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TEACH

MODULE BIOMECHANICS OF SPINE

Didactic Unit D: INSTRUMENTED ANALISYS OF THE SPINE

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

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1. Objectives

- To become familiar with the interpretation of the results obtained from a cervical kinematic assessment in a normal population.
- To understand the interpretation of the results obtained from an assessment of the cervical muscle strength in a pathological population.
- To know the interpretation of the results obtained from a lumbar kinematic assessment in a pathological population.
- To understand the interpretation of the results obtained from the assessment of the lumbar strength in a pathological population.
- To learn how to work with the pathological results of a biomechanical assessment of the cervical and/or lumbar spine through clinical cases.

Previous lessons reviewed the protocols and the different biomechanical analysis techniques that can be used to perform a biomechanical analysis of the spine. This lesson shows some of the results obtained in the biomechanical analysis of a person who suffers from spinal pain. Additionally, these results will be shown in relation to a normal pattern for the student to learn to identify the differences. Finally, the results of a clinical case will be reviewed to help the student become familiar with the results and understand their usefulness.

2. Pathological results in the assessment of the cervical spine

Neck pain is one of the most common reasons for consulting a doctor. It is considered that a high percentage of people will experience cervical pain at some point in their lives. It is the doctor who must assess the patient and determine the cause (diagnosis) of this pain, ruling out potentially serious causes. Since cervical pain can have multiple causes, a good anamnesis and examination will help to reach a diagnosis. Such diagnosis is complemented by a functional assessment of the cervical spine. For this assessment, biomechanical tests are used to provide information on the mobility and the muscle strength of the area. Therefore, the use of biomechanical tests in the clinical process of a patient’s evaluation is good to complement the diagnosis and have a more global vision of the patient's condition.

Assessment of the cervical range of motion (ROM)

The assessment of the cervical range of motion is one of the most important aspects of the patient's examination. With biomechanical analysis methods, in addition to accurately measuring the range of motion and comparing it to normal patterns, it is possible to identify marked limitations or significant asymmetries. A mechanical process that affects the cervical spine tends to cause asymmetric limitations. There are cervical pathologies that can be assessed using biomechanical analysis techniques, with which significant variations in cervical mobility with respect to a normal movement pattern can be found.[1] For example, trauma conditions involving the skeletal and ligament systems of the cervical spine that do not endanger the spinal cord, such as a cervical sprain, degenerative and rheumatic conditions such as cervical arthrosis and ankylosing spondylitis, or pain-related limitations of the cervical motion such as some conditions related to posture, work or stress.

Regarding the range of movement, the studies carried out show that it decreases compared with healthy subjects. The results vary depending on the measuring technique used and the protocol applied. Some works[2,3,4,5,6] focus on studying the range of motion in patients who perform a single maximum active movement. Other works[7] use the technique of forcing the patient to perform the maximum range in a passive way. Finally, in some studies[8], as you can see in the next subsection, the patients can be asked to perform the movement in a continuous and cyclical way to the maximum of their possibilities.

The graph examples below show altered results with respect to the range of cervical motion measured using biomechanical analysis techniques. By analysing them, the student will be able to identify the type of biomechanical technique used, interpret the graph, and understand the results based on the functional limitations shown.

Test: Assessment of the range of motion of the cervical spine in the three anatomical planes.

NORMAL	ALTERED

Figure 1. Cervical range of motion.

Measuring technique: Photogrammetry, inertial systems or inclinometers.

Type of analysis: Kinematic.

Graphic representation: Cervical range of motion (º) in the three planes (frontal, sagittal and transverse). The outer edge of the graph represents the normality zone.

Interpretation of the results: Left: Good mobility of the cervical spine in all the planes. **Right:** The mobility of the cervical spine is limited in different axes. The limitation of the flexion-extension is particularly noticeable, followed by the right lateral flexion and left rotation, the latter showing a significant asymmetry with respect to the right rotation.

Kinematic assessment of the cervical spine

Cervical mobility is the most widely used measure offering functional results to assess the condition of patients with cervical pathologies. It provides objective information on the degree of severity of a limitation of the cervical movements. It can also be used to monitor the patient during and after therapeutic interventions.

If the examiner is interested not only in the cervical range of movement, but also in the characteristics or more specific details about the movement performed, a kinematic analysis should be performed. This type of analysis provides more precise information, both numerically and graphically, on the speed and range of movement of the cervical spine. The systems used capture the movement in space and analyse it in greater detail, providing information such as range of motion, angular velocity, angular acceleration, smoothness of the movement or its repeatability. These measuring systems include 3D photogrammetry or inertial systems, which are currently used in these studies. The assessed person must perform repetitive or cyclical movements in a specific axis during a period of time established in the protocol used (usually 30s). These measurements include the angular movements of the head with respect to the trunk in relation to the three anatomical planes, but they can also provide information on the speed, acceleration of the movement and coupled movements. Note that this type of evaluation usually refers to an active rather than a passive movement.

With regard to the results obtained in a pathological pattern caused by cervical pain, a limitation in the range of motion is observed. In addition, Ohberg et al.[4] identified that angular velocity is the most discriminating variable to distinguish between a normal and a pathological movement pattern, the angular velocity being lower in the pathological group. With regard to the smoothness and repeatability of the movement, some authors[5, 9] analysed the smoothness and repeatability of the cervical movement and found that the movement was less smooth and less repeatable than the movement in people without any pathology or pain in the cervical spine.

In summary, from the clinical point of view, an injury at the level of the cervical spine, whether it affects soft parts or not, can cause a limitation in the range of movement of the cervical spine and/or its characteristics, which becomes slower, smoother and less repeatable.

Some of the graphic results that can be found in this type of assessment are shown below. A normal result is compared to that of a person with cervical pain that alters the function of the cervical spine motion.

