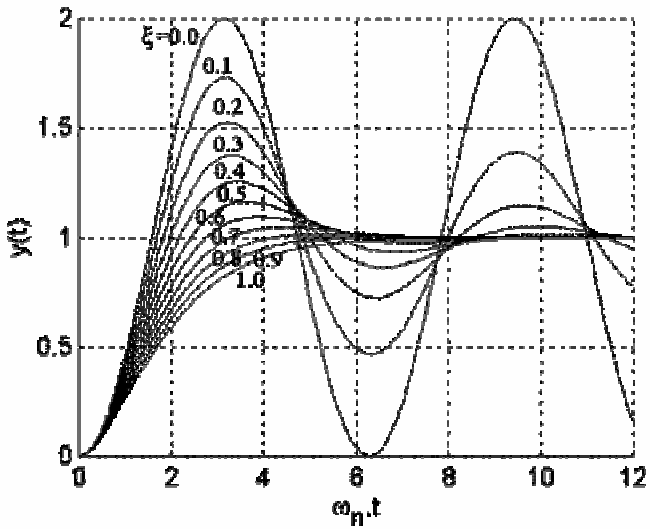
Second order system

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

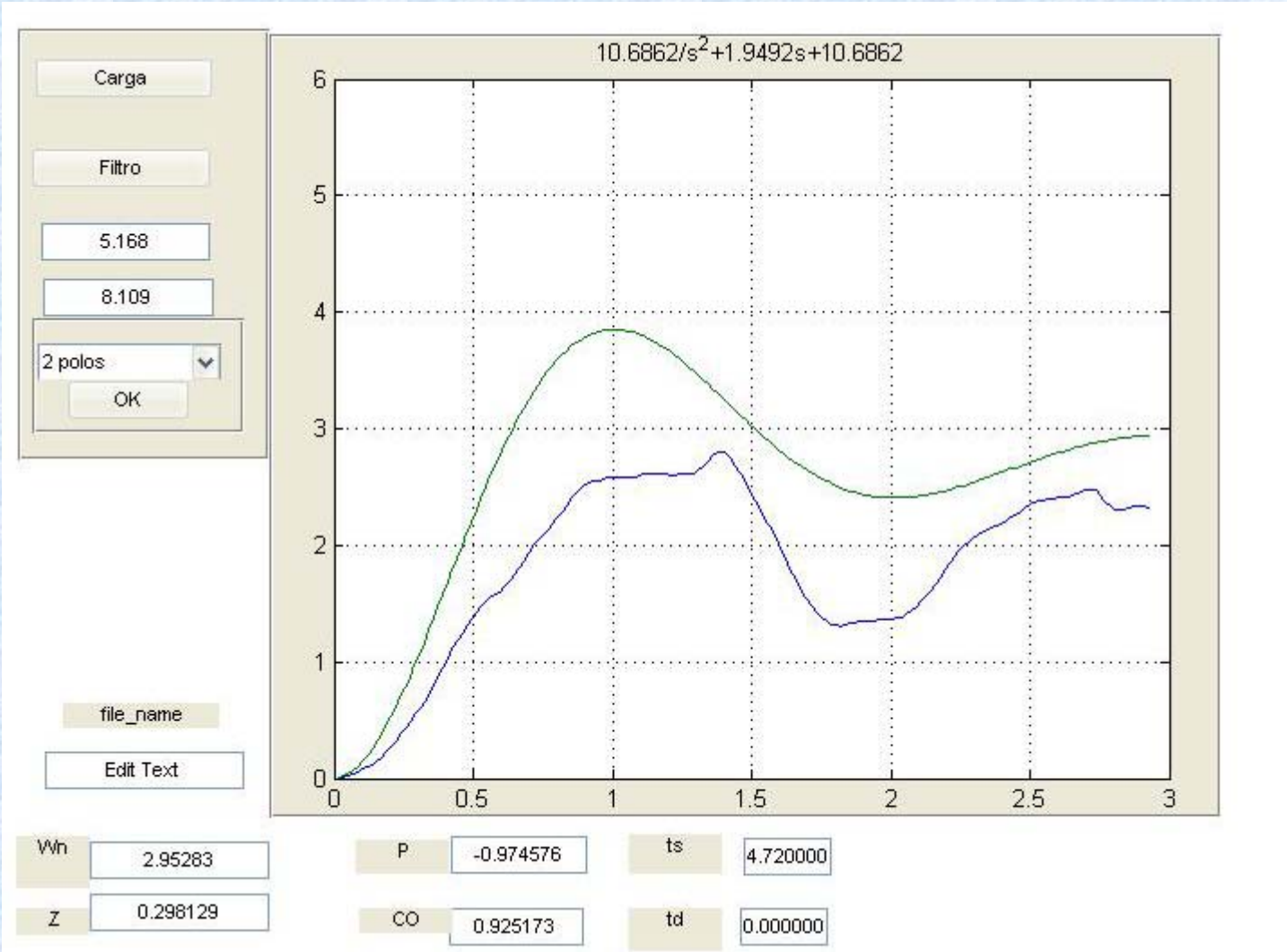
$$T_d = \frac{2\pi}{\omega_d} = \frac{1}{f_d}$$

