

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.3. How is a normal biomechanical assessment of the cervical spine?



OBJECTIVES

- To learn the purpose of biomechanical assessment in the clinical sphere.
- To see some results obtained from biomechanical assessment of the cervical spine.
- To become familiar with interpreting the results obtained from cervical kinematic assessment among a normal population.
- To become familiar with interpreting the results obtained from cervical muscular strength assessment in a normal population.
- To apply the knowledge learnt in a clinical case.

CONTENTS

- Clinical and biomechanical assessment
- Functional assessment of the cervical spine
- Assessment of cervical range of motion
- Kinematic assessment of the cervical spine
- Strength assessment of the cervical spine
- Key ideas

Clinical and biomechanical assessment

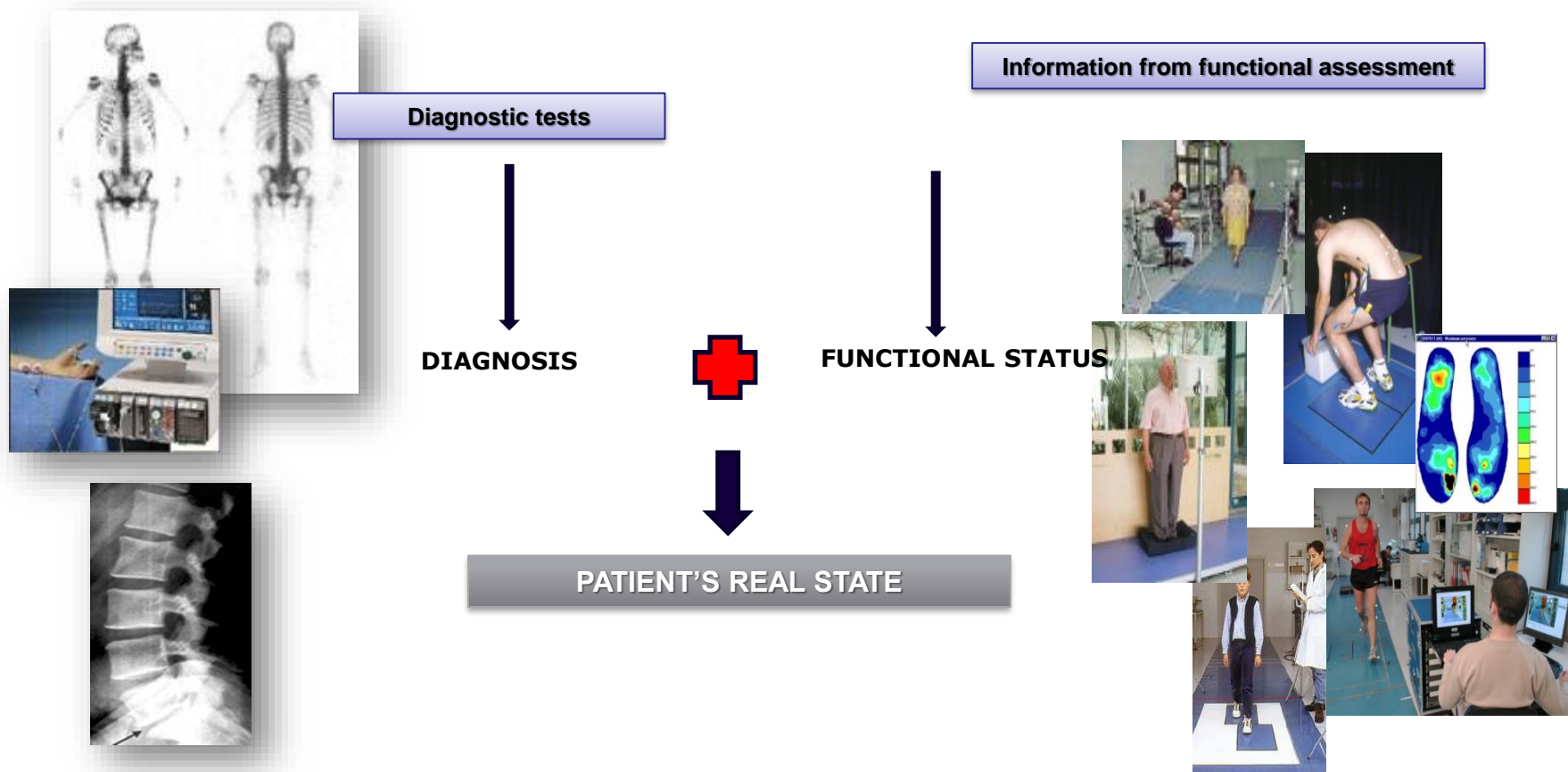
Why functional assessment?



