Erasmus+

Development of innovative training solutions in the field of functional evaluation aimed at updating of the curricula of health sciences schools

MODULE BIOMECHANICS OF SPINE

Didactic Unit D: INSTRUMENTED ANALYSIS OF THE SPINE

D.5. How do I interpret a biomechanics instrumented analysis report in a case of spinal pathology?

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OBJECTIVES

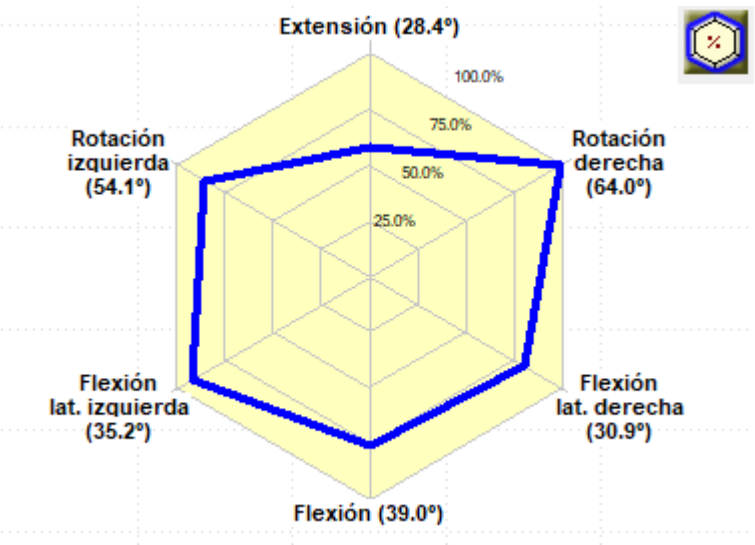
- To learn how to interpret the results of a cervical kinematic assessment in a pathological population.
- To learn how to interpret the results of an assessment of cervical muscle strength in pathological population.
- To learn how to interpret the results of a lumbar kinematic assessment in a pathological population.
- To learn how to interpret the results of the assessment of lumbar strength in a pathological population.
- To discuss the results of cervical and/or lumbar biomechanical assessment through clinical cases.

CONTENTS

- Pathological results of a cervical spine assessment
- Pathological results of a lumbar spine assessment
- Cervical biomechanical assessment. Clinical case
- Lumbar biomechanical assessment. Clinical case
- Key ideas

Assessment of the cervical range of motion

Cervical range of motion



MEASURING EQUIPMENT:
Photogrammetry system or inclinometers.

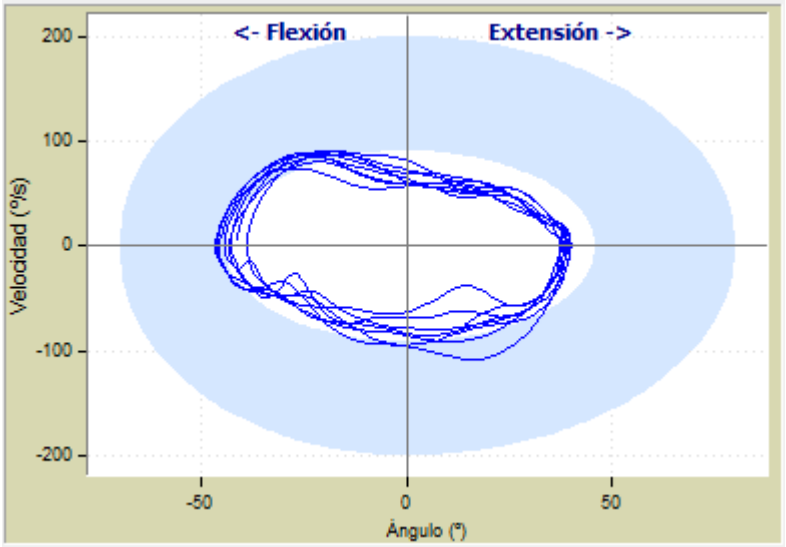
TYPE OF ANALYSIS: Kinematic.

GRAPH: Range of motion of the cervical spine in the three planes. The outer edge of the graph represents the normality zone.

INTERPRETATION OF THE RESULT:
Limited mobility (º) of the cervical spine in different axes of movement. The flexion-extension limitation is particularly noticeable, followed by left rotation, in which there is also a significant asymmetry with respect to right rotation.

Kinematic assessment of the cervical spine

Cervical mobility



MEASURING EQUIPMENT: Photogrammetry system.

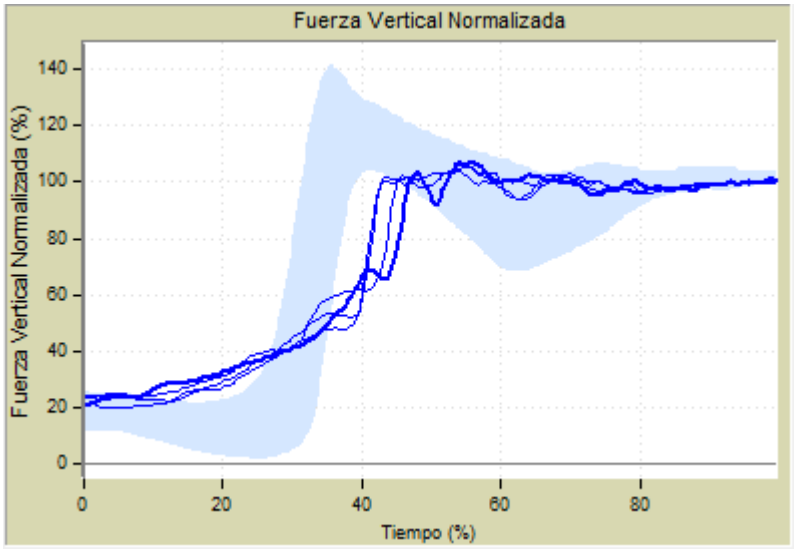
TYPE OF ANALYSIS: Kinematic.