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

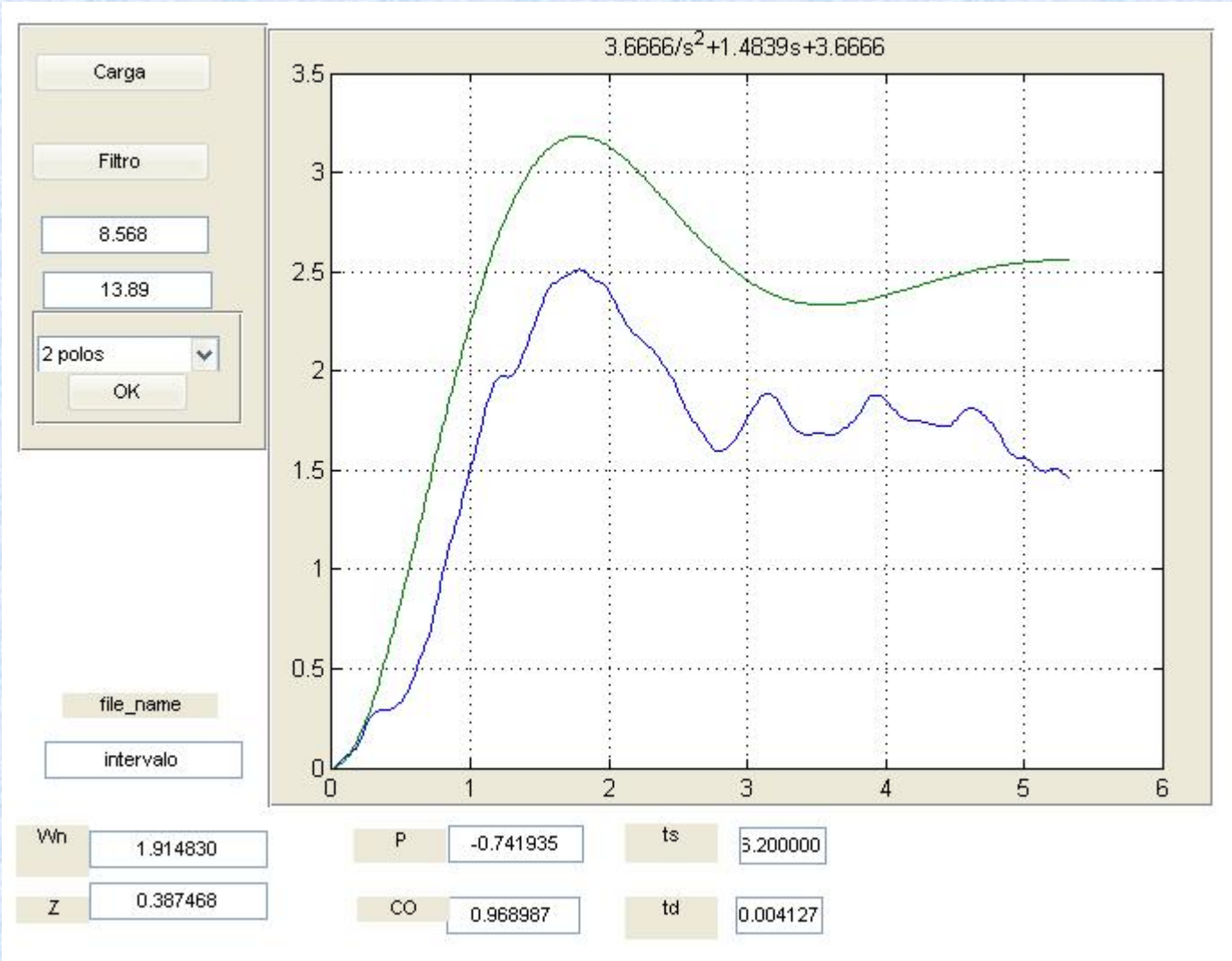
Remember $f = \omega/2\pi$

RESULTS

SCF-X 6AÑOS



CES-X 16 AÑOS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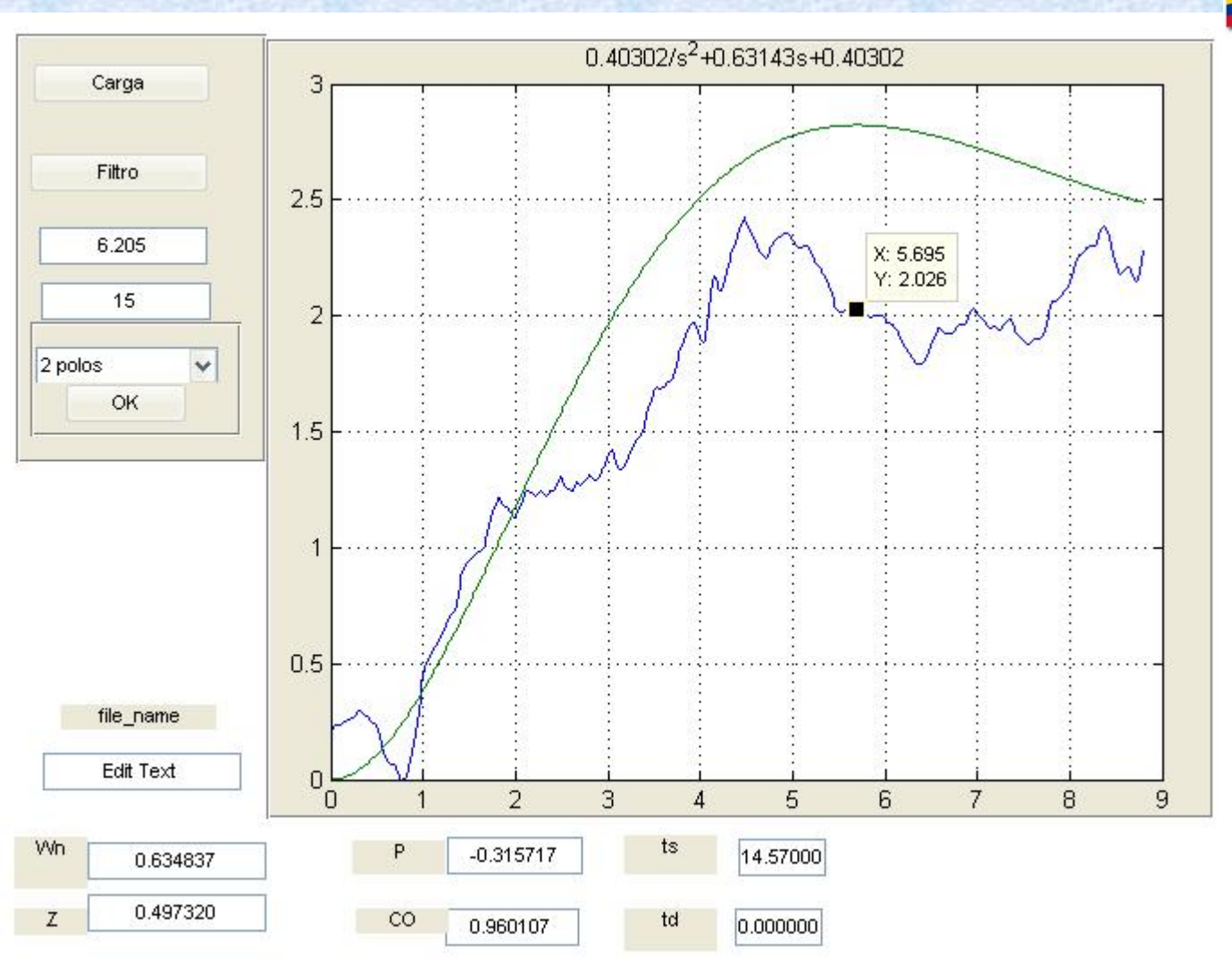
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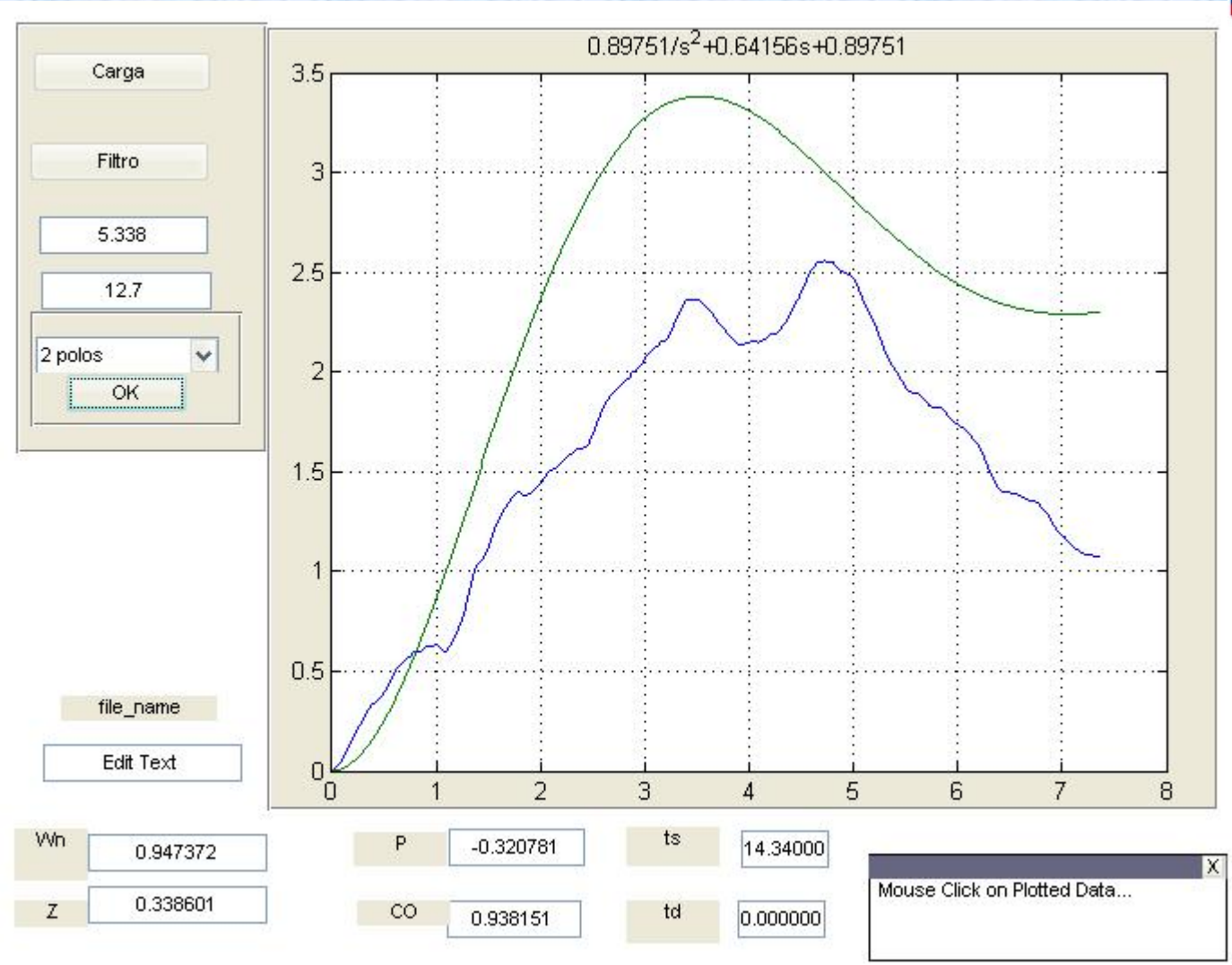
HL-X 30AÑOS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8
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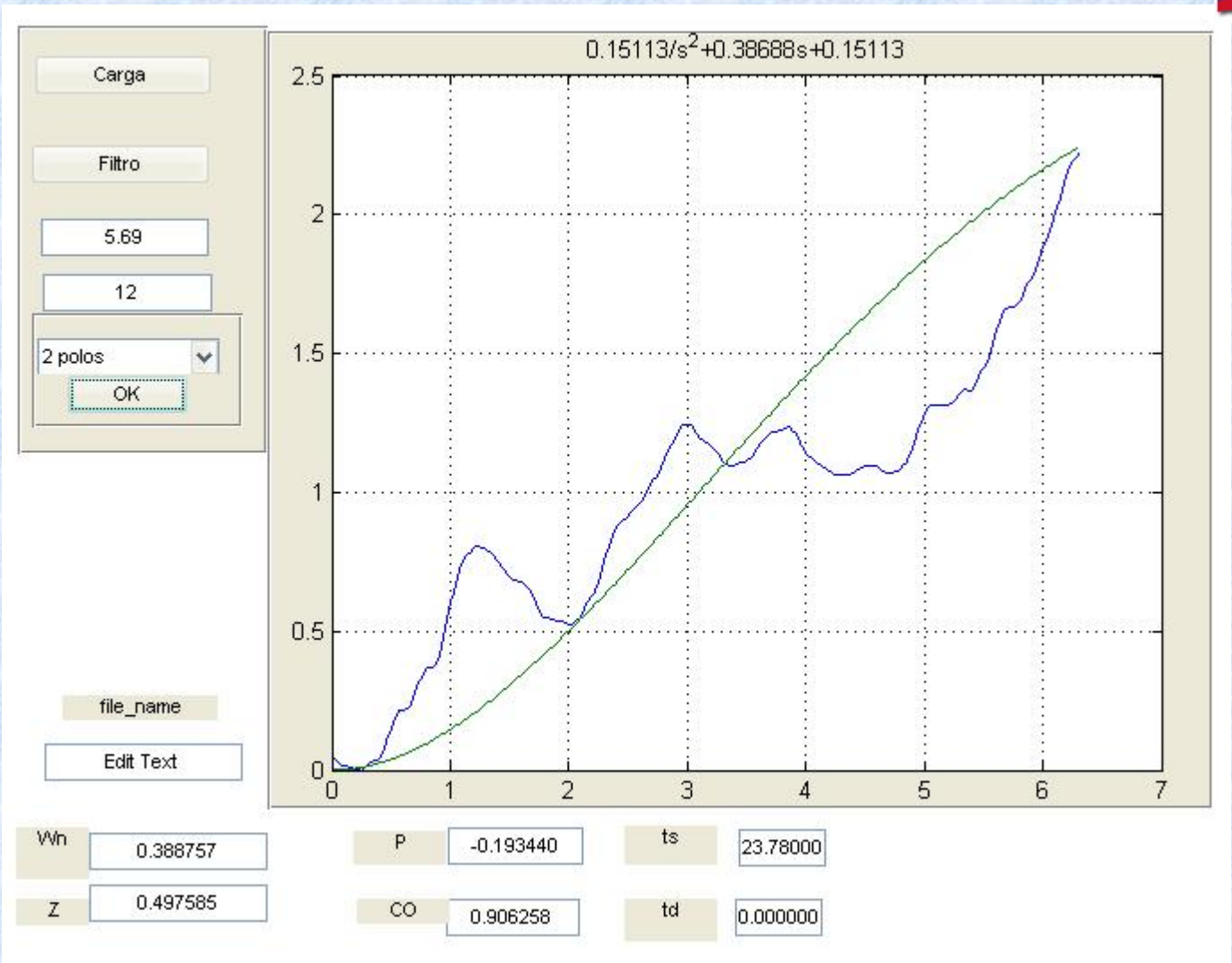
X
Mouse Click on Plotted Data...