Clinical and biomechanical assessment

Why functional assessment?

Diagnostic tests versus Biomechanical tests



REMEMBER:

There are different biomechanical assessment tests. The aspects that determine them are:

- What function is being assessed.
- What instrument and technique it uses.
- What assessment protocol has been used.

AND IN THIS EDUCATIONAL UNIT:

- **What results it provides, in what units and with what data analysis techniques they have been obtained.**
- **Standardised criteria for interpretation.**

Functional assessment of the CERVICAL SPINE.

ASSESSMENT FUNCTION	INSTRUMENTAL TECHNIQUE	RESULTS
MOBILITY		
Range of motion	Inclinometers, electrogoniometers	Range of motion (°)
Properties of the motion	Photogrammetry, inertial sensors	Range of motion (°) Velocity (°/s) / Angular acceleration Harmony Repeatability
STRENGTH		
Isometric force	Dynamometer	Isometric force (Nwm)
Muscle activity	Surface electromyography	Muscle activity (qualitative)

Assessment of cervical range of motion

	Pos. Neutra (OCC/D1)	Pos. Flexión (OCC/D1)	Pos. Extensión (OCC/D1)	Flexión	Criterio AMA	Extensión	Criterio AMA
1ª	9.7° / 19.6°	64.4° / 51.3°	-37.8° / 1.3°	23.0°	OK	29.0°	OK
2ª	12.7° / 21.0°	66.8° / 51.6°	-36.8° / -0.7°	23.0°	OK	27.0°	OK
3ª	8.0° / 17.3°	67.9° / 51.9°	-43.9° / -6.4°	25.0°	OK	28.0°	OK

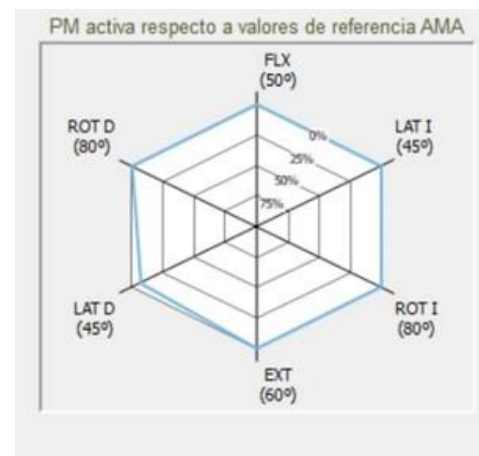


System with two electronic inclinometers, located on the corresponding bony protuberances (occipital-D1) to assess the maximum joint range for cervical spine flexion-extension motion.