GRAPH: Angular velocity (°/s) of the cervical spine versus the range of flexion-extension movement (°).

INTERPRETATION OF THE RESULT: Slow movement with limitation of the cervical spine extension, whereas flexion is close to normality limits.

Functional assessment of the lumbar spine

Activity: rising from a chair



MEASURING EQUIPMENT: Dynamometric platform

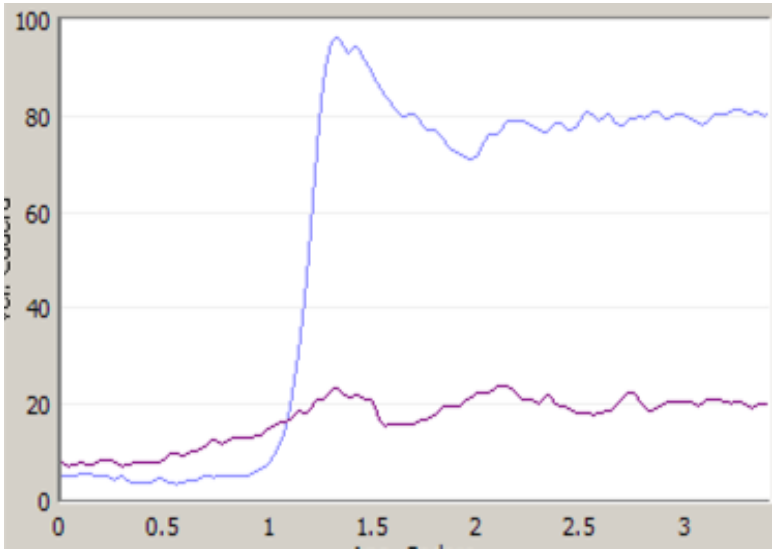
TYPE OF ANALYSIS: Kinetic.

GRAPH: It represents the different repetitions recorded of the reaction force during the sit-to-stand movement.

INTERPRETATION OF THE RESULT: Repeatable but altered force pattern. The slope of the curve is horizontal, with the maximum peak of the curve being lower and delayed in time. This means that the generated momentum is insufficient to stand up, which can be associated with pain, strength deficit or lack of coordination.

Functional assessment of the lumbar spine

Activity: rising from a chair
FORCE ASYMMETRY



MEASURING EQUIPMENT:

Dynamometric platform

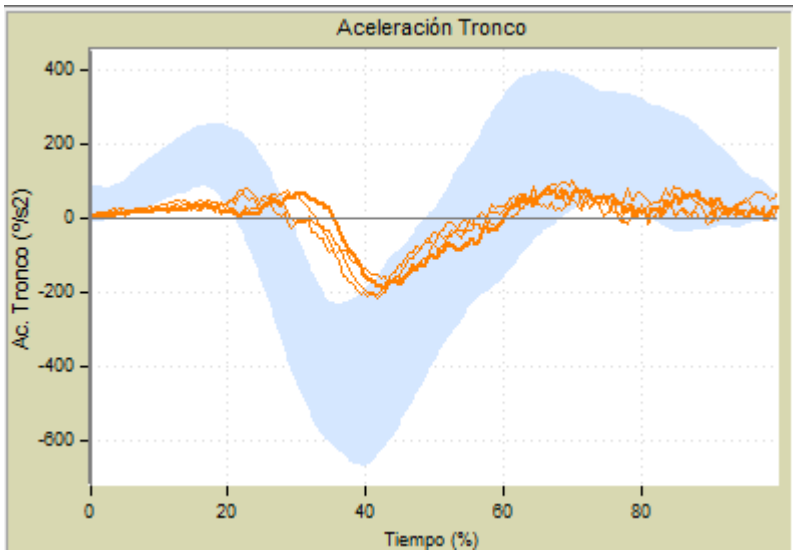
TYPE OF ANALYSIS: Kinetic.

GRAPH: It represents the reaction force generated by each lower limb during the sit-to-stand movement.

INTERPRETATION OF THE RESULT: Asymmetric force pattern. Increased weight-bearing on the lower right limb during the sit-to-stand, which implies an asymmetric movement.

Functional assessment of the lumbar spine

Activity: rising from a chair



MEASURING EQUIPMENT
Photogrammetry, inertial systems.

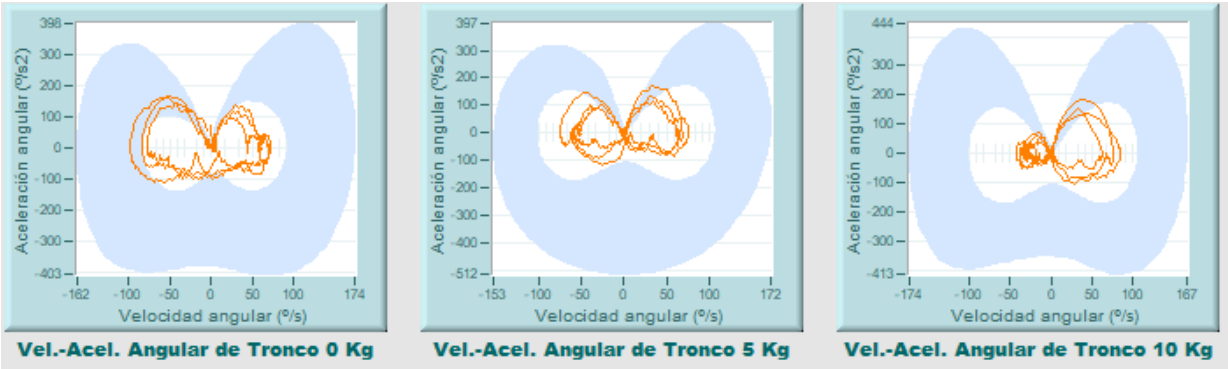
TYPE OF ANALYSIS: Kinematic.