Test: Assessment of the mobility of the cervical spine in the sagittal plane.

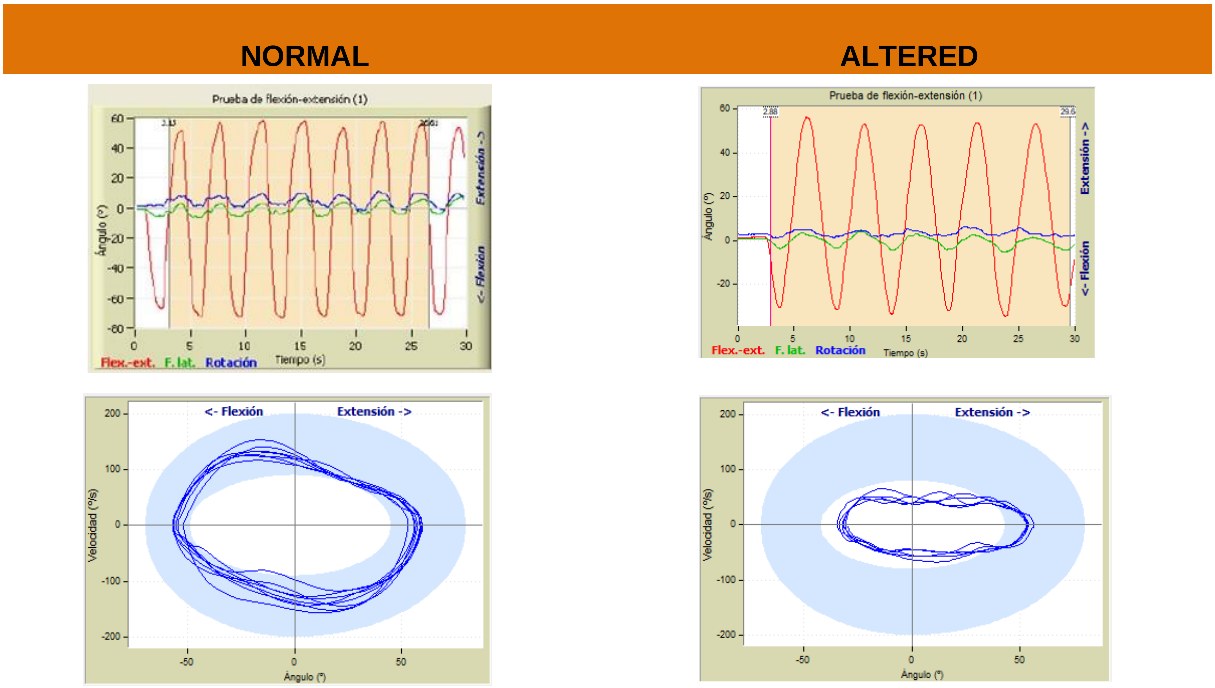


Figure 2. Extension-flexion mobility of the cervical spine.

Measuring technique: photogrammetry, inertial systems or inclinometers.

Type of analysis: kinematic.

Results (graph): Top: different cycles of flexion-extension mobility of the cervical spine in relation to the test time. **Bottom:** different cycles of the angular velocity of the cervical spine movement versus the range of flexion-extension motion. The blue band indicates where a normal movement pattern of the cervical spine would be located.

Interpretation of the results: **Top left:** the flexion-extension movement of the cervical spine is wide and fast. **Top right**: slow cervical movement with limited cervical flexion. **Bottom left:**

adequate speed and range of the cervical spine movement in the sagittal plane within reference values (the blue band representing normal values). **Bottom right**: Slow movement with limited flexion of the cervical spine, whereas the extension is within normal values.

Assessment of cervical muscle strength

The assessment of cervical muscle strength is useful to study its functional state. The strength test most widely used to evaluate this area of the spine is the assessment of the isometric cervical strength.

The peak torque of the cervical muscles decreases in people with cervical pain, both in the flexor and extensor muscles.[10] All the consulted authors agree that the extensor muscles weaken in the case of chronic neck pain. However, there is no agreement as to what happens in the cervical flexor muscles.

3. Pathological results in the assessment of the lumbar spine

Low back pain is a syndrome defined by the presence of pain in the lumbar spine or lumbar paravertebral muscles, which may be accompanied by radiated pain. The objective of the doctor is to identify the cause of the pain, the pathological process that causes it, and to make a decision about the treatment, the patient's progress and functional status, as well as to determine what the person can do or not to return to work or to a normal life model.

Low back pain is therefore frequent and globally widespread. Around 80% of the population will experience low back pain sometime in their life; it affects all ages with a peak incidence at around 45 years in both sexes. Chronic low back pain can cause high disability affecting working life and social relationships. The objectives of the treatment are to relieve symptoms and to improve the patient's function by reducing the limitations. For this purpose, it is necessary to assess the chances for improvement using biomechanical analysis techniques to evaluate the function.

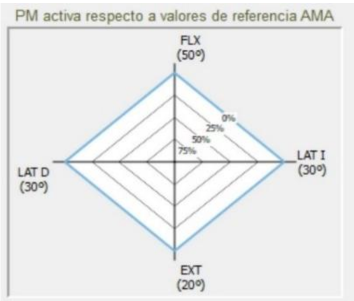
Both the normal and altered results of the biomechanical assessments commonly performed on patients with low back pain are shown below. These results were provided using techniques that analyse movement and force.

Assessment of the lumbar range of motion (ROM)

In this section, the clinical aspects discussed about the possibilities of assessment of the cervical range of motion can be applied to the lumbar spine. Therefore, with regard to the range of movement, a pathological pattern is expected to show a decrease in this range compared to the range of motion of healthy subjects.

Test: Assessment of the range of motion of the lumbar spine in the sagittal and frontal planes.