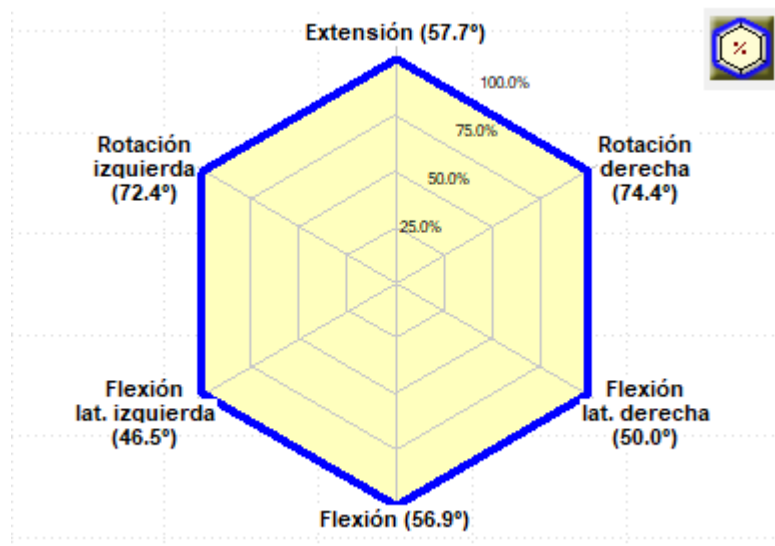
RESULTS:

Range of motion (°)

	Amplitud máxima	PM frente referencia AMA
Flexión	80°	0%
Extensión	70°	0%
Flexión Lateral Izquierda	45°	0%
Flexión Lateral Derecha	42°	7%
Rotación Izquierda	80°	0%
Rotación Derecha	80°	0%



Assessment of cervical range of motion



MEASURING APPARATUS: Inclinometers, electrogoniometers or photogrammetry.

TYPE OF ANALYSIS: Kinematic.

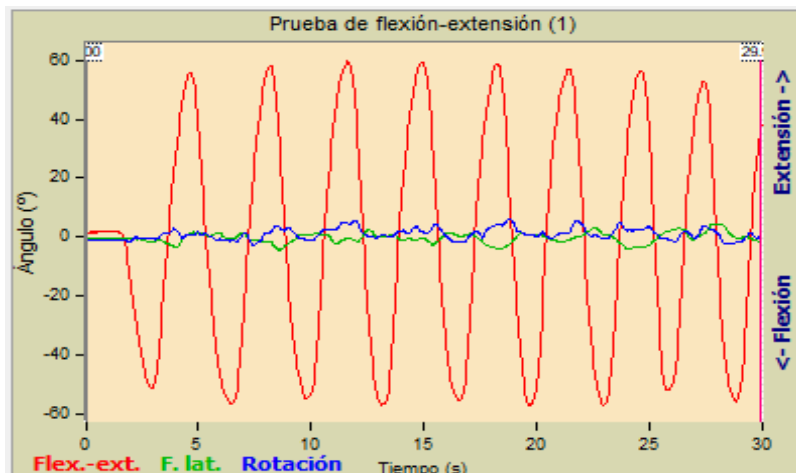
GRAPH: Cervical spine range of movement (°) in three planes. The graph's outer border represents the zone of normality.

INTERPRETATION OF THE RESULT: Good mobility of the cervical spine in all planes.

Kinematic assessment of the cervical spine

MEASURING APPARATUS: Photogrammetry, inertial sensors.

TYPE OF ANALYSIS: Kinematic.



GRAPH: This shows the cervical flexion-extension mobility (red line) over a period of time (30 s), together with the coupled kind of motions (green and blue lines).

INTERPRETATION OF THE RESULT: Cervical spine motion in the sagittal plane with a fast speed, since there is a high number of motion cycles in 30 s. The lateral flexion and rotation (coupled) movements are small, which falls within normal spinal behaviour.