GRAPH: It represents the angular acceleration of the trunk in different recorded repetitions of the sit-to-stand movement.

INTERPRETATION OF THE RESULT: Low accelerations, which implies slow trunk movement when performing the movement.

Functional assessment of the lumbar spine

Activity: lifting a weight



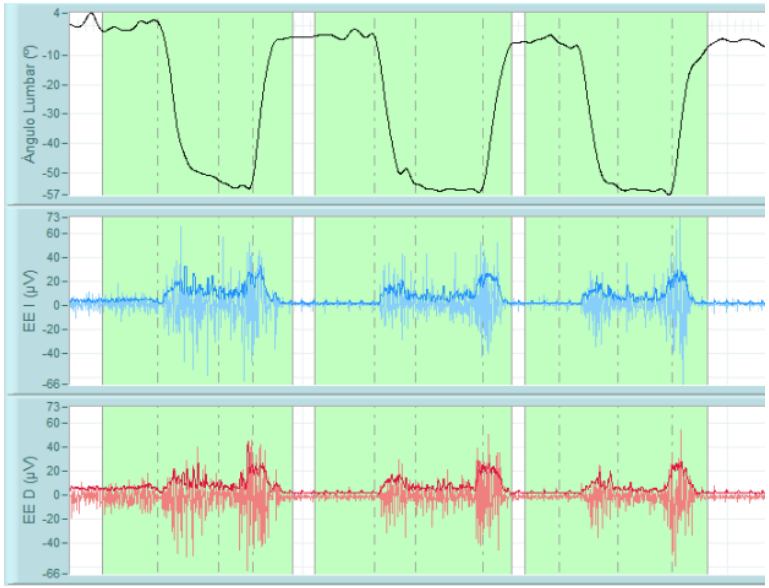
MEASURING EQUIPMENT: Photogrammetry, inertial systems.

TYPE OF ANALYSIS: Kinematic.

GRAPH: It represents the angular acceleration of the trunk versus its angular speed in different recorded repetitions of the movement of lifting a weight. The result is shown for increasing weights.

INTERPRETATION OF THE RESULT: Low acceleration and speed in all movements, which involves slow trunk motion. Slower movements are observed as the weight increases, therefore, the movement gets worse as the load handled increases.

Assessment of the flexion-relaxation phenomenon



MEASURING EQUIPMENT: Surface electromyography (sEMG).

GRAPH: Kinematic and EMG results during the flexion-relaxation test of the lumbar spine.

INTERPRETATION OF THE RESULT: No myoelectric silence is observed at maximum spine flexion.

Example outcome

Cervical clinical case

30-year patient.
She works as a clerk.
She had a rear-end collision 2 weeks ago.
Cervical pain.
Treatment: cervical immobilization and analgesics.
After removing the immobilization (one week after the accident), the patient reported limited mobility due to pain.
She is referred to the biomechanics laboratory to assess cervical mobility and prescribe a rehabilitation treatment.

On **physical examination**: the limited active mobility in the last degrees of all the movements is particularly noticeable, with preserved passive mobility, although painful. On palpation, symmetrical muscle tone with painful points in the left temporal region and right trapezius.

The results of the functional assessment of the cervical spine performed in one case are discussed below. This test **kinematically** analyses the movement of the cervical spine in simple activities to detect abnormal or non-functional movements secondary to cervical pain.

The **NEDCERVICAL/IBV** assessment equipment was used and the recording technique was photogrammetry.

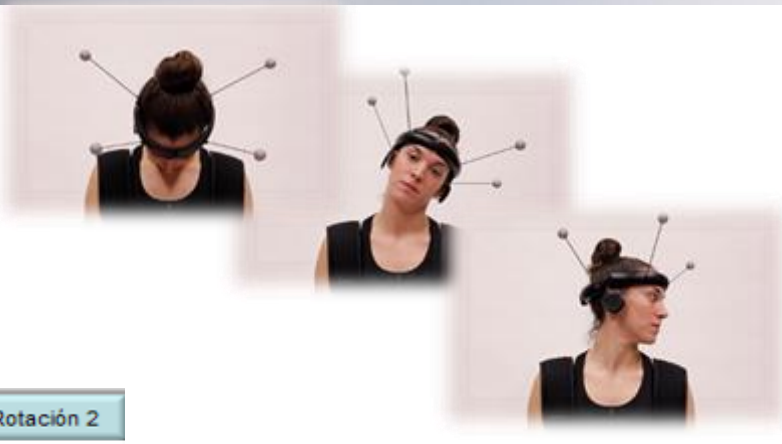
To perform the assessment, the system compares the parameters obtained with those of a group of subjects whose characteristics are comparable to those of the patient (data bases made up of normal and pathological subjects, segmented by age and gender.)

