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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.4. How is a normal biomechanical assessment of the lumbar spine?

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Politechnika Śląska

IBV INSTITUTO DE BIOMECÁNICA DE VALENCIA

VNIVERSITAT DE VALÈNCIA

AMSE THE ASSOCIATION OF MEDICAL SCHOOLS IN EUROPE

OBJECTIVES

- To recognise the normal results of a lumbar biomechanical assessment.
- To become familiar with the interpretation of the results obtained from the lumbar biomechanical assessment in a normal population.
- To become familiar with the interpretation of the results obtained from the assessment of lumbar muscle strength in a normal population.
- To apply the knowledge acquired to a clinical case.

CONTENTS

- Functional assessment of the lumbar spine
- Assessment of the lumbar range of motion
- Kinematic assessment of the lumbar spine
- Kinematic and kinetic assessment in daily activities and low back pain
- Force assessment of the lumbar spine
- Key ideas

Functional assessment of the lumbar spine

ASSESSMENT FUNCTION	INSTRUMENTAL TECHNIQUE	OUTCOMES
MOBILITY		
Range of movement	Inclinometers Electrogoniometers	Range of movement (º)
Characteristics of the movement	Photogrammetry Inertial systems Dynamometric platform	Range of movement (º) Angular acceleration (º/s2) /Velocity(º/s) Reaction force/Asymmetries Repeatability
FORCE		
Isokinetic force	Dynamometer	Torque (Nw m)
Muscle activity	Surface electromyography	Muscle activity (flex-relax phenomenon)

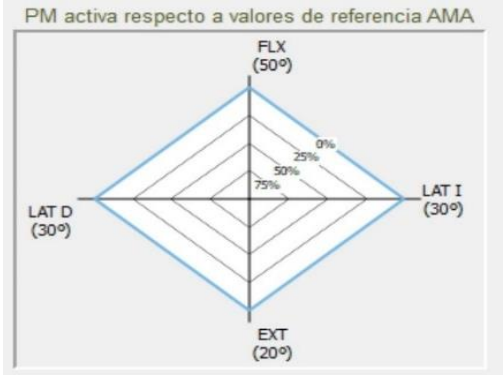
Assessment of the lumbar range of motion

	Pos. Neutra (D12/SACRO)	Pos. Flexión (D12/SACRO)	Pos. Extensión (D12/SACRO)	Flexión	Criterio AMA	Extensión	Criterio AMA
1ª	-20.2º / 36.1º	70.3º / 65.4º	-40.5º / 23.5º	61.0º	OK	7.0º	>5º
2ª	-27.6º / 23.4º	74.8º / 68.5º	-43.4º / 27.6º	57.0º	OK	20.0º	OK
3ª	-24.3º / 25.1º	74.2º / 69.3º	-41.7º / 28.4º	54.0º	OK	20.0º	OK
4ª	-21.8º / 27.4º	79.5º / 74.8º	-41.1º / 25.6º	53.0º	OK	17.0º	OK

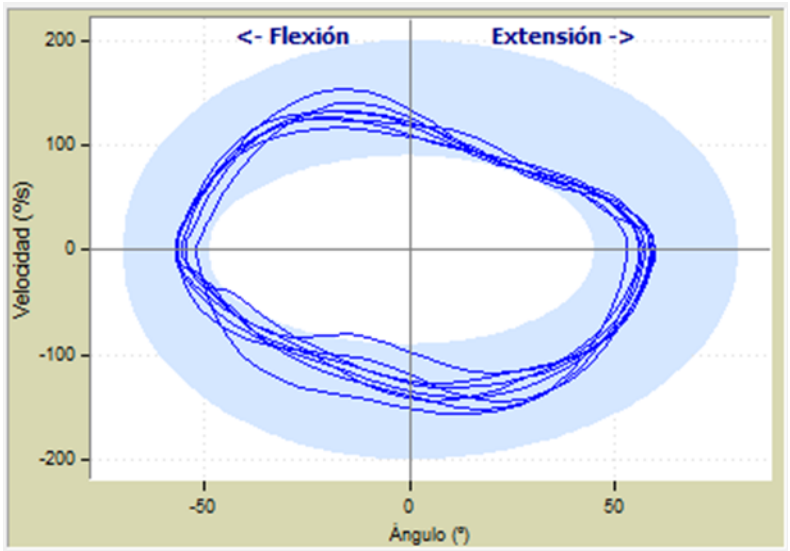
Electronic dual inclinometry system placed on the appropriate bony prominences (T12-sacrum) to assess the maximum joint range in the flexion-extension movement of the lumbar spine.