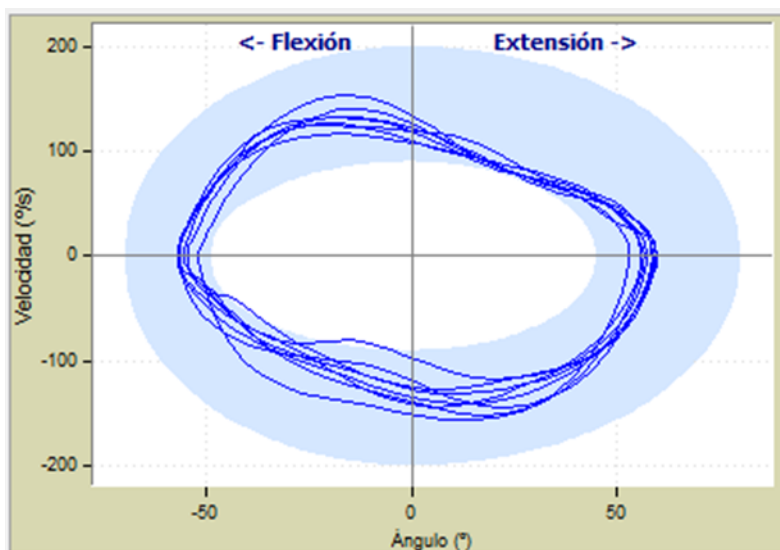
Kinematic assessment of the cervical spine

MEASURING APPARATUS: Photogrammetry

TYPE OF ANALYSIS: Kinematic.

GRAPH: Angular velocity ($^{\circ}/s$) of the cervical spine for flexion-extension range of motion ($^{\circ}$).

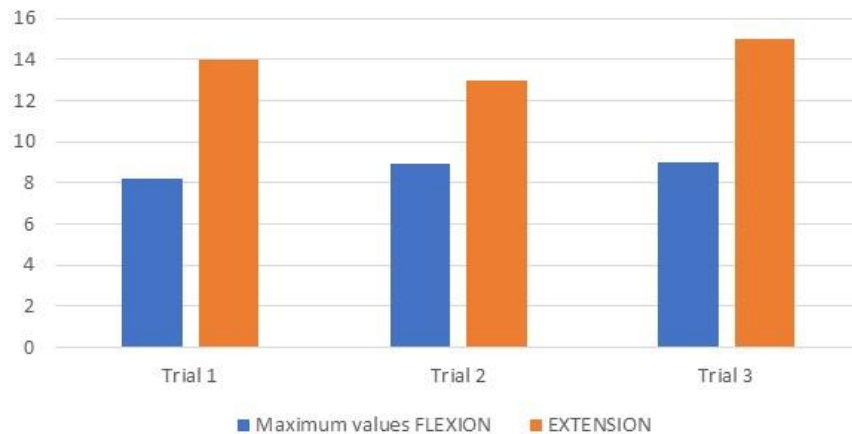
INTERPRETATION OF THE RESULT: Cervical spine motion in the sagittal plane with a high speed and range within benchmark values (the blue band represents normal values).



Strength assessment of the cervical spine

	FLEXION (Kg)	EXTENSION (Kg)
Test 1	8.2	14
Test 2	8.9	13
Test 3	9	15
Average	8.7	14
Maximum	9	15
CV	5.0	7.1

Isometric (Kg)



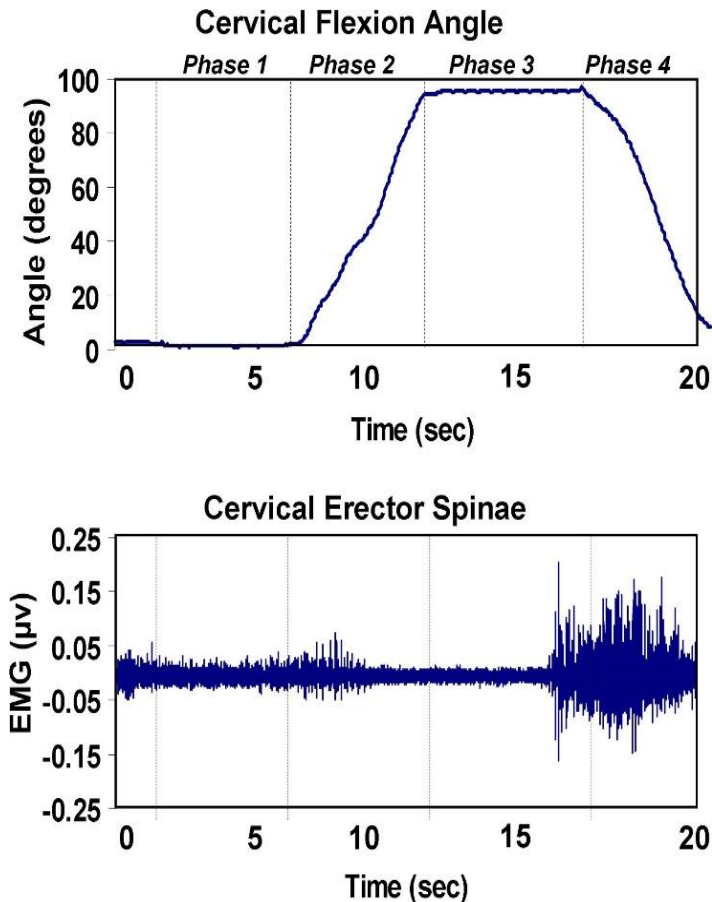
MEASURING APPARATUS: Dynamometer.