The assessment protocol is standardised and consists of two movements:

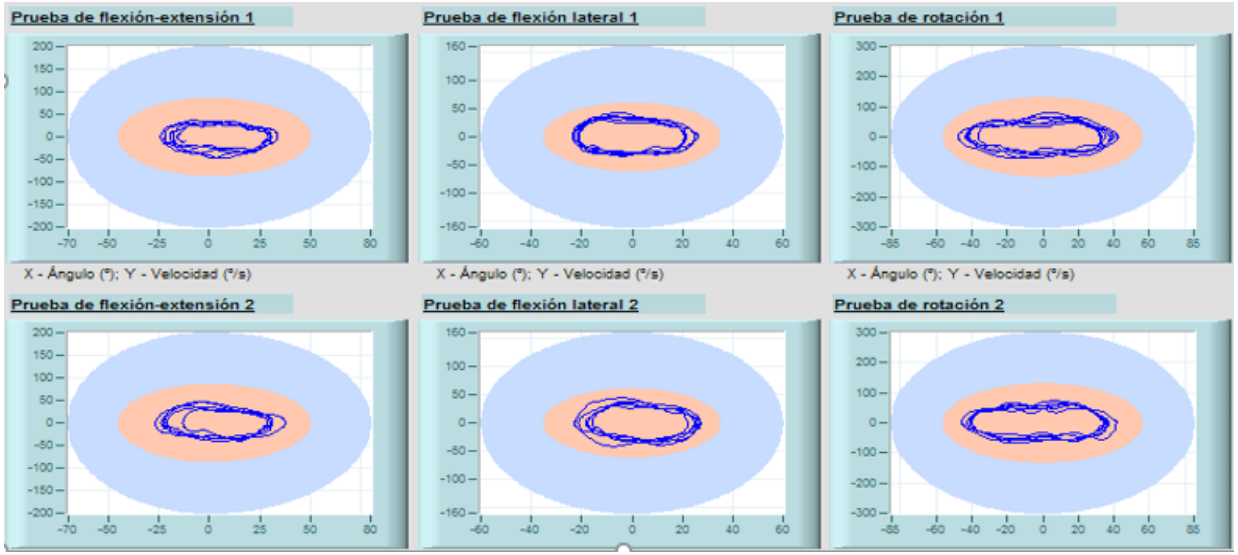
Limit test: it analyses the functional limits of movement in each spatial direction.

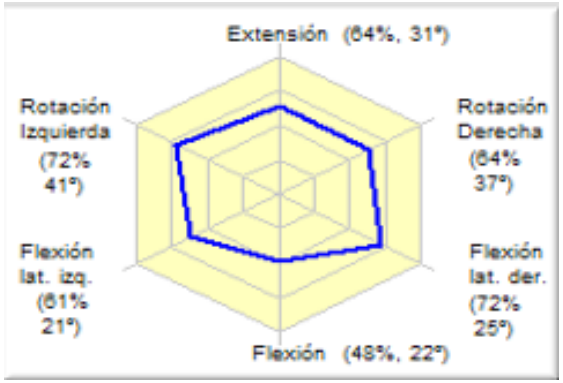
Functional test (or lamp test): it analyses the cervical movement while the patient directs her vision to the lamps located on the ceiling.

	Rango	Vel. máx.	Acel. máx.	Armonía	Rep. intraprueba
Flex.-ext. 1	52.1	33.5	28.3	100.0	56.7
Flex.-ext. 2	54.5	37.9	26.8	100.0	57.6
Flex. lat. 1	68.3	48.1	44.9	100.0	81.0
Flex. lat. 2	69.9	46.4	34.8	100.0	62.7
Rotación 1	73.1	45.4	31.1	100.0	50.4
Rotación 2	69.8	45.5	34.3	100.0	59.7



	Flex.-ext. 1	Flex.-ext. 2	Flex. lat.1	Flex. lat. 2	Rotación 1	Rotación 2
Valoración	55.9	57.0	69.3	65.4	64.2	64.8
Rep. interprueba	95.5		89.8		94.1	





	Rango		Velocidad máxima		Aceleración máxima		
	Flex.-ext.	Rotación	Flex.-ext	Rotación	Flex.-ext.	Rotación	Valoración
Prueba 1 (izq.)	54.0	39.4	39.9	19.8	29.1	18.2	33.4
Prueba 2 (central)	43.1	-	36.8	-	31.9	-	37.3
Prueba 3 (der.)	67.9	56.9	43.2	33.0	32.8	24.7	43.1

Altered

The function studied is considered to be normal when the Index of Normality is between 90 and 100%.

The lower the Index of Normality, the greater the degree of functional alteration.

Lumbar clinical case

60-year patient.
Lorry driver.
He fell off the lorry, which resulted in wedge fracture of L1
He was administered a conservative treatment of the fracture.
Back brace removed 3 months later.
Four months after the fracture, he continued to report low back pain radiating to the right lower limb.

On physical examination: low back pain but no muscle contractures on palpation. Lumbar flexion is painful. Negative Lasègue and Bragard. Good muscle function.

The MRI performed shows that the anterior wedge fracture of vertebral body L1 is consolidated and cannot be observed. There are degenerative signs in the disc space of L4-L5 and L5-S1 without compromising both conjunction holes.

The results of a case after performing a functional assessment of the lumbar spine are discussed below. This test kinetically and **kinematically** analyses the movement of the lumbar spine in simple activities to detect abnormal or non-functional movements secondary to cervical pain.

The **NEDLUMBAR/IBV** assessment equipment was used and the recording technique was photogrammetry and two dynamometric platforms.

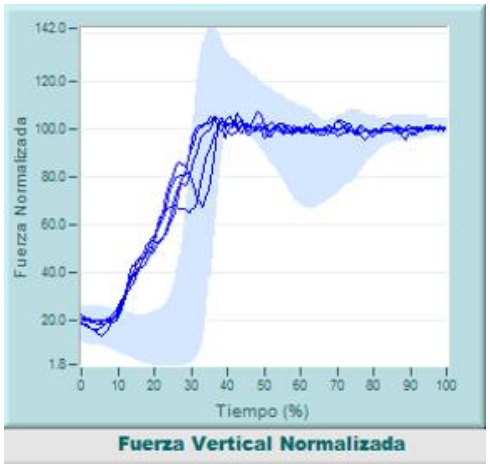
To perform the assessment, this system compares the results obtained with those of a group of subjects whose characteristics are comparable to those of the patient (databases made up of normal and pathological patients segmented by age and gender).