RMG-X 47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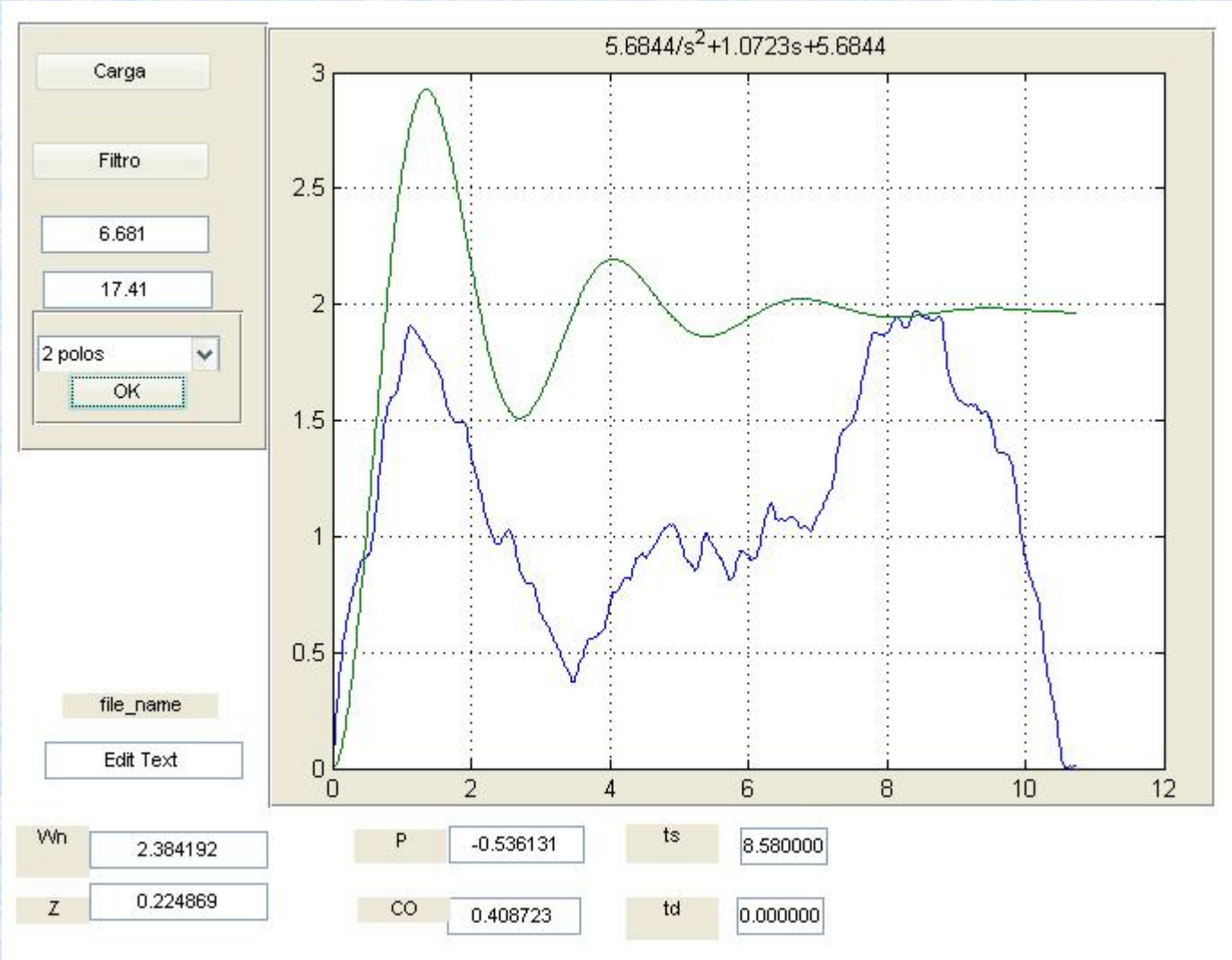
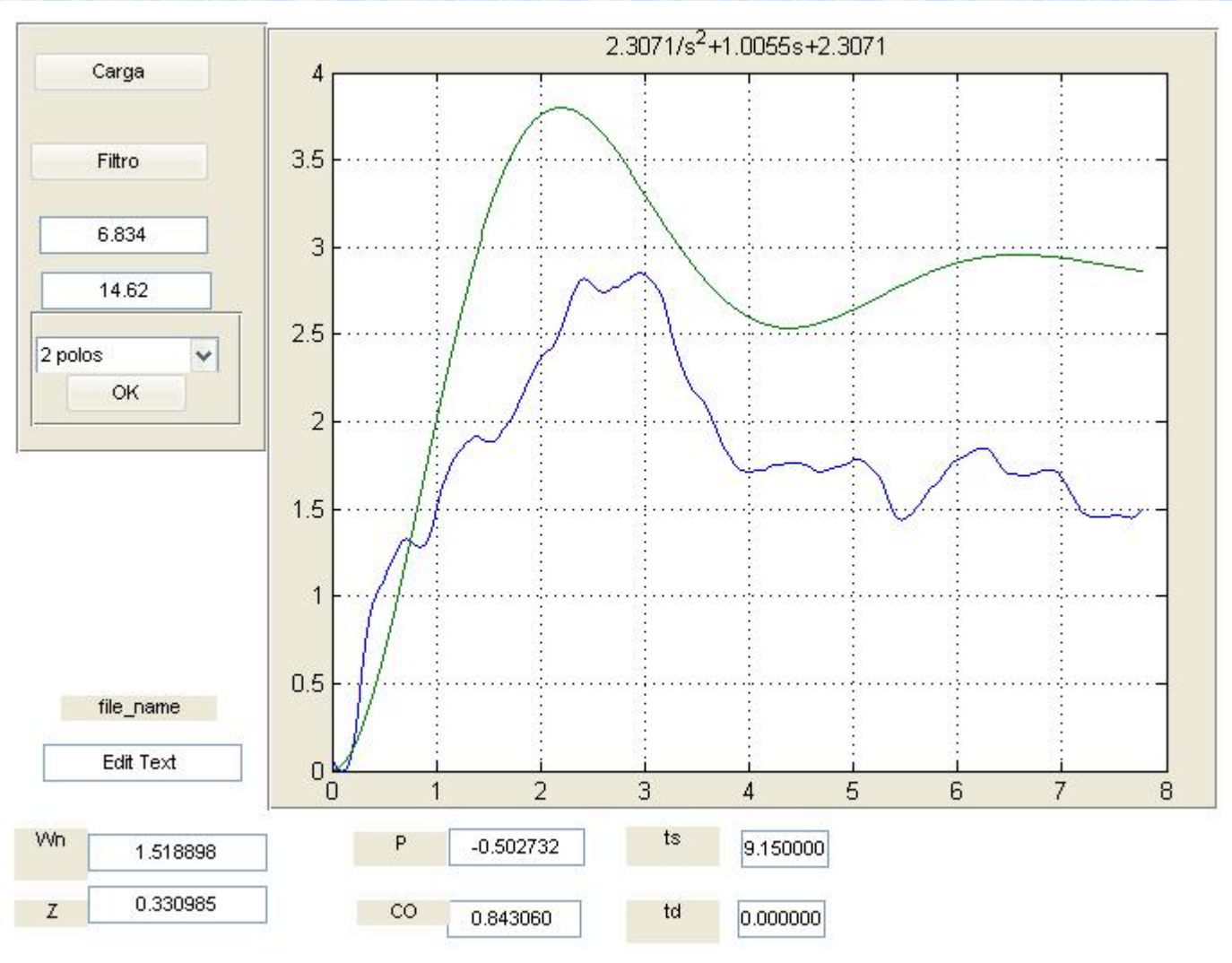
SAMSA –X 69AÑOS