TYPE OF ANALYSIS: Dynamic.

PARAMETERS AND GRAPHS: Maximum force (kg) from the muscle group assessed (spinal flexors and extensors) in a test with three repetitions for each muscle group.

INTERPRETATION OF THE RESULT: The extensor's strength is greater than the flexor's strength, which agrees with normal agonist-antagonist behaviour. The high repeatability of the results is confirmed (coefficient of variation (CV) <10%).

Strength assessment of the cervical spine



MEASURING APPARATUS: Surface EMG

Raw surface EMG trace for the cervical erector spinae (bottom) from a subject displaying the flexion-relaxation phenomenon with activation prior to re-extension, during the experimental protocol. The cervical flexion angle is also shown (top). Data is presented for the different phases of the protocol: upright (Phase 1), forward flexion (Phase 2), full flexion (Phase 3), re-extension (Phase 4). Image and note from Burnett, A., O'Sullivan, P., Caneiro, J. P., Krug, R., Bochmann, F., & Helgestad, G. W. (2009). "An examination of the flexion-relaxation phenomenon in the cervical spine in lumbo-pelvic sitting"; *Journal of Electromyography and Kinesiology*, 19(4), e229-e236.

Example of results



[This photo](#)

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Below, we comment on the results from a case following a functional assessment of a cervical spine. This test **kinetically** analyses cervical spine motion in simple activities to detect anomalous or non-functional motion as a side effect to a painful spinal condition.

The assessment apparatus used is the NEDCERVICAL/IBV, and the recording technique was photogrammetry.

in order to carry out the assessment, this system compares the results obtained with those from a group of subjects comparable to the patient's characteristics (databases with normal and pathological data, and data segmented by age and gender).