The assessment protocol is standardised and consists of two movements:

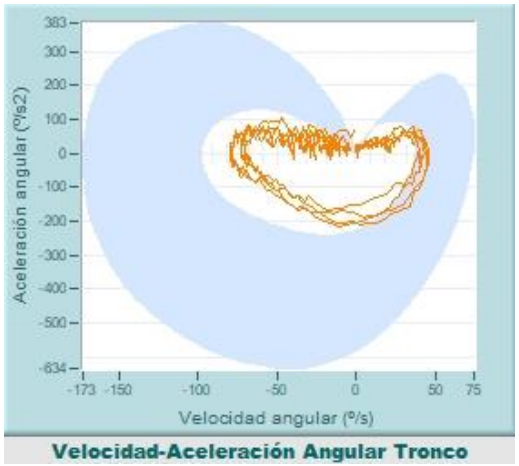
Activity of **rising from a chair.**
Activity of **lifting weights**.

The results obtained tell us about the movement pattern performed through biomechanical information on force, mobility, acceleration and repeatability of the movement, among others.

At the end, the study of the activity is summarised in a functional index. If the result of this index is higher than 90%, the ability of the person assessed to perform the activity falls within normality.



Fuerza Vertical Normalizada

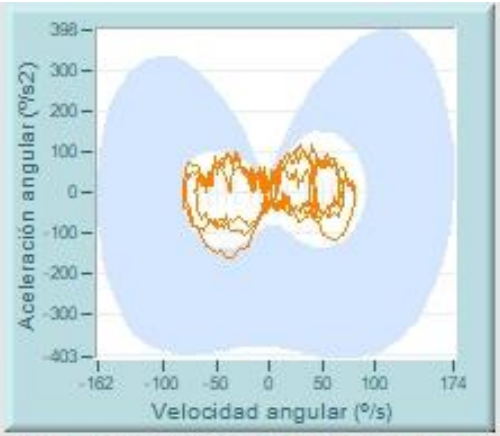


Velocidad-Aceleración Angular Tronco

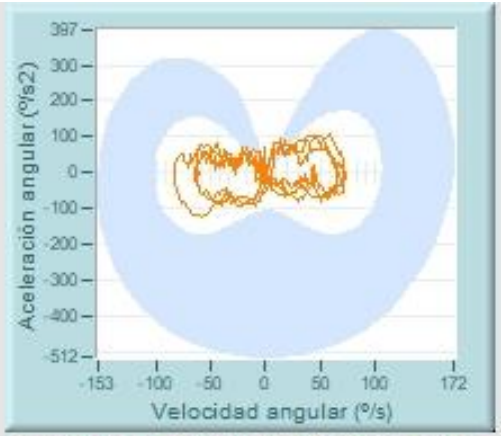
Prueba de Silla

Tiempo total (s)	4.9	56%
Fase Inclinación (%)	26.8	95%
Fase Descarga (%)	13.1	63%
Fase Levantamiento (%)	60.2	100%
Fuerza Vertical Mínima (%)	17.9	75%
Fuerza Vertical Máxima (%)	110.3	96%
Asimetría de Fuerzas (%)	11.5	78%
Mayor Apoyo	IZQUIERDA	
Movilidad Lumbar (º)	33.5	100%
Inclinación Torácica (º)	43.8	77%
Rotación Torácica (º)	7.3	83%
Vel. Ang. Máx. Tronco en Flexión (º/s)	43.5	80%
Acel. Ang. Máx. Tronco en Flexión (º/s2)	60.8	48%
Vel. Ang. Máx. Tronco en Extensión (º/s)	-75.9	80%
Acel. Ang. Máx. Tronco en Extensión (º/s2)	-188.6	65%
Variabilidad		100%
Repetibilidad		80%

Valoración Global 71%



Vel.-Acel. Angular de Tronco 0 Kg



Vel.-Acel. Angular de Tronco 5 Kg

Vel.-Acel. Angular de Tronco 10 Kg

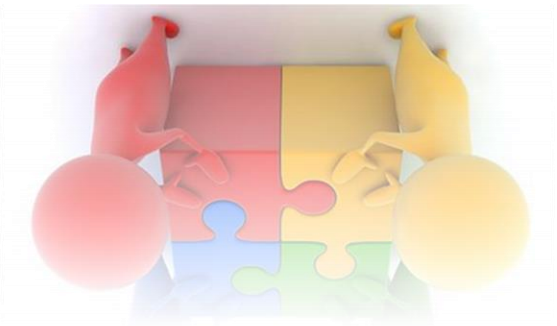
	0 Kg		5 Kg		10 Kg
Tiempo total (s)	3.5	48%	4.3	42%	
Fuerza Vertical Máxima (%)	109.0	45%	114.6	58%	
Asimetría de Fuerzas (%)	3.4	100%	11.5	98%	
Mayor Apoyo	IZQUIERDA		IZQUIERDA		
Movilidad Lumbar (º)	45.3	100%	43.4	100%	
Inclinación Torácica (º)	64.8	100%	66.7	100%	
Rotación Torácica (º)	8.0	85%	8.2	77%	
Vel. Ang. Máx. Tronco en Flexión (º/s)	72.5	54%	70.1	57%	
Acel. Ang. Máx. Tronco en Flexión (º/s2)	105.5	37%	111.0	45%	
Vel. Ang. Máx. Tronco en Extensión (º/s)	-76.6	65%	-70.7	63%	
Acel. Ang. Máx. Tronco en Extensión (º/s2)	-117.9	51%	-105.4	52%	
Repetibilidad		100%		82%	

Prueba de Peso

Valoración Global 65%

Activity class

Working on clinical cases (Documents)



Question guide of the cervical case

Is there a limitation of cervical mobility?