NORMAL	ALTERED



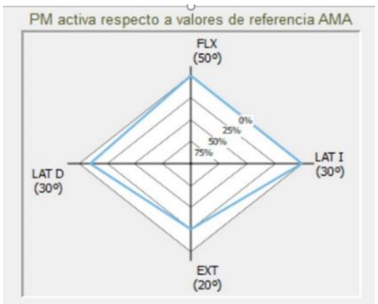


Figure 3. Lumbar range of motion.

Measuring technique: Photogrammetry, inertial systems or inclinometers.

Type of analysis: Kinematic.

Graph results: Lumbar range of motion in the sagittal and frontal plane. The outer edge of the graph represents the area of normality. The AMA reference values were used.

Interpretation of the results: **Left**: Good mobility of the lumbar spine in all planes. **Right**: Limited range of motion of the lumbar spine. The limitation in the extension is particularly noticeable, followed by right flexion.

Assessment in daily life activities

The speed at which a movement is performed or the time needed to perform it are essential aspects in any study on the mobility of people with spinal damage or injury. As early as 1986, the speed of movement was considered as a quantitative measure in people with back disorders, which could help to monitor the progress of a disease or treatment.[11] An interesting parameter in the relation between speed of movement and functional impairment is determining how long it takes a person to complete an activity, such as rising from a chair. Since many works[12,13,14] agree that it takes less than 2s, we will take that reference value. The importance of knowing the measurement protocol applied should be highlighted again, since, as previously mentioned, the values we will find depend on such protocol.

If the results of the activity performance speed of a normal group are compared with those of a group with low back pain, the total time it takes to perform the movement clearly increases when there is pain. Low back pain is a symptom that causes the person to perform a slow and imprecise movement; however, this result is sometimes due to the fear that the pain will recur or worsen. This aspect of the movement can be analysed through parameters such as the total time needed to perform the movement, or other more specific parameters such as the angular speed and/or acceleration of the trunk.

The vertical reaction force is another interesting result in the biomechanical assessment of lumbar spine pain. This force is related to the energy and the necessary momentum to stand up from the chair or to lift weight. The greater the momentum, the higher the maximum peak of this reaction force, which is recorded with a dynamometric platform. As described by Kralj et al.[15], normal subjects perform a fast and energetic movement that helps them to stand up from the chair. Conversely, studies performed on subjects with low back pain found a decrease in the maximum vertical force. This could also occur in patients with other neuromuscular disorders, as shown in the study by Yoshida et al.[12] with neurological patients or even in people with a deficit in quadriceps strength.

Some of the graphic results obtained with this test after assessing an activity in a person with low back pain are included below. The student can learn to detect the differences with respect to a normal performance pattern.

Activity: rising from a chair

Test: Biomechanical assessment of the activity of rising from a chair.

NORMAL	ALTERED

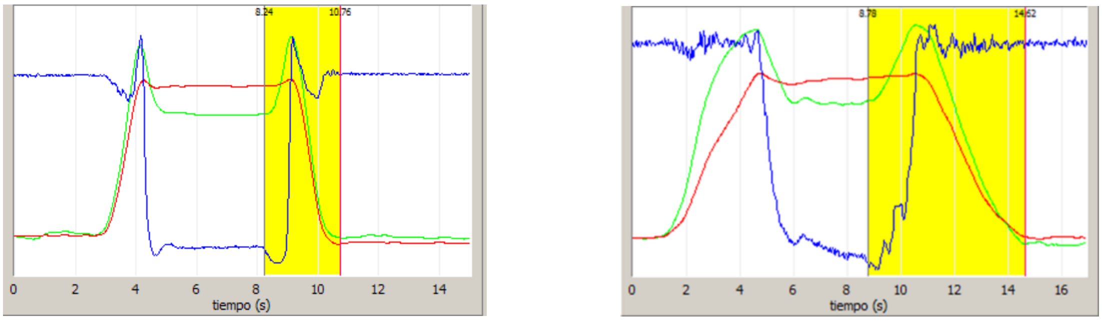


Figure 4. Reaction force and mobility of the trunk and knee in the sit-to-stand activity.

Measuring technique: Photogrammetry, inertial systems or inclinometers together with dynamometric platforms.

Type of analysis: Kinematic and dynamic.

Graph results: Reaction force (blue line) and mobility of the knee (red line) and trunk (green line) during the sit-to-stand movement (yellow band).

Interpretation of the results: Left: Smooth and fast movement with good momentum to perform it. **Right**: Increased performance time. Difficulty generating the necessary momentum to stand up. This data is located in the oscillations at the beginning of the slope of the reaction force.

NORMAL	ALTERED

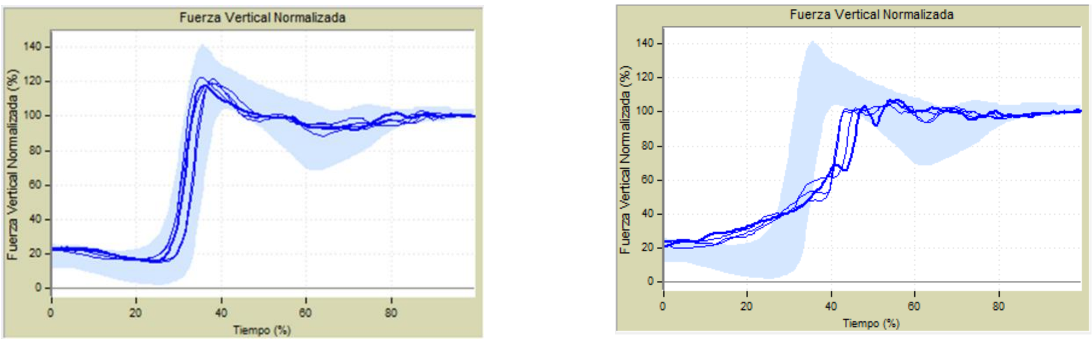


Figure 5. Reaction force when performing the sit-to-stand activity.