OUTCOMES: Range of movement (º) and mobility loss (ML)

	Amplitud máxima	PM frente referencia AMA
Flexión	63º	0%
Extensión	35º	0%
Flexión Lateral Izquierda	42º	0%
Flexión Lateral Derecha	50º	0%



Kinematic assessment of the lumbar spine



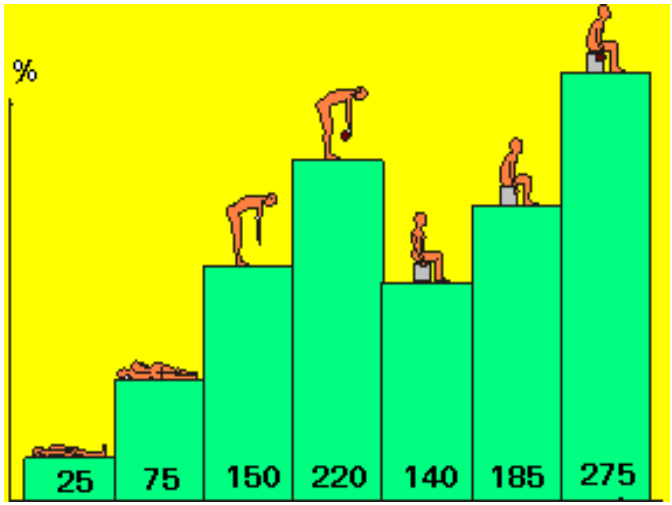
MEASURING EQUIPMENT:
Photogrammetry, inertial systems.

TYPE OF ANALYSIS: Kinematic.

GRAPH: Angular velocity (º/s) of the lumbar spine versus flexion-extension range of motion (º). The blue band represents the normal reference values for both speed and range of motion.

INTERPRETATION OF THE RESULT:
Movement of the lumbar spine in the sagittal plane at a normal speed, and range within reference values.

Kinematic and kinetic assessment in daily activities



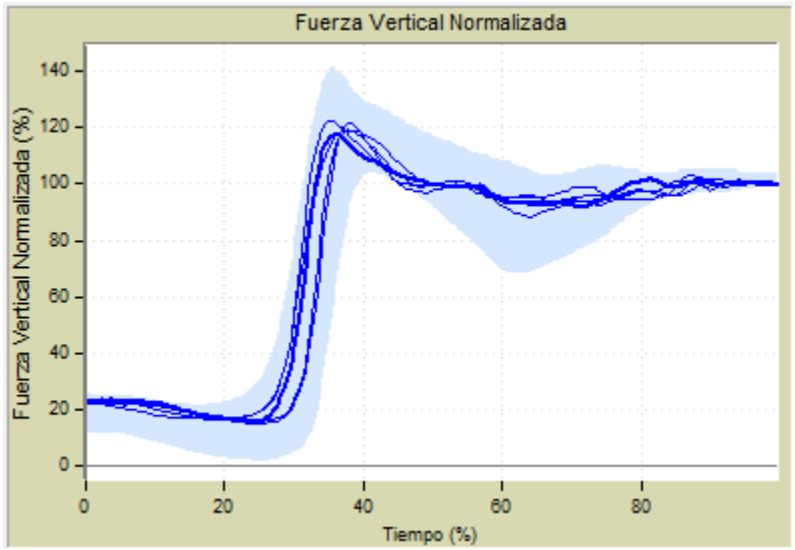
Graphical comparison of intradiscal pressures at L3-L4 during different activities (Image: Nachemson, A. L. (1976). The lumbar spine an orthopaedic challenge. *spine*, *1*(1), 59-71)

In people with low back pain, activities such as bending the trunk or lifting weights are associated with significant increases in intradiscal pressure and therefore pain.