Which is the most limited movement?

Does he perform quick neck flexion-extension movements?

Is there any asymmetry in the movement?

Based on the graph, does he perform repeatable movements?

Is there an improvement in the second biomechanical assessment session?

Case solution

Is there a limitation of cervical mobility in the first assessment? Yes

Which is the most limited movement? Flexion

Does he perform quick neck flexion-extension movements? No. They are slow.

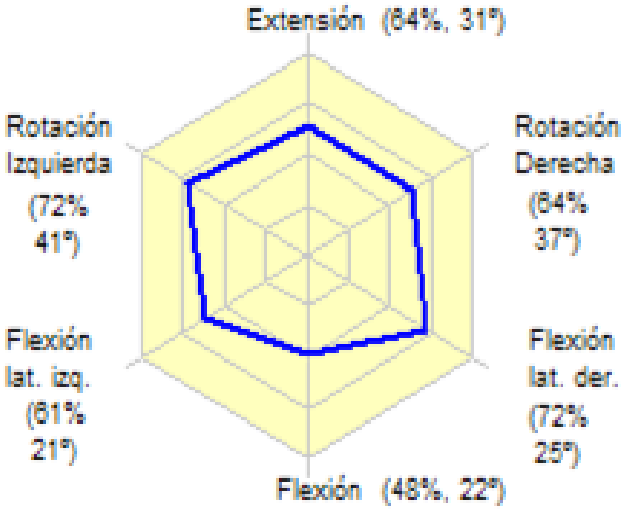
Is there any asymmetry in the movement? No

Based on the graph, does he perform repeatable movements? For instance, in rotations. Yes

Is there an improvement in the second biomechanical assessment session? Yes

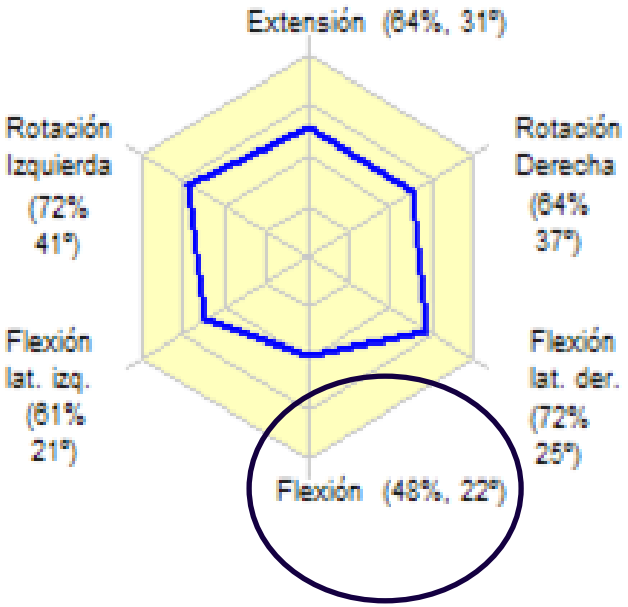
Solutions:

Is there a limitation of cervical mobility in the first assessment?



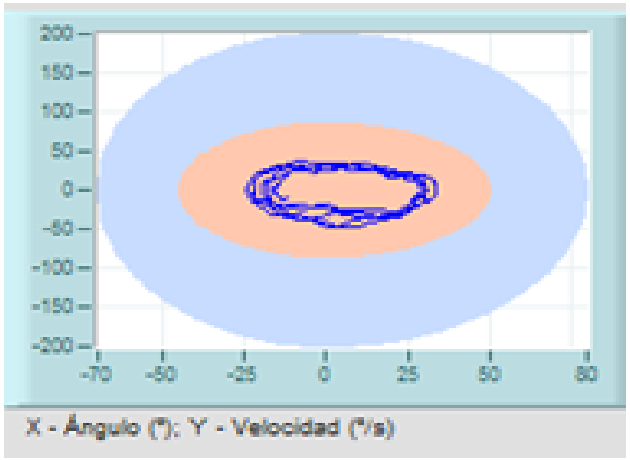
Solutions:

Which is the most limited movement?



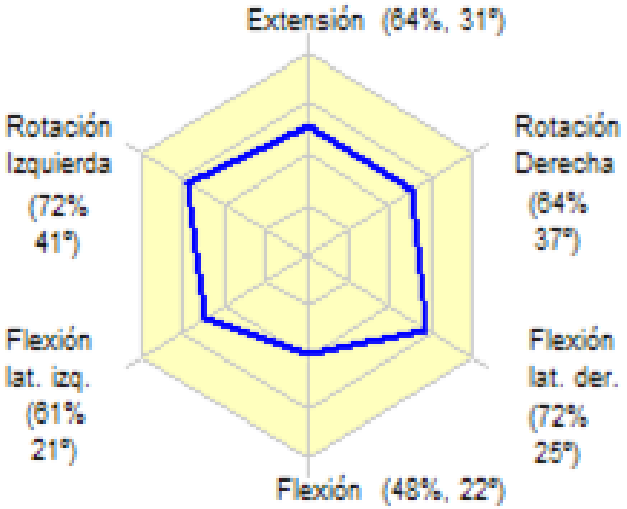
Solutions:

Does he perform quick neck flexion-extension movements?