Measuring technique: Dynamometric platform.

Type of analysis: Dynamic.

Graph results: Different recorded repetitions of the reaction force during the sit-to-stand activity.

Interpretation of the results: Left: Repeatable and normal force pattern (the blue band represents the normal pattern), which means adequate momentum to perform the movement (good strength and coordination of the trunk and lower limbs). **Right:** Repeatable but altered force pattern. The slope of the curve is horizontal, with its peak 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.

NORMAL	ALTERED

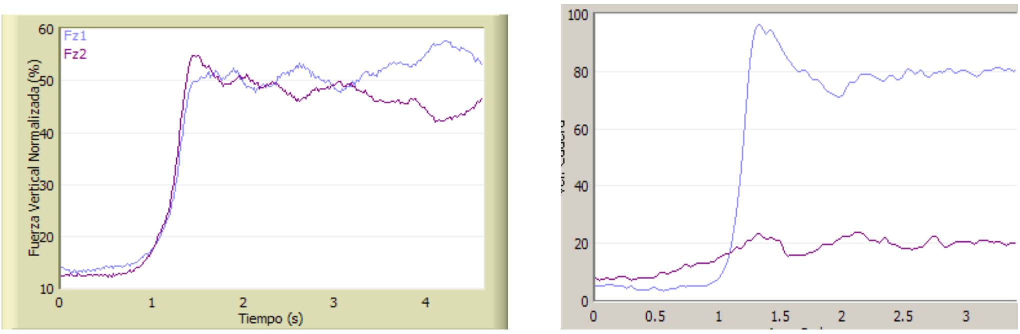


Figure 6. Reaction force of each foot support when rising from the chair.

Measuring technique: Dynamometric platform.

Type of analysis: Dynamic.

Graph results: Reaction force generated by the support on each lower limb when performing the sit-to-stand activity.

Interpretation of the results: Left: Symmetrical force pattern. Similar weight-bearing on both lower limbs when performing the sit-to-stand movement. **Right:** Asymmetric strength pattern. Greater weight on the right lower limb (light blue line) when rising from the chair, which implies an asymmetric movement that may be related to the radiation of low back pain to the left leg.

NORMAL	ALTERED

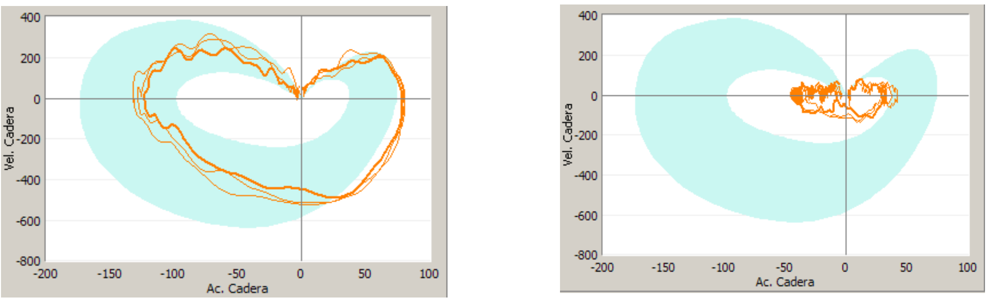


Figure 7. Angular velocity with versus the angular acceleration of the spine during the sit-to-stand activity.

Measuring technique: Photogrammetry, inertial systems or inclinometers.

Type of analysis: Kinematic.

Graph results: Represents the angular velocity versus the angular acceleration of the trunk during the analysis of the sit-to-stand activity.

Interpretation of the results: Left: Rapid movement to perform the activity assessed. It is within a normal functional movement pattern. **Right:** Slow movement away from a normal pattern in the total performance of the movement, which may be related to low back pain.

Activity: Lifting a weight

Test: Biomechanical assessment of the activity of lifting a weight.