JSE 80 YEARS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Analysis of results

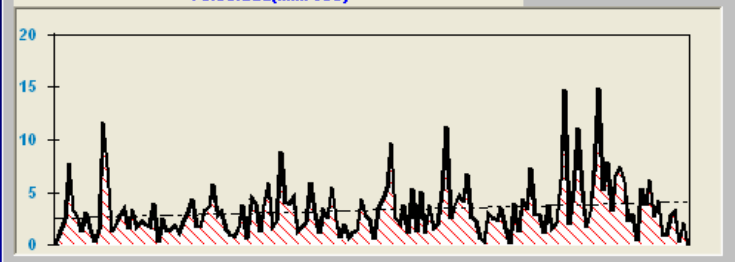
We are improving the mathematical algorithm in order to obtain more consistent information of all the parameters involved, we will be working on statistical procedures to correlate some specific parameters of the second order function with our data.

Infrasound stimulus - Baropodometric platform

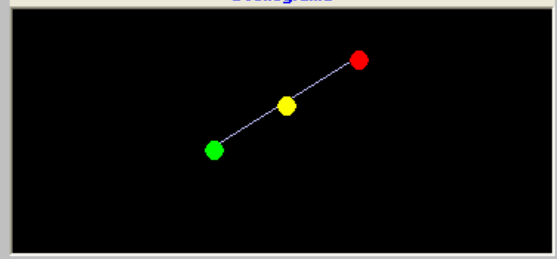
ARAT 11 YEARS NO ST.

Stabilometria

Velocidad(mm/sec)



Oscilograma

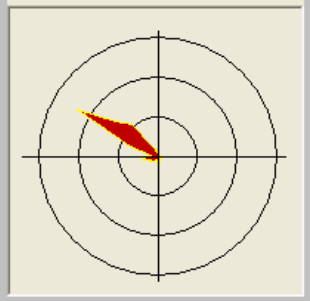


Global

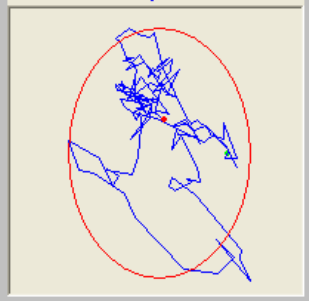
Fases: G

Tiempo (sec.): 0-30

Radar Balance



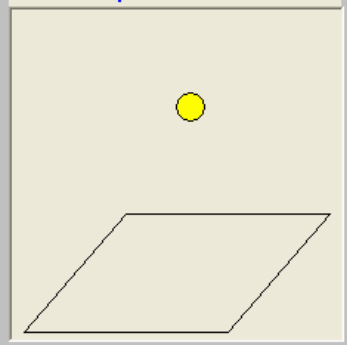
Elipce



Valor de referencia sin calzado y tiempo de adquisicion de 51,2 segundos in appojo bipodal (paciente adulto)

Valores calculados			OA	OC
Velocidad media	mm/sec	3.335	10 (3/18)	16.7 (11/22.5)
Velocidad L/L	mm/sec	2.145	10 (3/18)	16.7 (11/22.5)
Velocidad A/P	mm/sec	2.217	10 (3/18)	16.7 (11/22.5)
Longitud del Ovillo	mm	100.036	429 (307/599)	613 (346/880)
Superficie de la Elipse	mm²	85.366	91 (39/210)	225 (79/638)
Y Medio	mm	-1.384	-29 (-57/-1)	-27 (-51/-3)
X Medio	mm	-2.777	1 (-10/+12)	0 (-10/+11)
Indice Romberg		101	25	

Representación 3D

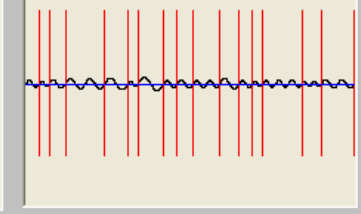


Recopilación

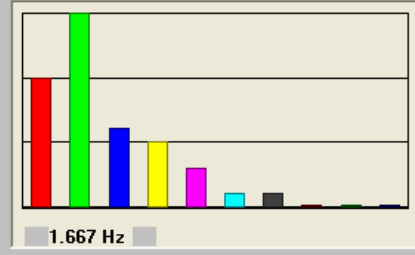
Selección Adquisiciones

- (•) Bipodalico OA
- ( ) Bipodalico OC
- ( ) Monopodálica OA Izq.
- ( ) Monopodálica OA Der.
- ( ) Monopodálica OC Izq.
- ( ) Monopodálica OC Der.

Ciclo de compensación



Distribución ciclo de compensación

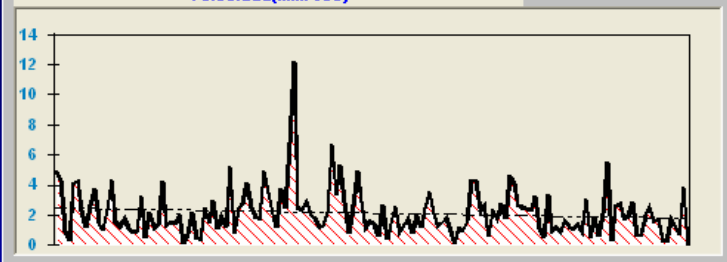


Cerrar

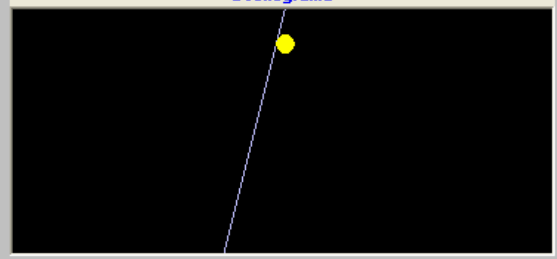
ARAT 11 YEARS UNDER ST.

Stabilometria

Velocidad(mm/sec)



Oscilograma



Global

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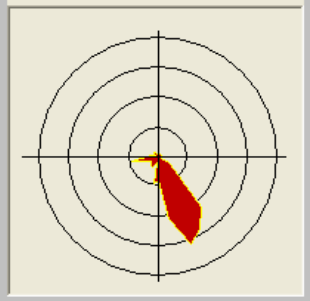
Fases

G

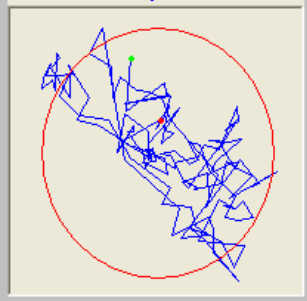
Tiempo (sec.)