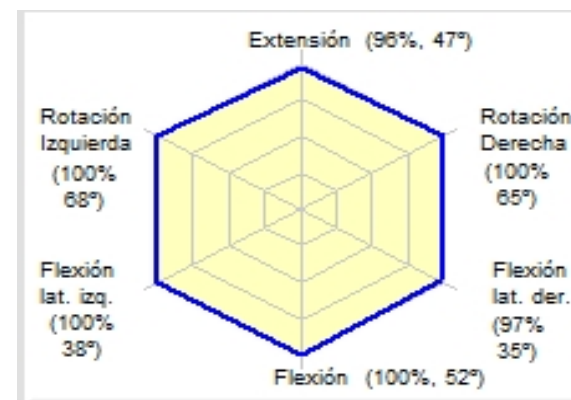
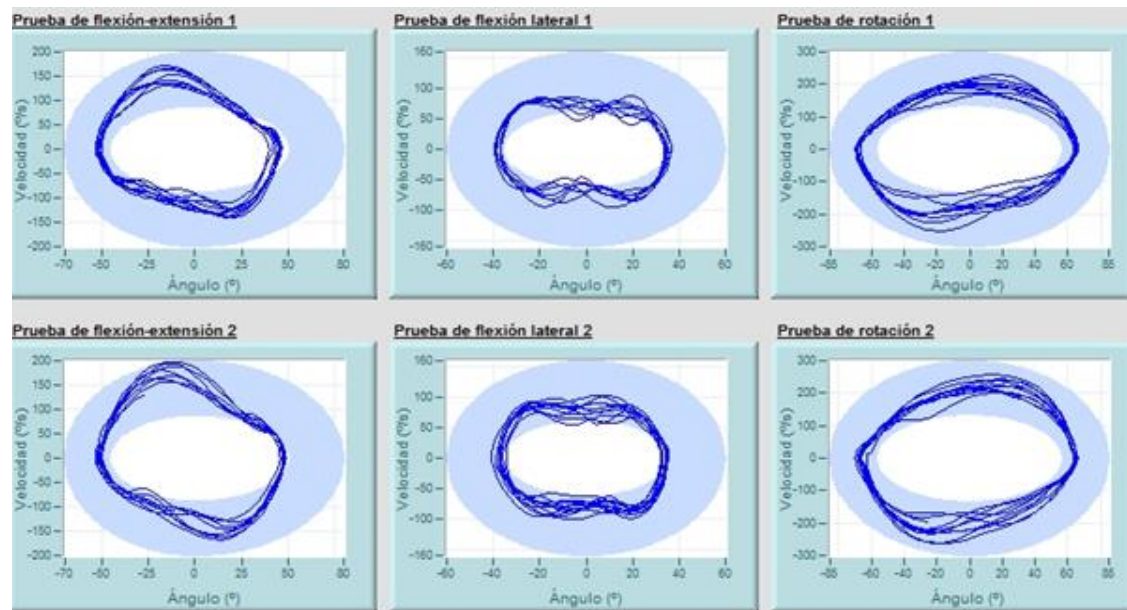
The assessment protocol is standardised and uses two gestures:

Limit Test: This analyses the functional limits to motion in each of the spatial directions.

Functional test (or lights test): This analyses the cervical movement while the patient stares towards lights located on the ceiling.

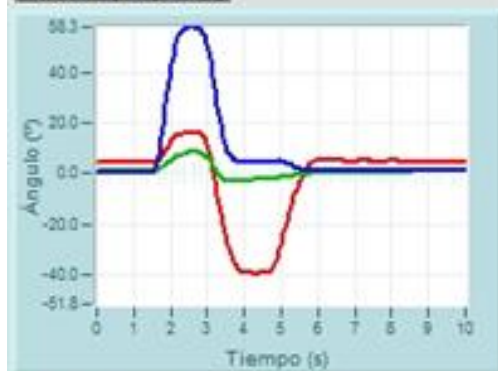
	Rango	Vel. máx.	Acel. máx.	Armonía	Rep. intraprueba
Flex.-ext. 1	96.9	100.0	100.0	100.0	100.0
Flex.-ext. 2	98.4	100.0	100.0	100.0	100.0
Flex. lat. 1	100.0	100.0	100.0	100.0	72.1
Flex. lat. 2	100.0	100.0	100.0	100.0	75.7
Rotación 1	100.0	100.0	100.0	100.0	81.6
Rotación 2	100.0	100.0	100.0	100.0	90.1

	Flex.-ext. 1	Flex.-ext. 2	Flex. lat. 1	Flex. lat. 2	Rotación 1	Rotación 2
Valoración	99.0	99.5	96.9	97.3	98.0	98.9
Rep. interprueba	99.7		99.0		98.1	



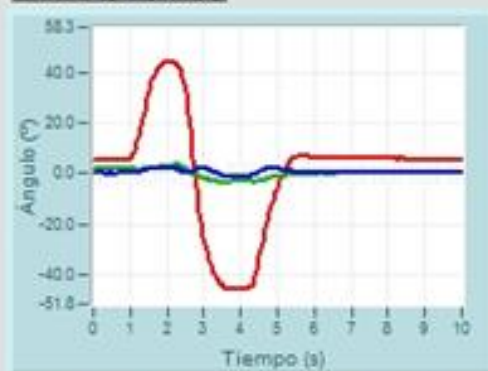


Prueba 1 (lámpara 1):