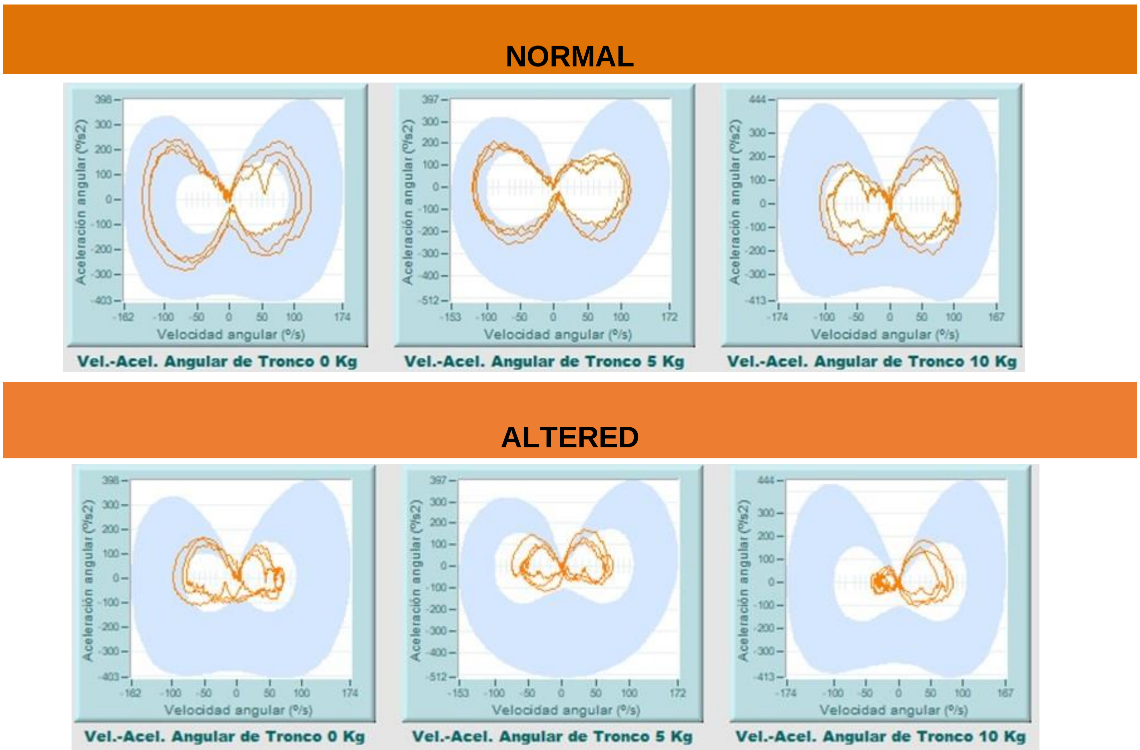


Figure 8. Angular velocity versus the angular acceleration of the spine during the activity of lifting a weight.

Measuring technique: Photogrammetry, inertial systems or inclinometers.

Type of analysis: Kinematic.

Graph results: Angular acceleration versus angular speed of the trunk in different recorded repetitions of the movement of lifting a weight. The result for increasing weights is shown from left to right.

Interpretation of the results: Top: Normal angular acceleration and speed of the trunk for all the weights lifted (the blue band represents the normal pattern of acceleration and speed in this movement), which implies good mobility and speed in the movement performed. **Bottom:** Low acceleration and speed in all movements, which involves slow trunk movement. Slower movements are observed as the weight is increased, therefore, the movement gets worse as the load handled increases.

Force assessment. Isokinetics

Another bodily function that can be analysed with a biomechanical analysis technique and a well-established protocol is muscle strength. The relationship between trunk muscle strength and low back pain is important. In addition, exercise and retraining are known to help both to treat and prevent low back pain.

The most widespread method to assess strength in people with low back pain is an isokinetic analysis. The drawback is that most publications on lumbar spine isokinetics focus on normal people, very few on people with low back pain.

At a general level, the results of these works show a significant decrease in the torque for both flexor and extensor muscles in all patients with low back pain, regardless of gender. In addition, the extensors/flexors ratio is reversed in relation to the healthy population, so there is a general weakness of the extensors compared to the flexors.

Another finding when comparing the normal results with those of people with low back pain is that the speed of movement during the assessment influences the degree of the decrease in muscle strength compared with a healthy population.

So far, we have discussed the results in the frontal plane. If we also consider the axial plane, the rotational force is also limited in people with low back pain in comparison to the rotational force of people without pain. Still, the decrease in the force recorded is much lower than the decrease found in the sagittal plane. It should be noted again that the results found no differences by gender.

The work by Dvir et al.[16] includes various papers on isokinetics and low back pain by Mayer et al[17,18,19] that should be reviewed by the students who are interested in this test and its results in lumbar spine pathologies. These references are listed below. However, they should be reviewed by the teacher before recommending them to the students.

- Smith, S. S., Mayer, T. G., Gatchel, R. J., & Becker, T. J. (1985). Quantification of lumbar function. Part 1: Isometric and multispeed isokinetic trunk strength measures in sagittal and axial planes in normal subjects. *Spine*, *10*(8), 757-764.
- Mayer, T. G., Smith, S. S., Keeley, J. A. N. I. C. E., & Mooney, V. E. R. T. (1985). Quantification of lumbar function. Part 2: Sagittal plane trunk strength in chronic low-back pain patients. *Spine*, *10*(8), 765-772.
- Mayer, T. G., Smith, S. S., Kondraske, G., Gatchel, R. J., Carmichael, T. W., & Mooney, V. E. R. T. (1985). Quantification of lumbar function. Part 3: Preliminary data on isokinetic torso rotation testing with myoelectric spectral analysis in normal and low-back pain subjects. *Spine*, *10*(10), 912-920.

Assessment of muscle activity. Surface electromyography

The flexion-relaxation phenomenon (FRP) is one of the most studied physiological indicators of low back pain. The analysis of muscle response through surface electromyography signals suggests that there are changes in the EMG signal during trunk flexion tasks.[20] In healthy people, there is a specific pattern of activation of the erector spinae muscle coupled to an interaction of lumbar and pelvic movement, also specific, during trunk flexion and extension. This spine-pelvis interaction is known as the "lumbopelvic rhythm".[21]

The classic studies by Floyd et al.[22,23] showed the absence of the flexion-relaxation phenomenon in patients with low back pain, which was later observed in numerous studies.[20,21,24,25,26] These authors, among others, also observed a higher average activity of the erector spinae at the end of the flexion in patients with low back pain. Similarly, Nouwen et al[24]. observed a decrease in the average activity of the erector spinae in the extension, whereas Sihvonen[21] and Shirado[25] noticed a decrease in the maximum amplitude of the EMG in extension.

A persistent activation of the lumbar spine erector muscles during full trunk flexion is typically observed in individuals with low back pain as a protective "splint" response to increase lumbar stabilization in response to pain or tissue injury.[27] The FRP deficit found in patients with low back pain has been found to be associated with pain [28], self-reported disability[20] and fear of pain or re-injury.[29]

The absence of FRP in patients with low back pain has also been associated with muscle spasm[30], reduced range of motion, and exacerbated stretch reflexes.[31]

However, the results are not uniform, which makes it difficult to draw conclusive ideas. The reasons given to explain this lack of homogeneity in the results are[25]:

- **Diversity in the inclusion criteria**, which show variation in the characteristics of pain history and include patients with different clinical diagnoses within the same group, or other influential factors such as joint laxity.
- Differences in the **conditions of the dynamic tests to assess** the function of the back (cadences/coordination of trunk/hip movements, performance speed and the measuring technique itself).
- Differences in the **homogeneity of the groups** (physical condition, strength, age, gender distribution).