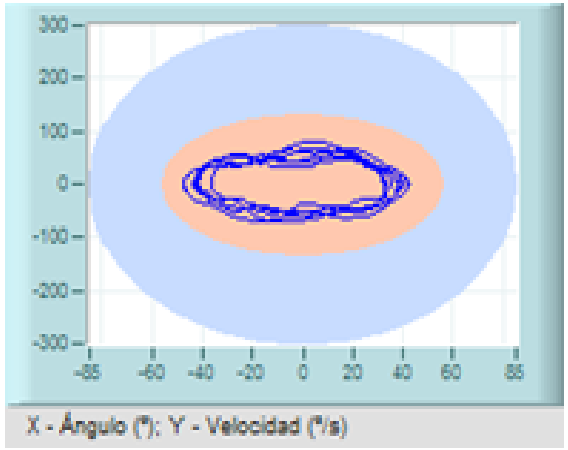
Solutions:

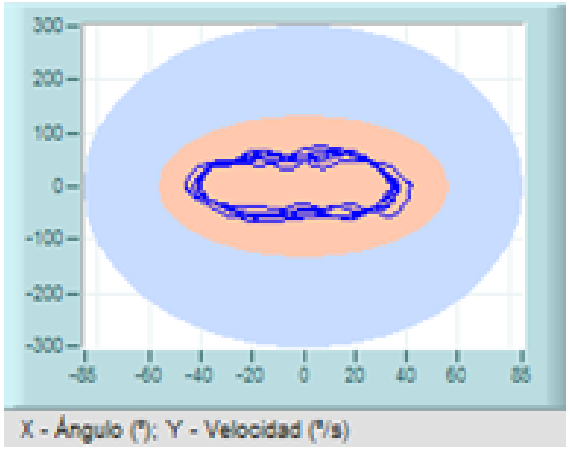
Is there any asymmetry in the movement?



Solutions:

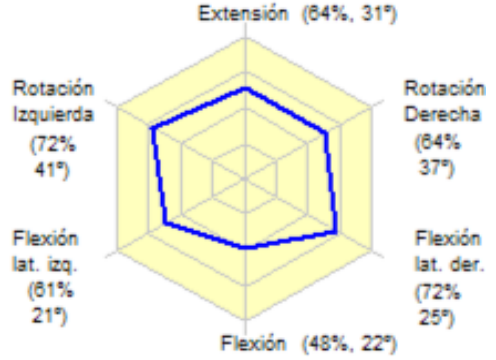
Based on the graph, does he perform repeatable movements? For instance, in rotations.

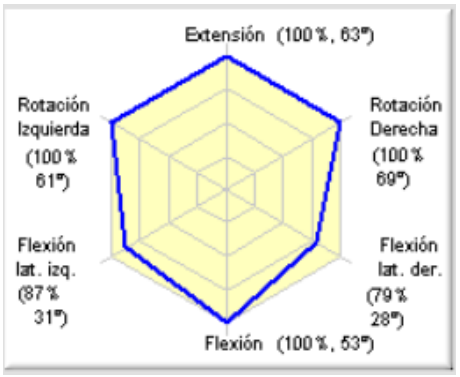


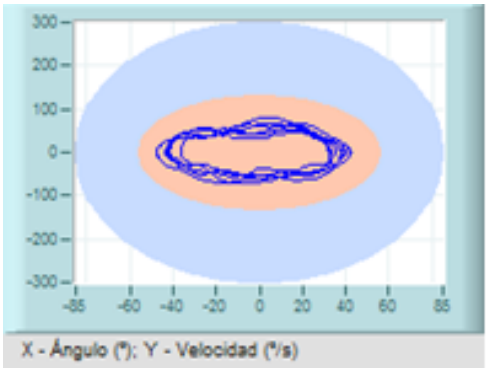


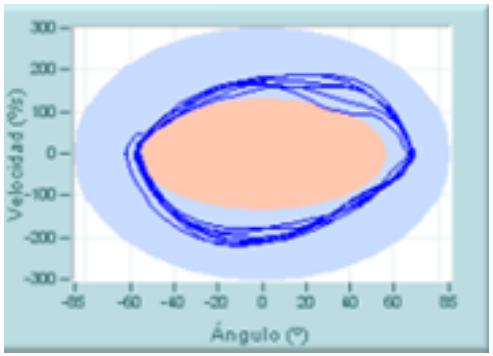
Solutions:

Is there an improvement in the second biomechanical assessment session?









Question guide of the lumbar case

Is there an increase in the time needed to perform each activity?

Is there any element in the graphs of the sit-to-stand that you can associate with difficulty in performing such movement? Why? (Discuss with the teacher)

Do you think that the speed of movement of the trunk is fast and corresponds to normal motion?

Can you find any asymmetry in the support while performing the activity?

Has the patient improved compared to the previous session? Why? (Discuss with the teacher)

Case solution

Is there an increase in the time needed to perform each activity? Yes

Is there any element in the graphs of the sit-to-stand that you can associate with difficulty in performing such movement? Why? (Discuss with the teacher) Yes

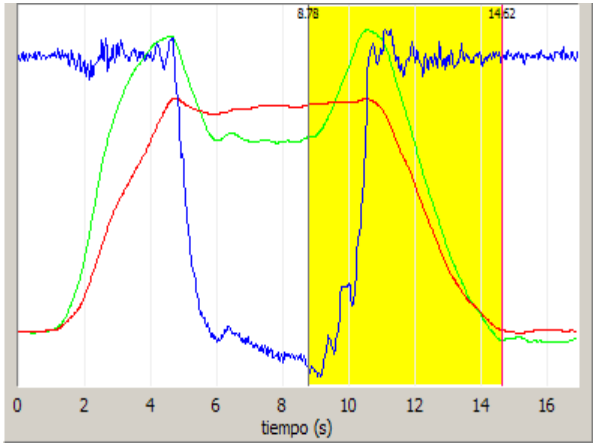
Do you think that the speed of movement of the trunk is fast and corresponds to normal motion? No