0-30

Radar Balance



Elipce

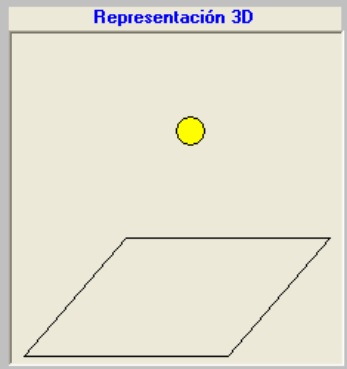


Valor de referencia sin calzado y tiempo de adquisicion de 51,2 segundos in appojo bipodal (paciente adulto)

Valores calculados

			OA	OC
Velocidad media	mm/sec	2.149	10 (3/18)	16.7 (11/22.5)
Velocidad L/L	mm/sec	1.303	10 (3/18)	16.7 (11/22.5)
Velocidad A/P	mm/sec	1.466	10 (3/18)	16.7 (11/22.5)
Longitud del Ovillo	mm	64.470	429 (307/599)	613 (346/880)
Superficie de la Elipse	mm²	16.966	91 (39/210)	225 (79/638)
Y Medio	mm	1.708	-29 (-57/-1)	-27 (-51/-3)
X Medio	mm	0.697	1 (-10/+12)	0 (-10/+11)
Indice Romberg		340	25	

Representación 3D



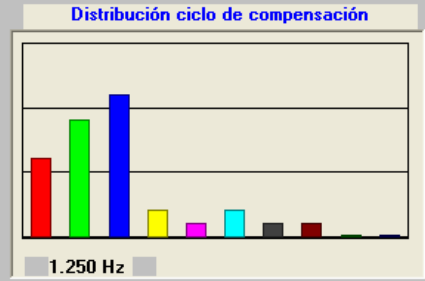
Recopilación

Selección Adquisiciones

- (•) Bipodalico OA
- ( ) Bipodalico OC
- ( ) Monopodálica OA Izq.
- ( ) Monopodálica OA Der.
- ( ) Monopodálica OC Izq.
- ( ) Monopodálica OC Der.