Test: Assessment of the lumbar spine flexion-relaxation phenomenon.

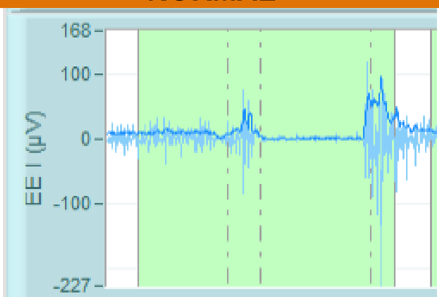
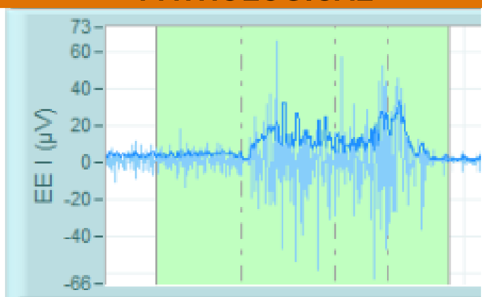
NORMAL	PATHOLOGICAL
	

Figure 9. Electromyographic signal of the left spinal erector.

Measuring technique: Surface electromyography.

Graph results: Muscle activity of the left spinal erector during an activity involving maximum trunk flexion and extension.

Interpretation of the results: Left: Signal recording that resembles myoelectric silence at maximum spine flexion. **Right:** Absence of myoelectric silence recorded in the flexion-relaxation biomechanical test, which is compatible with lack of relaxation of the spinal erectors in a process of low back pain.

In a healthy population, the surface EMG response of the flexion-relaxation phenomenon is characterised by **three** clearly defined **phases**; however, these limits are much less distinguishable in patients with low back pain.

4. Cervical assessment. Clinical case

Case: 49-year old woman.

Profession: Educational psychologist. Director of nursery school.

Medical record: Not relevant.

Clinical picture resulting in sick leave: Neck pain after traffic accident, rear-end collision.

Diagnostic tests performed and results: The X-ray at the emergency room showed cervical rectification.

The cervical NMR evidenced disc protrusions at C4-C5 and C5-C6 with mild biforaminal and spinal canal stenosis predominantly at C5-C6.

Treatment prescribed: Rehabilitation.

Progress: During the first evaluation in the consulting room, she reports cervical pain that limits her activities.

Physical examination: Pain on palpation of the paravertebral muscles and limited mobility in lateral flexions and rotations.

> Given this clinical picture, a biomechanical test was performed to monitor her disability process. The test made it possible to objectify the mobility of the cervical spine considering both the ranges of movement and the smoothness of the movements, which may be affected by pain. As you can see later, the first assessment shows a pattern of significant functional disorder with a marked limitation of cervical mobility. The patient started a rehabilitative treatment and another biomechanical assessment was performed after 19 rehabilitation sessions, which showed a significant improvement in the limitation. The aim of these tests was to have a more objective measure of this limitation that could be used as control in subsequent assessments.

Next, the results of the biomechanical assessment are discussed in greater detail so that the student can become familiar with them and evaluate their usefulness.

Biomechanical Assessment Test: Assessment of the cervical spine using a biomechanical test

This test kinematically analyses the movement of the cervical spine to detect abnormal or non-functional movement patterns secondary to a painful cervical condition.

The **assessment system** used consists of a 3D photogrammetry system. To perform the evaluation, the parameters obtained are compared with those of a group of subjects whose characteristics are comparable to those of the patient (data bases made up of normal and pathological data, compiled by the IBV).

The **measurement protocol used** consists of the following test:

Limit test. It analyses the functional limits of the movement in each spatial direction. In each measurement, the patient is asked to perform repetitive cycles of each movement, which is continuously analysed, at a fast but comfortable speed and reaching the maximum joint range for 30 seconds.

Results of the biomechanical assessment test

1. **Results of the cervical assessment at the beginning of the sick leave**

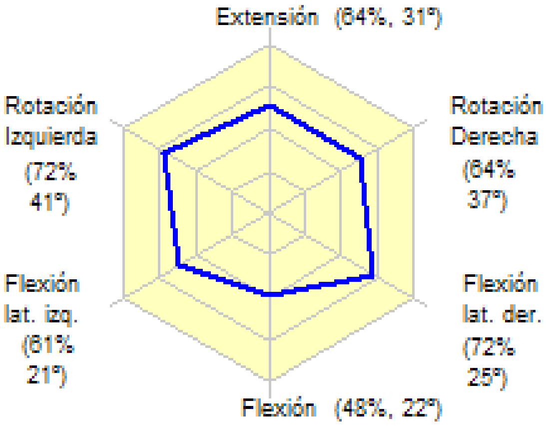


Figure 10. Visual hexagon of the range of motion together with its percentage of normality.

NOTE: Mobility values are also displayed as a percentage value. The percentage value indicates how far the result obtained is from the normal movement pattern of the measuring system used. Thus, values above 90% means that they are above the normal pattern, whereas values below 90% indicate that they are moving away from this pattern and, consequently, the deficiency is greater.

The ranges of motion obtained in each axis of movement of the cervical spine are globally reduced. In this analysis, the deviation from normality of the flexion-extension range is particularly noticeable, especially in the cervical flexion. Figure 13 shows how the joint ranges of all the movements are reduced, with flexion being the most limited movement (22°).