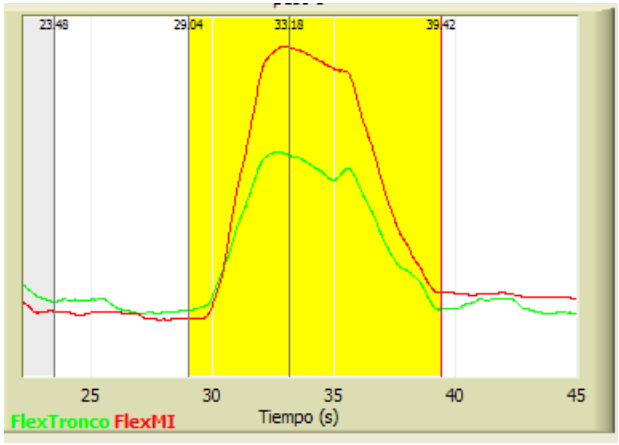
Can you find any asymmetry in the support while performing the activity? Yes

Has the patient improved compared to the previous session? Why?

Solutions:

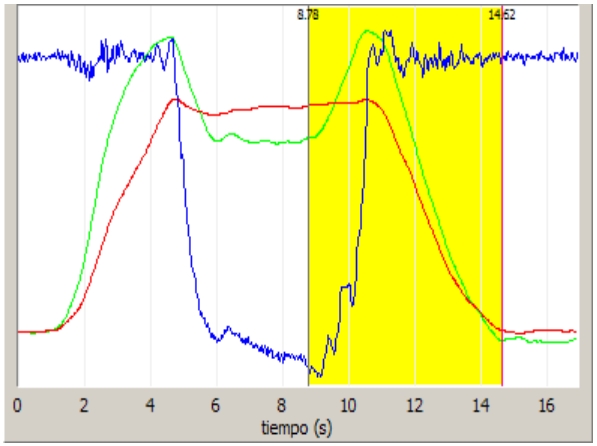
Is there an increase in the time needed to perform each activity?





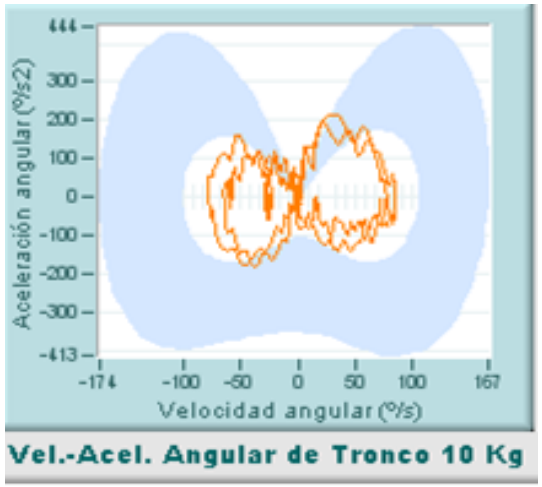
Solutions:

Is there any element in the graphs of the sit-to-stand that you can associate with difficulty in performing such movement?



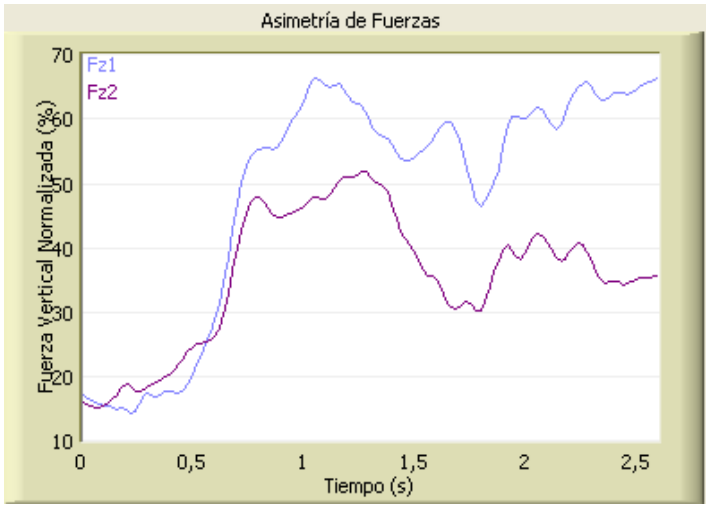
Solutions:

Do you think that the speed of movement of the trunk is fast and corresponds to normal motion?



Solutions:

Can you find any asymmetry in the support of both lower limbs when performing the activity?



Has the patient improved compared to the previous session?

Discuss as a group why

Key ideas

The biomechanical analysis techniques that allow us to know the strength and mobility of the spine provide objective information about its functionality.

The range of motion of both the lumbar spine and the cervical spine can be analysed using biomechanical analysis techniques. Limited ranges of motion are a common result in people with pain.

Strength can also be assessed in people with low back pain, mainly using isokinetic systems. The most common results include a decrease in strength together with changes in the agonist/antagonist muscles ratio.

Another test related to muscle activity in people with low back pain is the flexion-relaxation analysis. The result of this test is usually altered since the phenomenon known as myoelectric silence disappears.

The movement patterns in daily life activities can also be assessed in people with low back pain. The results provided by this biomechanical analysis measure the functional alteration and serve as a guide to monitor the patient's progress.

In order to obtain reliable results, all these tests require highly standardised measurement protocols and a good command of the recording techniques applied.