The biomechanical analysis of these activities provides a more precise definition of them, detecting movement disorders that may be associated with pathology or a functional alteration of the spine.

Kinematic and kinetic assessment in daily activities

Activity: rising from a chair



MEASURING EQUIPMENT: Dynamometric platform.

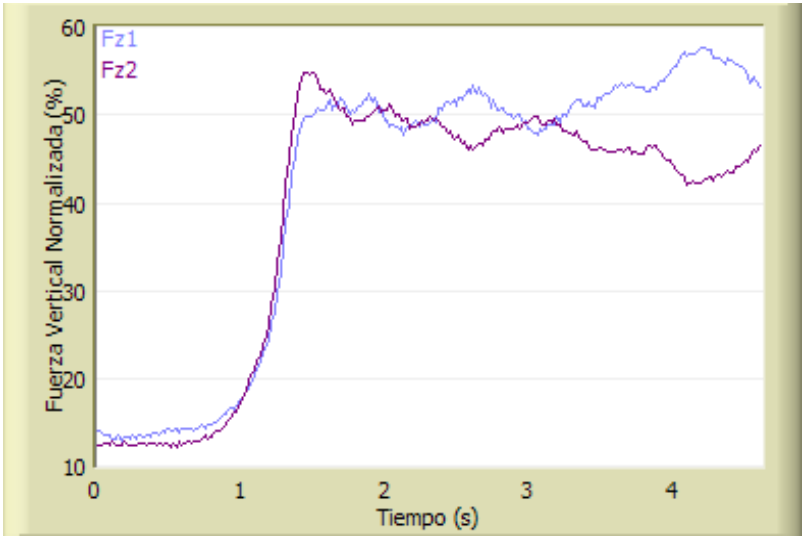
TYPE OF ANALYSIS: Kinetic.

GRAPH: It represents the different recorded repetitions of the **reaction force** during the sit-to-stand movement. The blue band represents the normal pattern of force in this movement.

INTERPRETATION OF THE RESULT: Repeatable and normal reaction force pattern, which means adequate momentum to perform the sit-to-stand movement (strength and coordination of trunk and lower limbs).

Kinematic and kinetic assessment in daily activities

Activity: rising from a chair
FORCE ASYMMETRY



MEASURING EQUIPMENT: 2 dynamometric platforms.

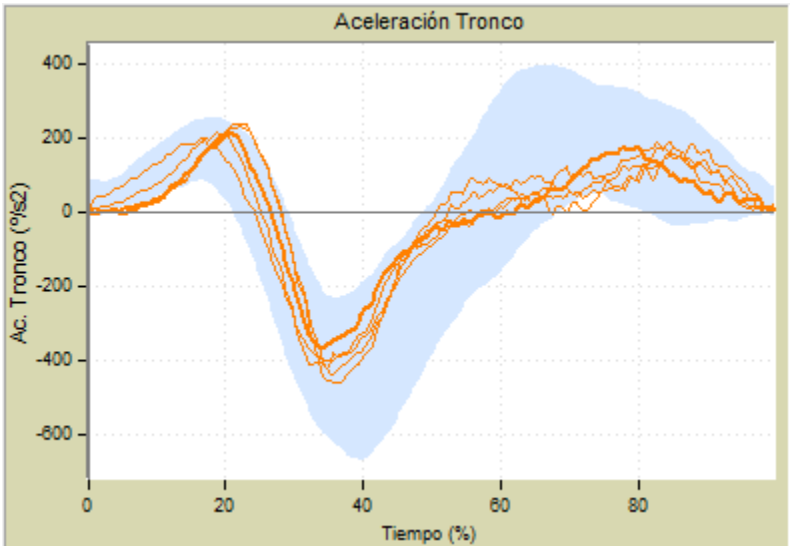
TYPE OF ANALYSIS: Kinetic.

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

INTERPRETATION OF THE RESULT: Symmetrical force pattern. Similar weight-bearing on both lower limbs when performing the sit-to-stand movement.

Kinematic and kinetic assessment in daily activities

Activity: rising from a chair



MEASURING EQUIPMENT: Photogrammetry or inertial system.