With regard to the mobility of the cervical spine in relation to its speed of movement, the results obtained are as follows:

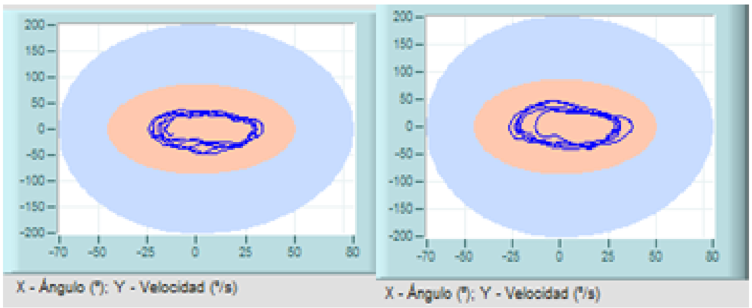


Figure 11. Flexion-extension test of two consecutive measurements.

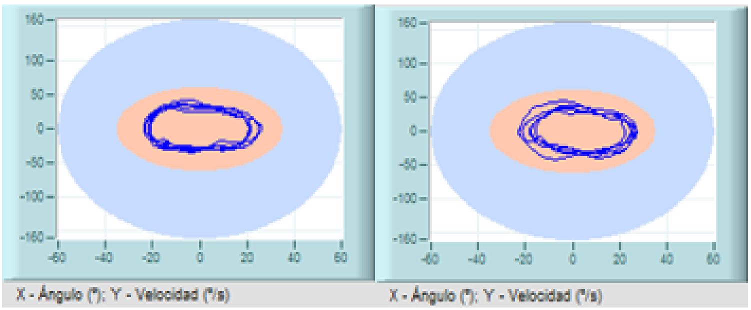


Figure 12. Lateral flexion test of two consecutive measurements.

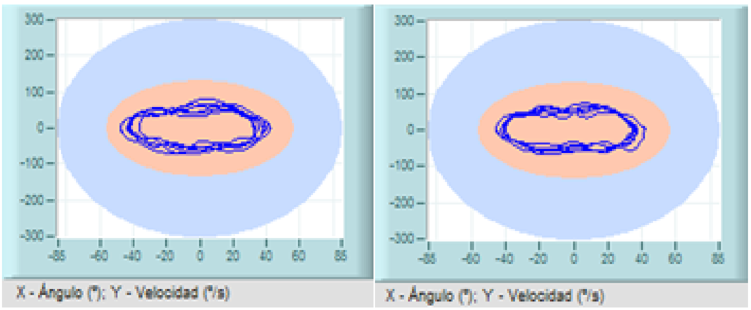


Figure 13. Rotation test of two consecutive measurements.

In Figure 11, Figure 12 and Figure 13, you can see the velocity values represented on the ordinate axis and the maximum angle reached on the abscissa axis. The important thing about this graph is the blue normality band that represents the movement of people without any pathology and who are the same age and gender as the patient. This movement pattern was calculated with the same assessment equipment that was used with this patient. You can see that all the tracing is located within the salmon-coloured area, which means that the patient's angular speeds and movements are far from the normal pattern, and therefore greatly diminished, something compatible with a mobility pattern limited by pain.

The repeatability between the same test was high, as you can see in the similarity of the records when comparing the same movement. This parameter is one of the aspects considered to analyse the sincerity of the patient's effort during the assessment.

With this result, and in coherence with the physical examination, a significant limitation of the patient's mobility is observed, which means that she is still in an acute period of the injury and that it is necessary to continue with the sick leave process; therefore, the patient must remain under a rehabilitative treatment programme.

A new assessment is scheduled after 19 sessions of physical treatment. In the following assessment, the patient was practically asymptomatic. Her cervical mobility was normal and the evaluation showed no significant data. A new biomechanical assessment was performed to objectify the improvement. The results are shown below:

2. Results of the cervical assessment at the end of the rehabilitation treatment

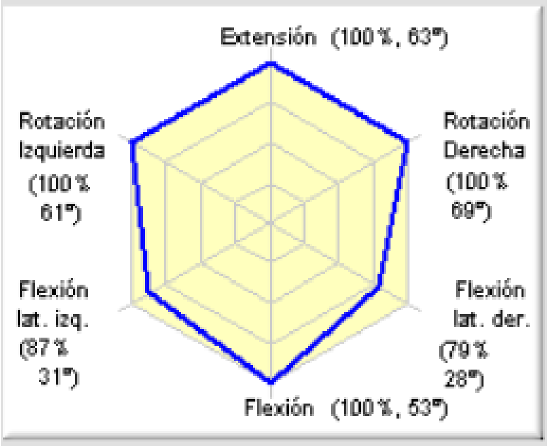


Figure 14. Visual hexagon of the range of motion after a 2-month progress together with the percentage of normality.

The ranges of motion obtained in each axis of movement were practically normal. In flexion-extension, the average value obtained was 106º. In lateral flexion, the value obtained was 59º. Finally, the average value for rotations was 130º.

It is particularly noticeable that the range of lateral flexions is slightly away from normality.

Regarding the mobility of the spine in relation to its speed of movement, the results were as follows:

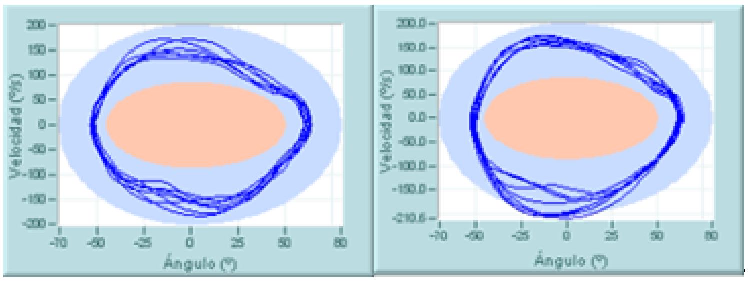


Figure 15. Cervical flexion-extension test of two consecutive measurements.