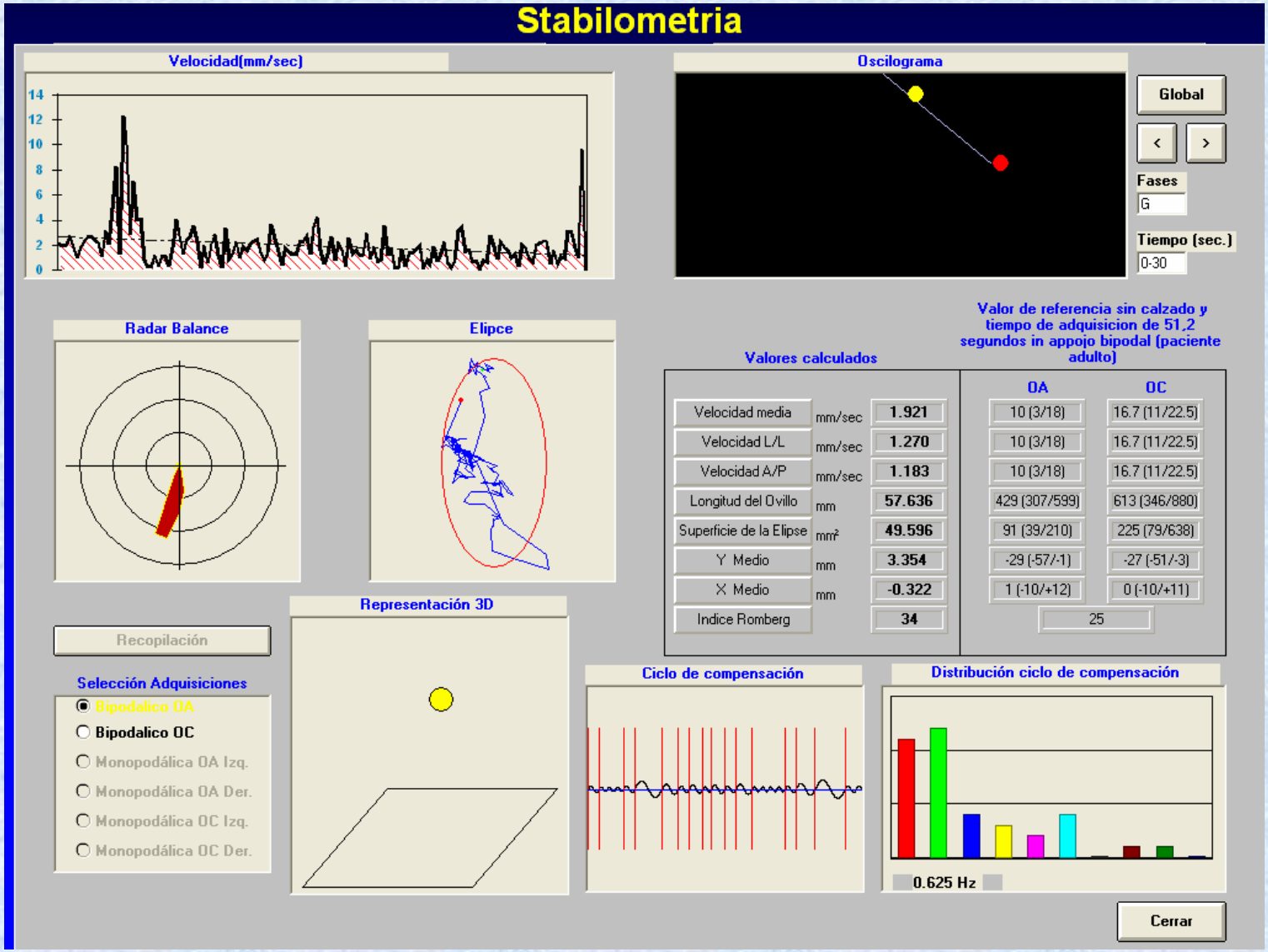
Ciclo de compensación

Distribución ciclo de compensación

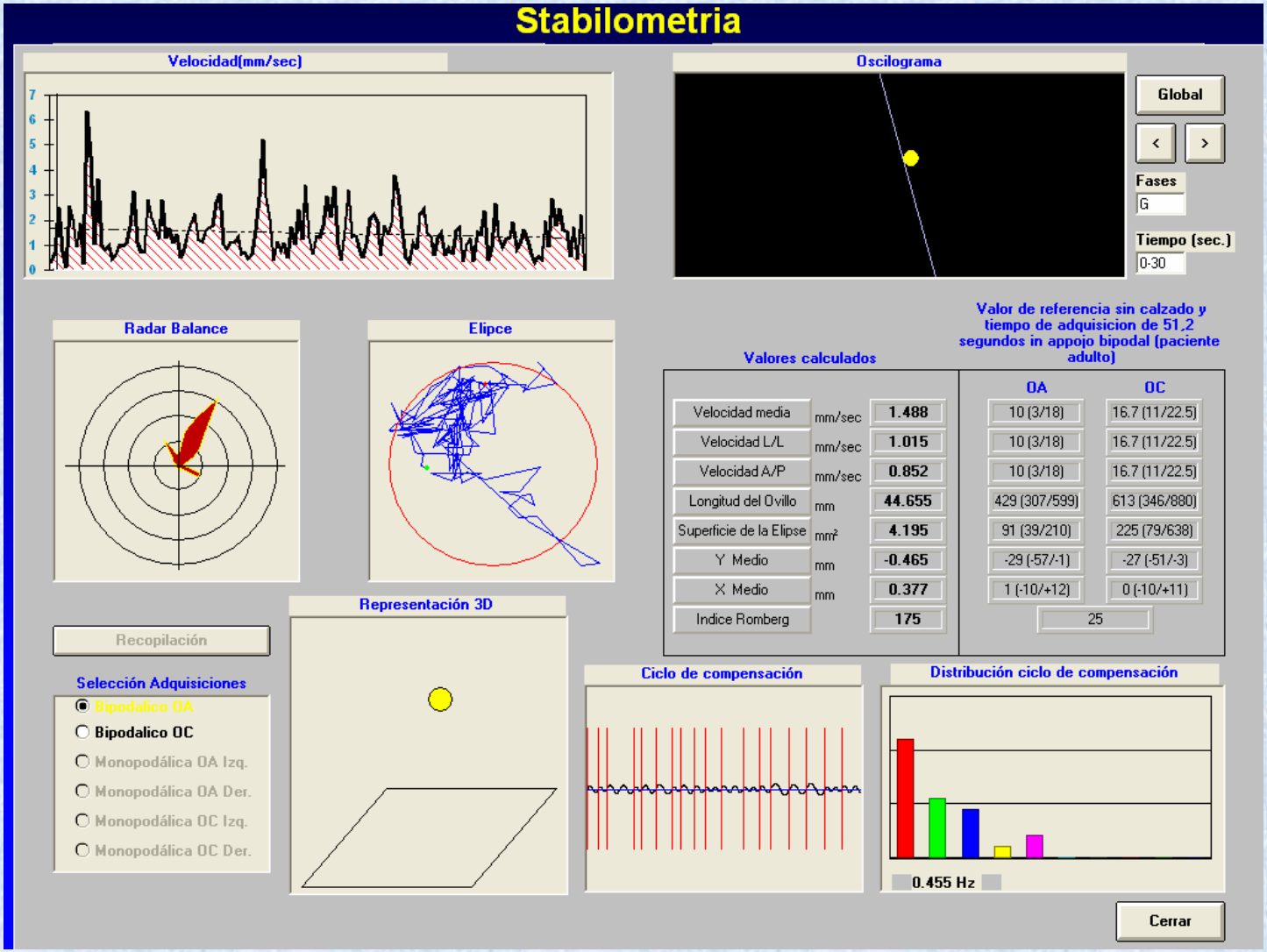


Cerrar

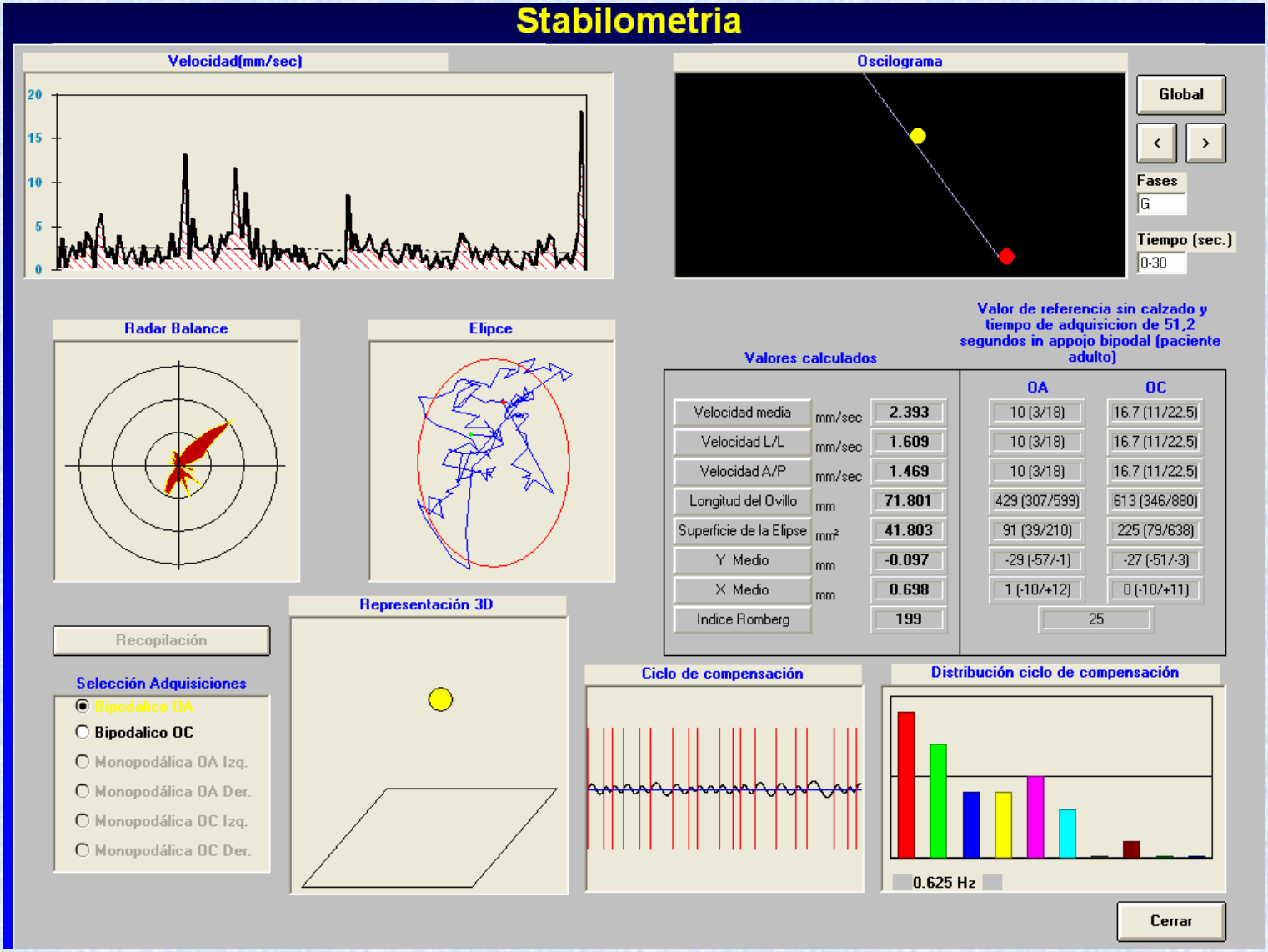
MC 24 YEAR NO ST.



MC 24 YEARS UNDER ST.



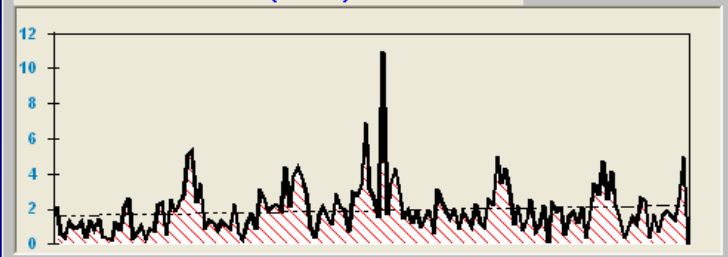
ALH 49 YEARS NO ST.



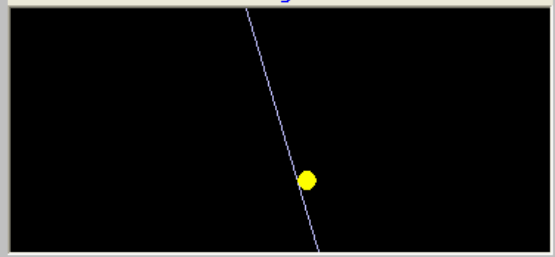
ALH 49 YEARS UNDER ST.

Stabilometria

Velocidad(mm/sec)



Oscilograma



Global

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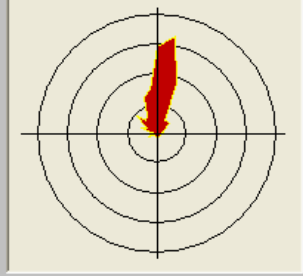
Fases

G

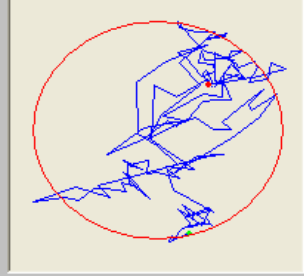
Tiempo (sec.)

0-30

Radar Balance



Elipce

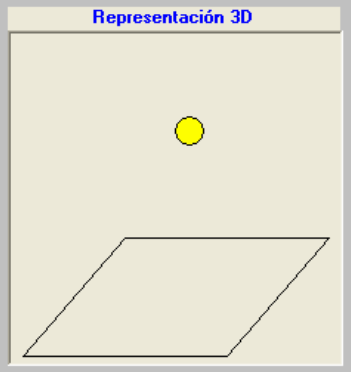


Valor de referencia sin calzado y tiempo de adquisicion de 51,2 segundos in appojo bipodal (paciente adulto)

Valores calculados

			OA	OC
Velocidad media	mm/sec	1.950	10 (3/18)	16.7 (11/22.5)
Velocidad L/L	mm/sec	1.506	10 (3/18)	16.7 (11/22.5)
Velocidad A/P	mm/sec	1.001	10 (3/18)	16.7 (11/22.5)
Longitud del Ovillo	mm	58.502	429 (307/599)	613 (346/880)
Superficie de la Elipse	mm²	18.329	91 (39/210)	225 (79/638)
Y Medio	mm	-1.986	-29 (-57/-1)	-27 (-51/-3)
X Medio	mm	0.045	1 (-10/+12)	0 (-10/+11)
Indice Romberg		638	25	

Representación 3D



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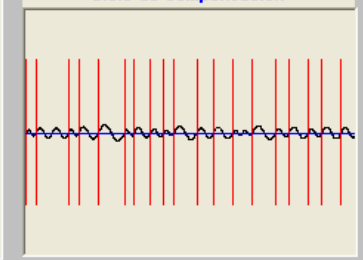
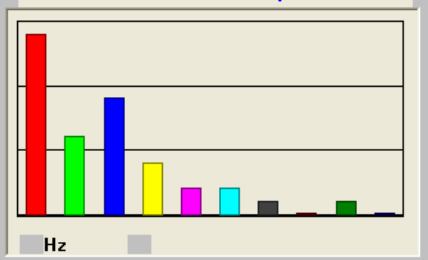
- ( ) Bipodalico OC
- ( ) Monopodálica OA Izq.
- ( ) Monopodálica OA Der.
- ( ) Monopodálica OC Izq.
- ( ) Monopodálica OC Der.