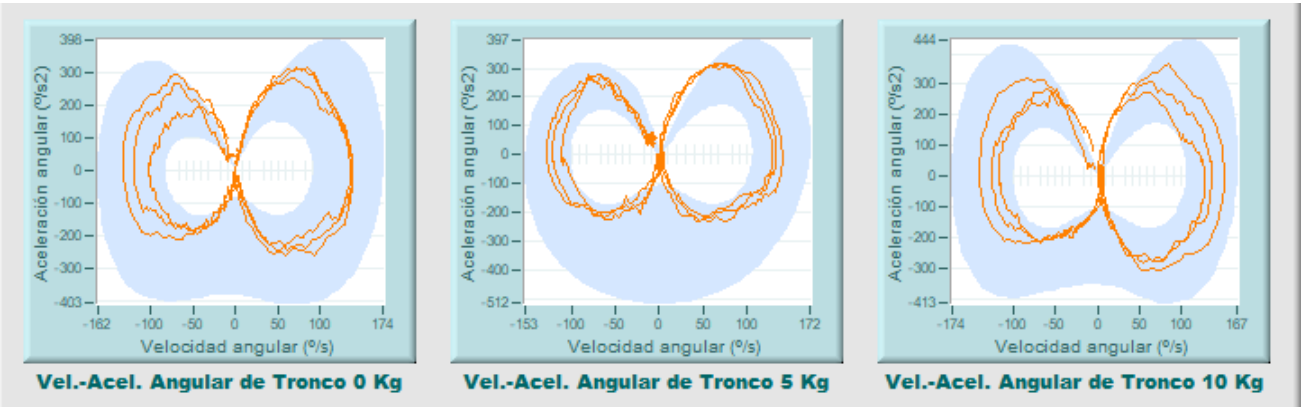
TYPE OF ANALYSIS : Kinematic.

GRAPH: It represents the angular acceleration of the spine (º/s2) in different recorded repetitions of the sit-to-stand activity. The blue band represents the normal pattern of acceleration in this activity.

INTERPRETATION OF THE RESULT: Normal angular acceleration of the spine, which involves speed and effectiveness in the movement performed.

Kinematic and kinetic assessment in daily activities

Activity:
lifting a weight



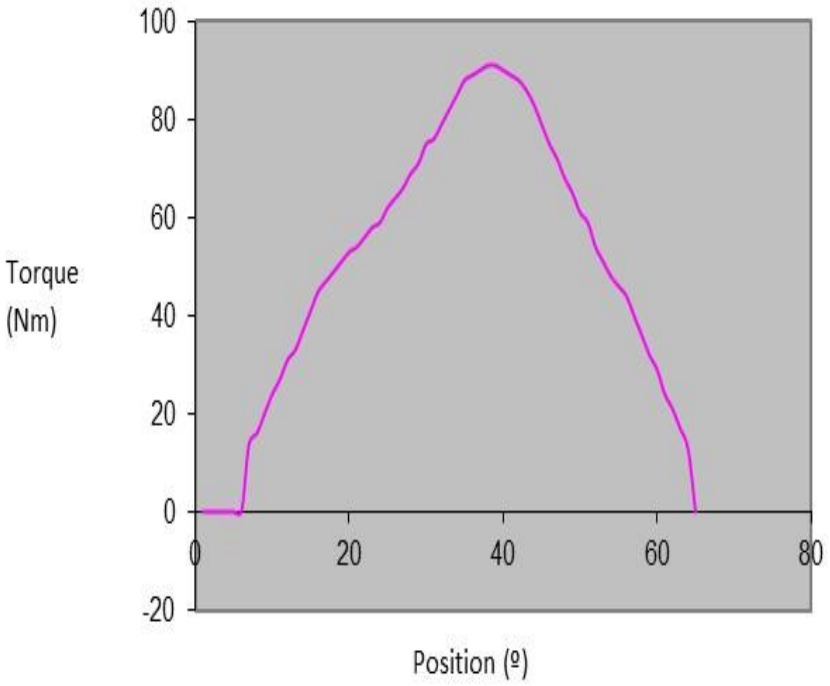
MEASURING EQUIPMENT: Photogrammetry or inertial system.