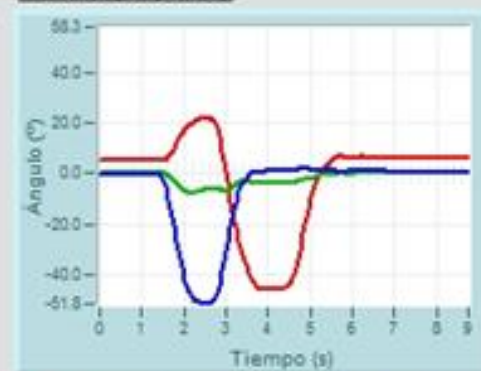
Flex.-extensión Flex. lateral Rotación

Prueba 2 (lámpara 2):



Flex.-extensión Flex. lateral Rotación

Prueba 3 (lámpara 3):



Flex.-extensión Flex. lateral Rotación

	Rango		Velocidad máxima		Aceleración máxima		Valoración
	Flex.-ext.	Rotación	Flex.-ext.	Rotación	Flex.-ext.	Rotación	
Prueba 1 (izq.)	100.0	100.0	100.0	100.0	95.1	100.0	99.2
Prueba 2 (central)	100.0	-	100.0	-	100.0	-	100.0
Prueba 3 (der.)	100.0	100.0	100.0	100.0	100.0	100.0	100.0



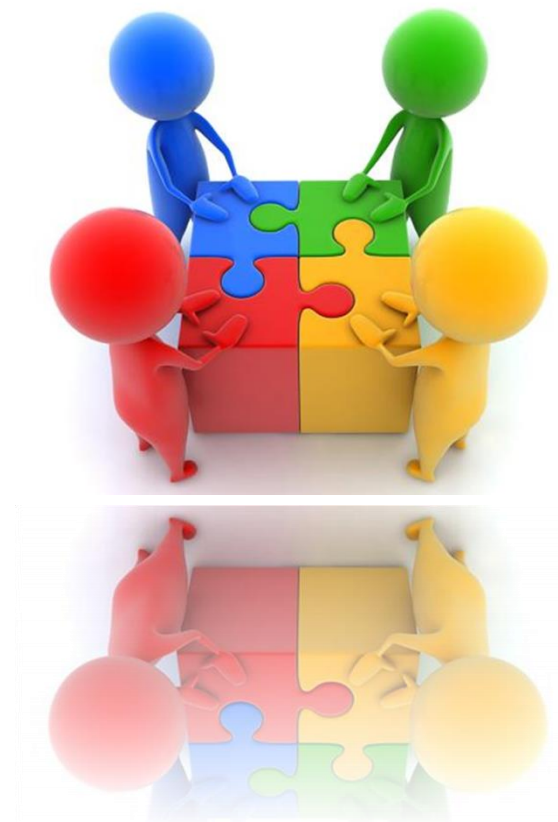
Normal

The function studied is considered normal when the normality index is between 90 and 100%.

The lower the normality index, the greater the level of functional alteration.

Class activity

Working on a clinical case
(Document)



Questions guide

What is the average range of motion for the maximum extension recorded for the cervical spine?

Is the mobility recorded in the rotations considered to fall within normality?

What do you think in general about the speed of the motions?

In general, were the motions carried out smoothly?

Can the motions performed be considered repeatable?

Was the functional test found to be limited?

Functionally, what is the mobility like in general?

Solution to the case

What is the average range of motion for the maximum extension recorded for the cervical spine? **58°**

Is the mobility recorded in the rotations considered to fall within normality? **Yes**

In general, how would you describe the speed of the motions? **Normal and fitting the corresponding benchmark for age and gender.**

In general, were the motions carried out smoothly? **Yes**

Can the motions performed be considered repeatable? **Yes**

Was the functional test found to be limited? **No**

Functionally, what is the mobility like in general? **Normal**



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