Ciclo de compensación



Distribución ciclo de compensación

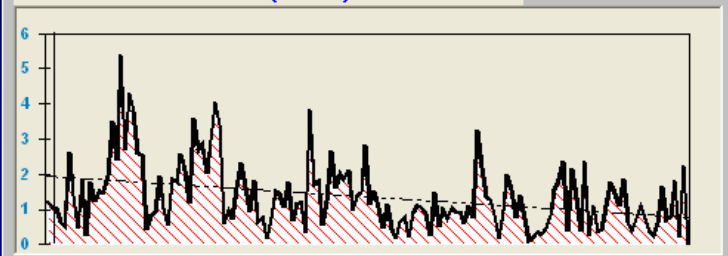


Cerrar

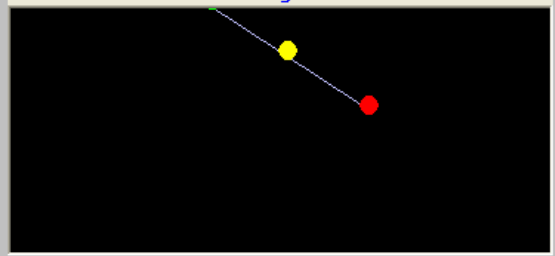
MAL 55 YEARS NO ST.

Stabilometria

Velocidad(mm/sec)



Oscilograma



Global

< >

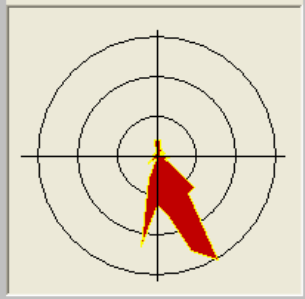
Fases

G

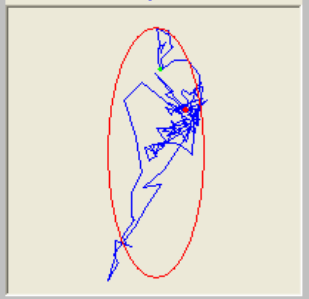
Tiempo (sec.)

0-30

Radar Balance



Elipce

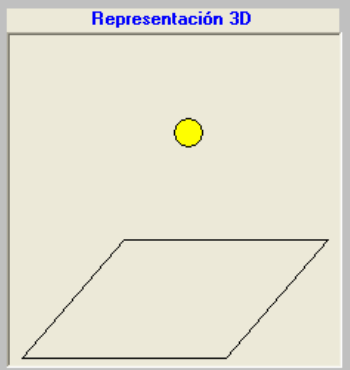


Valor de referencia sin calzado y tiempo de adquisicion de 51,2 segundos in appojo bipodal (paciente adulto)

Valores calculados

			OA	OC
Velocidad media	mm/sec	1.361	10 (3/18)	16.7 (11/22.5)
Velocidad L/L	mm/sec	0.822	10 (3/18)	16.7 (11/22.5)
Velocidad A/P	mm/sec	0.938	10 (3/18)	16.7 (11/22.5)
Longitud del Ovillo	mm	40.834	429 (307/599)	613 (346/880)
Superficie de la Elipse	mm²	23.296	91 (39/210)	225 (79/638)
Y Medio	mm	1.154	-29 (-57/-1)	-27 (-51/-3)
X Medio	mm	0.277	1 (-10/+12)	0 (-10/+11)
Indice Romberg		17	25	

Representación 3D

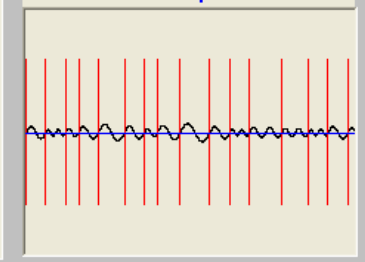


Recopilación

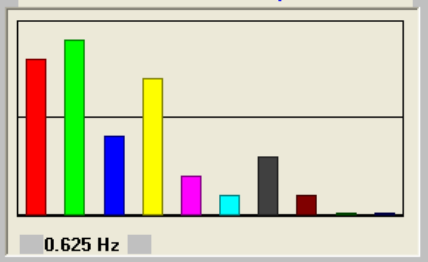
Selección Adquisiciones

- (•) Bipodalico OA
- ( ) Bipodalico OC
- ( ) Monopodálica OA Izq.
- ( ) Monopodálica OA Der.
- ( ) Monopodálica OC Izq.
- ( ) Monopodálica OC Der.

Ciclo de compensación



Distribución ciclo de compensación

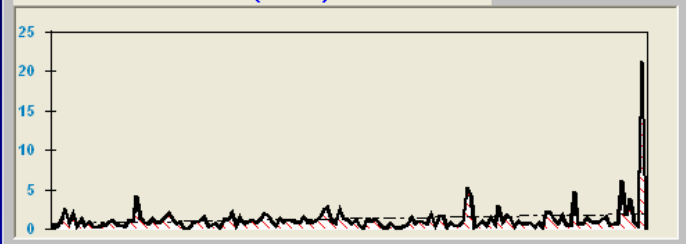


Cerrar

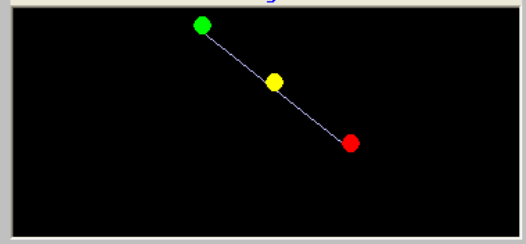
MAL 55 YEARS UNDER ST.

Stabilometria

Velocidad(mm/sec)



Oscilograma



Global

< >

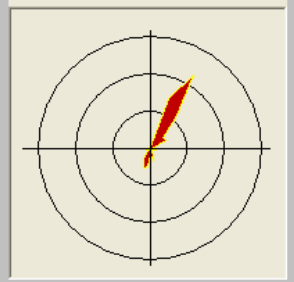
Fases

G

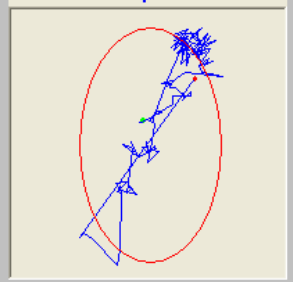
Tiempo (sec.)

0-30

Radar Balance



Elipce



Valor de referencia sin calzado y tiempo de adquisicion de 51,2 segundos in appojo bipodal (paciente adulto)

Valores calculados

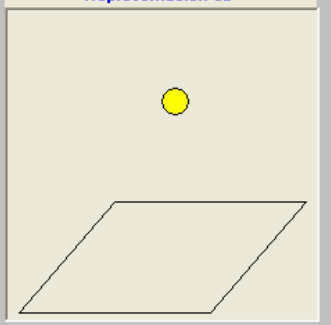
			OA	OC
Velocidad media	mm/sec	1.278	10 (3/18)	16.7 (11/22.5)
Velocidad L/L	mm/sec	0.779	10 (3/18)	16.7 (11/22.5)
Velocidad A/P	mm/sec	0.866	10 (3/18)	16.7 (11/22.5)
Longitud del Ovillo	mm	38.351	429 (307/599)	613 (346/880)
Superficie de la Elipse	mm²	20.837	91 (39/210)	225 (79/638)
Y Medio	mm	-0.709	-29 (-57/-1)	-27 (-51/-3)
X Medio	mm	0.638	1 (-10/+12)	0 (-10/+11)
Indice Romberg		123	25	

Recopilación

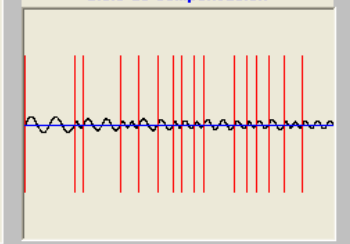
Selección Adquisiciones

- (•) Bipodalico OA
- ( ) Bipodalico OC
- ( ) Monopodálica OA Izq.
- ( ) Monopodálica OA Der.
- ( ) Monopodálica OC Izq.
- ( ) Monopodálica OC Der.