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 the three increasing weights. The blue band represents the normal pattern of acceleration and speed in this movement.

INTERPRETATION OF THE RESULT: The angular speed and acceleration of the trunk are normal for all the weights lifted, which implies good mobility and speed in the movement performed. The movement does not get worse when the weight lifted is increased.

Force assessment of the lumbar spine



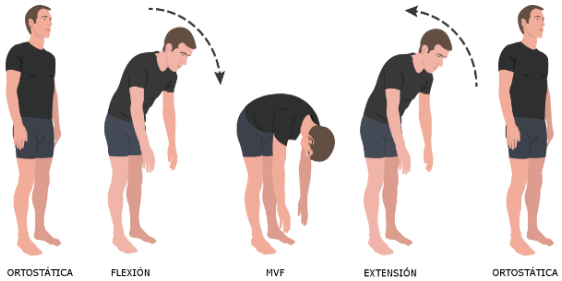
MEASURING EQUIPMENT: Isokinetic dynamometer.

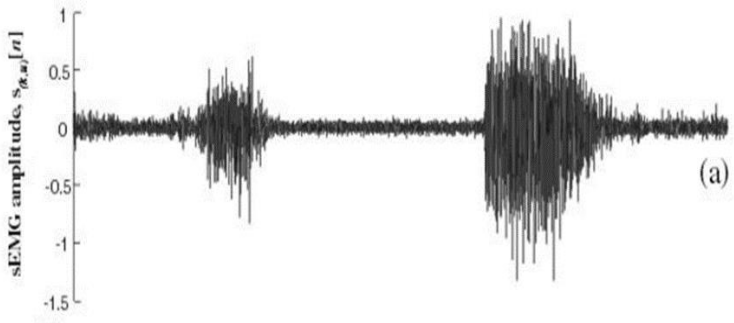
TYPE OF ANALYSIS: Physiological (strength).

GRAPH: Curve of the concentric isokinetic moment of torsion. The vertical axis reflects the amount of force produced by the muscle, and the horizontal axis the range of movement where the assessment is performed.

INTERPRETATION OF THE RESULT: A high slope both at the beginning and the end of the curve indicates that the subject can produce force and stop producing it. For a more accurate interpretation, the maximum peak it reaches depends on the maximum force values with which we are comparing.

Force assessment of the lumbar spine





MEASURING EQUIPMENT: Surface electromyography.

TYPE OF ANALYSIS: Physiological.

GRAPH: It represents the muscle activity during a lumbar spine flexion-extension test.

INTERPRETATION OF THE RESULT: The activity of the lumbar paraspinal muscles decreases in relation to the beginning of the trunk flexion and extension, which is compatible with the flexion-relaxation phenomenon.

Example of the outcomes

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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 lumbar pain.

The **NEDLUMBAR/IBV** assessment system was used, together with photogrammetry and two force dynamometric platforms as recording techniques.

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

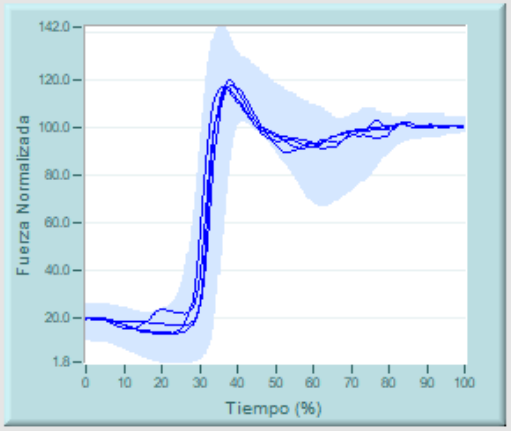
The assessment protocol is standardised and includes two activities:

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

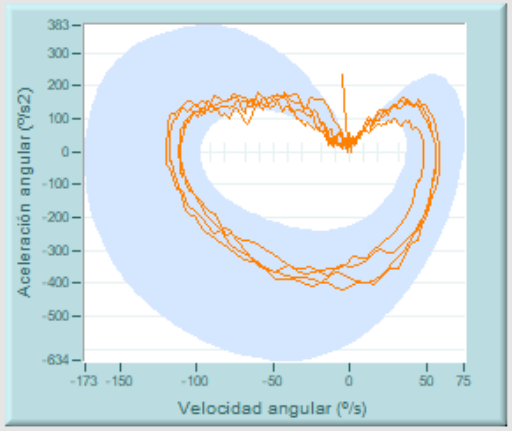
The results obtained provide biomechanical information about the movement pattern performed such as force, mobility, acceleration and repeatability of the movement, among others.

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

Activity: **rising from a chair**



Fuerza Vertical Normalizada

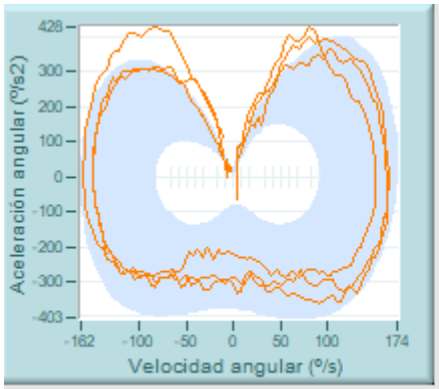


Velocidad-Aceleración Angular Tronco

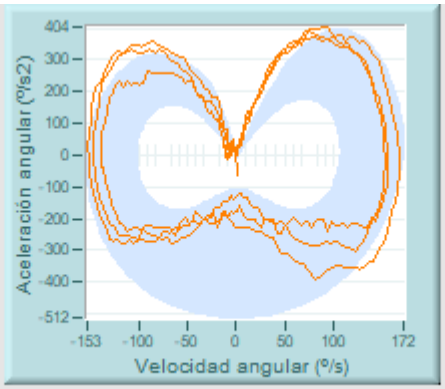
Tiempo total (s)	2.8	97%
Fase Inclinación (%)	29.3	100%
Fase Descarga (%)	4.1	100%
Fase Levantamiento (%)	66.5	95%
Fuerza Vertical Mínima (%)	14.9	90%
Fuerza Vertical Máxima (%)	117.8	100%
Asimetría de Fuerzas (%)	1.6	100%
Mayor Apoyo	IZQUIERDA	
Movilidad Lumbar (º)	23.9	81%
Inclinación Torácica (º)	36.0	94%
Rotación Torácica (º)	3.6	100%
Vel. Ang. Máx. Tronco en Flexión (º/s)	55.1	100%
Acel. Ang. Máx. Tronco en Flexión (º/s2)	127.2	100%
Vel. Ang. Máx. Tronco en Extensión (º/s)	-115.5	100%
Acel. Ang. Máx. Tronco en Extensión (º/s2)	-371.9	100%
Variabilidad		100%
Repetibilidad		100%