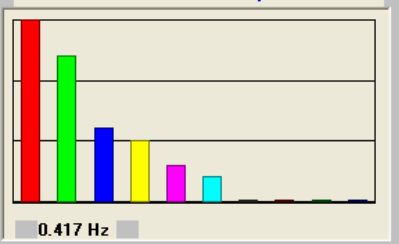
Representación 3D



Ciclo de compensación



Distribución ciclo de compensación

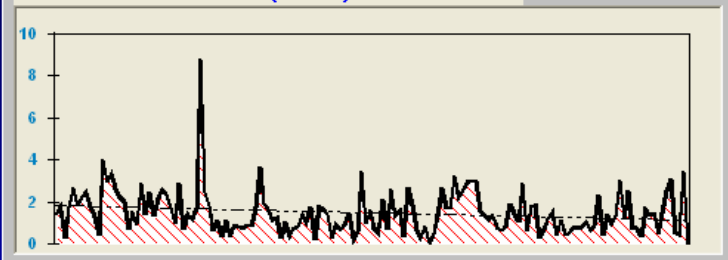


Cerrar

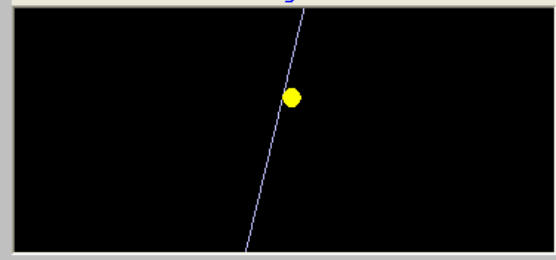
DAC 58 YEARS NO ST.

Stabilometria

Velocidad(mm/sec)



Oscilograma



Global

< >

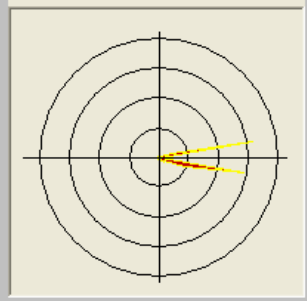
Fases

G

Tiempo (sec.)

0-30

Radar Balance



Elipce

Valor de referencia sin calzado y tiempo de adquisicion de 51,2 segundos in appojo bipodal (paciente adulto)

Valores calculados

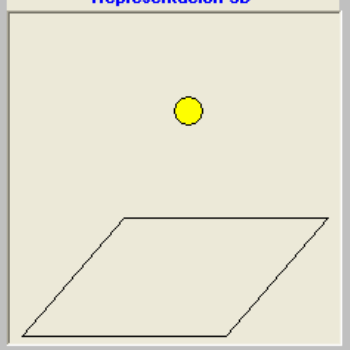
			OA	OC
Velocidad media	mm/sec	1.486	10 (3/18)	16.7 (11/22.5)
Velocidad L/L	mm/sec	1.099	10 (3/18)	16.7 (11/22.5)
Velocidad A/P	mm/sec	0.820	10 (3/18)	16.7 (11/22.5)
Longitud del Ovillo	mm	44.573	429 (307/599)	613 (346/880)
Superficie de la Elipse	mm²	16.105	91 (39/210)	225 (79/638)
Y Medio	mm	0.049	-29 (-57/-1)	-27 (-51/-3)
X Medio	mm	2.574	1 (-10/+12)	0 (-10/+11)
Indice Romberg		30	25	

Recopilación

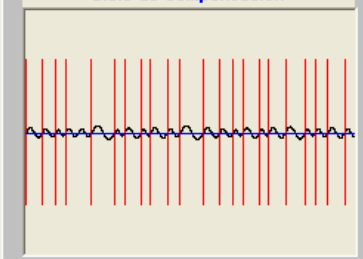
Selección Adquisiciones

- (•) Bipodalico OA
- ( ) Bipodalico OC
- ( ) Monopodálica OA Izq.
- ( ) Monopodálica OA Der.
- ( ) Monopodálica OC Izq.
- ( ) Monopodálica OC Der.

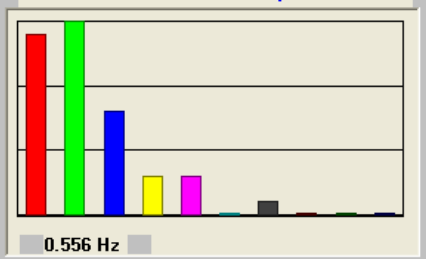
Representación 3D



Ciclo de compensación

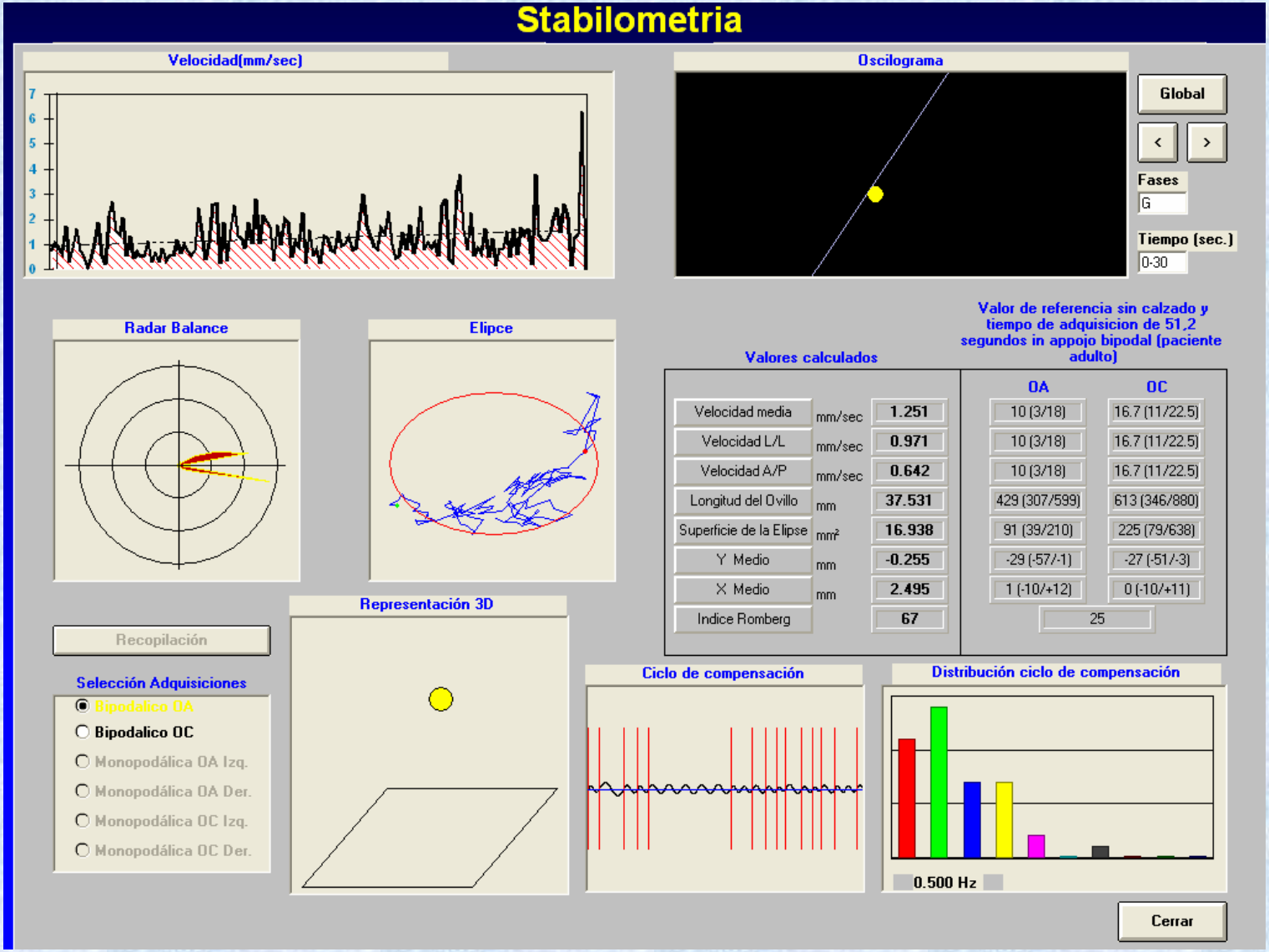


Distribución ciclo de compensación



Cerrar

DAC 58 YEARS UNDER ST.



Analysis of results

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.

Third stimulus

We are working on the third stimulus, this is a vibratory system, as soon as we have some results we will let you know.

THANK YOU