Valoración Global 98%

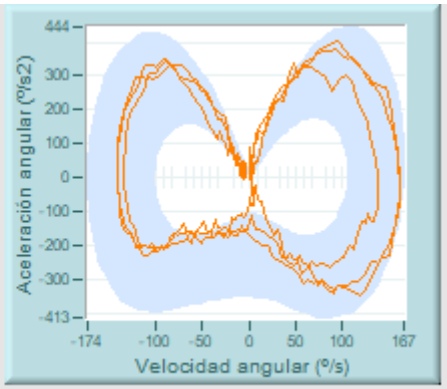
Activity: **lifting a weight**



Vel.-Acel. Angular de Tronco 0 Kg



Vel.-Acel. Angular de Tronco 5 Kg



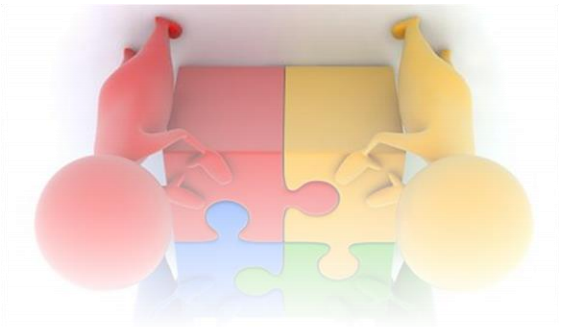
Vel.-Acel. Angular de Tronco 10 Kg

	0 Kg		5 Kg		10 Kg	
Tiempo total (s)	1.5	100%	1.8	98%	1.9	100%
Fuerza Vertical Máxima (%)	131.9	100%	132.0	100%	132.0	100%
Asimetría de Fuerzas (%)	8.6	100%	7.7	100%	3.0	100%
Mayor Apoyo	DERECHA		DERECHA		DERECHA	
Movilidad Lumbar (º)	40.0	100%	39.7	100%	42.2	100%
Inclinación Torácica (º)	67.8	100%	64.5	100%	72.8	100%
Rotación Torácica (º)	7.2	94%	7.8	80%	10.4	62%
Vel. Ang. Máx. Tronco en Flexión (º/s)	159.6	100%	158.6	100%	154.7	100%
Acel. Ang. Máx. Tronco en Flexión (º/s2)	390.8	100%	388.3	100%	372.4	100%
Vel. Ang. Máx. Tronco en Extensión (º/s)	-152.3	100%	-145.7	100%	-139.9	100%
Acel. Ang. Máx. Tronco en Extensión (º/s2)	-308.9	100%	-271.7	100%	-220.1	100%
Repetibilidad		100%		100%		100%

Valoración Global 91%

Class activity

Working on a clinical case (document)



Questions guide

Were the records obtained valid in terms of repeatability?

Was a validity straight leg raising test necessary?

What was the maximum range recorded for each movement?

Is the mobility recorded for each axis considered as normal?

What values were taken as a reference for normality?

What is the most limited movement or with the greatest loss of mobility? And the least limited movement?

Is the loss of mobility recorded significant?

Were important asymmetries found in the laterality of the movements?

Case solution

Were the records obtained valid in terms of repeatability? Yes, they meet the validity criteria of the AMA; three consecutive repetitions are obtained whose maximum flexion and extension value falls within 5º from the mean.

Was a validity straight leg raising test necessary? No, because the flexion-extension mobility recorded by the inclinometers on the sacrum was greater than 55º.

What was the maximum range recorded for each movement? Flexion: 25º Extension: 5º Left lateral flexion: 23º Right lateral flexion: 22º

Is the mobility recorded for each axis considered as normal? No, because there is a significant loss of mobility with respect to the values that were taken as reference. For example, there is a loss of mobility of 75% for extension and 50% for flexion.

Case solution

What values were taken as a reference for normality?

The mobility values of the American Medical Association.

What is the most limited movement or with the greatest loss of mobility? And the least limited movement?

Extension was the most limited movement, with 75% of mobility loss. The least limited movement was left lateral flexion, with 22% of mobility loss.

Is the loss of mobility recorded significant?

It was in the case of flexion/extension.

Were important asymmetries found in the laterality of the movements?

No. Asymmetry in laterality can only be observed in lateral flexions, and there is only 1º of difference.

Key ideas

- Mobility changes with age, and the range of motion reduces as the person gets older. It is important to compare the values obtained using the same protocols and measuring equipment.
- In order to measure the range of motion of the spine more accurately, the American Medical Association (AMA) recommends the use of inclinometers as an accurate method to estimate true spine motion.
- Low back pain causes limitations when performing frequent and common activities of daily life, such as sitting and getting up from a chair or lifting and handing weights in both domestic and work tasks. The kinematic and kinetic analysis of these movements allows us to define them more accurately through the analysis of the range of motion (ROM), the angular acceleration and speed with which the movement is performed, and other parameters such as the reaction force and the repeatability of the movement.
- There are systems to measure the strength of the paravertebral muscles. Isokinetic systems, which keep the angular velocity of the movement constant throughout the whole range of motion selected, are one of the most widely used.
- The activity of the trunk muscles can be indirectly estimated by means of electromyography. This is the reason why surface EMG is a frequently used technique to assess the lumbar area, specifically to analyse muscle behaviour during movements such as trunk flexion-extension. In the case of lumbar pathologies, an analysis of the myoelectric silence is performed.

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