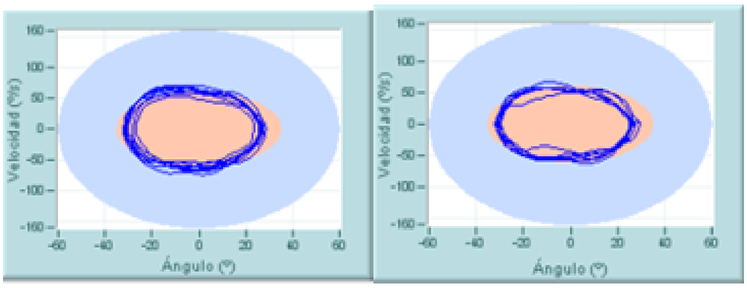


Figure 16. Cervical lateral flexion test of two consecutive measurements.

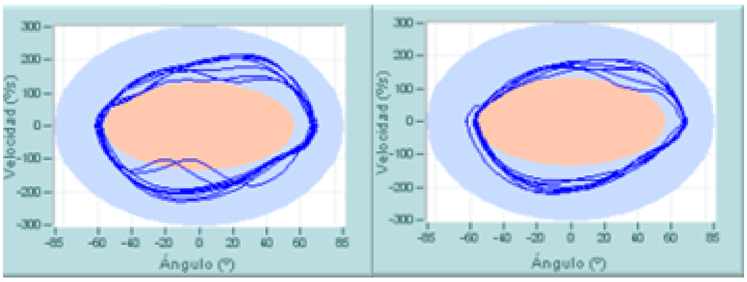


Figure 17. Cervical rotation test of two consecutive measurements.

The graphs now show that all the tracing is within the normal area (blue colour). This means that the patient performs the movements at normal angular speeds and with normal mobility, which indicates that pain no longer interferes with the function assessed.

In light of the results obtained in the cervical functional assessment, we can conclude that the previous pathology or/or the symptoms reported do not have a significant current impact on the functional capacity of this patient based on the values obtained for the different parameters analysed, which confirms the existence of a normal functional level.

Progress: It has been favourable. The symptoms disappeared and, at the end of the treatment, the patient is recovered. On physical examination, the general condition is good. No pain on palpation of cervical spinous processes. Complete joint range in all the arcs of mobility. Discomfort on palpation of the left trapezius with no contractures.

The patient can return to work.

5. Lumbar assessment. Clinical case

Case: 47-year old man.

Profession: Welder.

Medical record: Previous low back pain events.

Clinical picture resulting in sick leave: Low back pain after efforts in the workplace.

Diagnostic tests performed and their results: The previous lumbar NMR showed degenerative disc disease at L4-L5 and disc herniation at L5-S1 lateralized to the left with possible involvement of the S1 root.

Treatment prescribed: Rehabilitation.

Progress: In the first consultation, the patient reported pain and limited movements of the lumbar spine.

Physical examination: At the beginning, the mobility of the lumbar spine was 45º for the lumbar flexion and 5º for extension. He reported pain during lumbar extension and on palpation of the lumbar spinous processes and right sacroiliac joint. Bilaterally negative Lasègue's sign.

Because of the limitation of the patient's lumbar mobility, two biomechanical lumbar assessment tests were performed during the monitoring of his sick leave. The first assessment, performed after 17 days of sick leave, shows a pattern of mild functional limitation. Given this objectified limitation and the signs found in the physical examination, the patient continues the rehabilitation programmes, showing a clear improvement in a second evaluation 7 weeks after the sick leave.

The results of the tests performed are discussed in more detail below:

Biomechanical Assessment Test: Assessment of the lumbar spine using a biomechanical test

The **objective** of this test is to analyse both dynamically and kinematically the activity that may be limited by painful lumbar spinal pathology and detect abnormal or non-functional movements.

The **assessment system** used consists of 2 dynamometric platforms and a 3D photogrammetry system. To carry out the functional assessment, the system automatically compares the parameters obtained with those of a group of subjects whose characteristics are comparable to the age and gender of the patient assessed.

The **measurement protocol used in this patient** involves performing two movements:

Rising from a chair – This movement biomechanically analyses the activity of rising from a sitting to a standing position.

Figure 18. Biomechanical and functional assessment test of the sit-to-stand movement using a photogrammetry system and dynamometric platforms.

Lifting weight – This movement biomechanically analyses the action of bending over to pick up a weight, lift it, and move it from a low level to a higher level. Boxes of 0.5 kg and 10 kg are used.

Figure 19. Biomechanical and functional assessment test using a photogrammetry system and dynamometric platforms to evaluate the movement of bending over, pick up a weight and lift it.

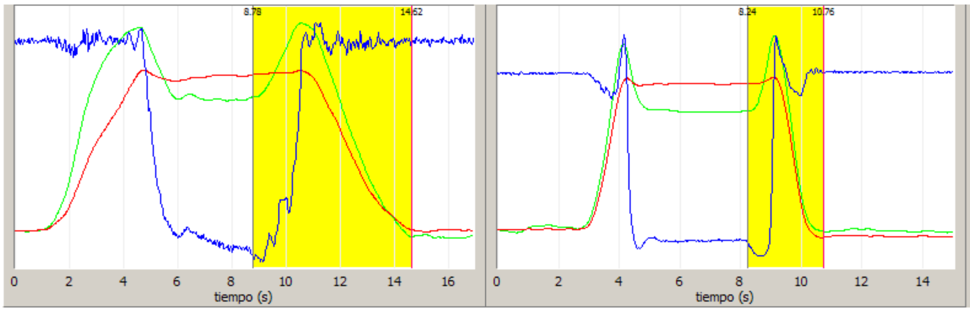
Results of the biomechanical assessment test

1. Results of the lumbar assessment after 17 days of sick leave

The graphs representing the movement performed by the patient are shown below, together with the graphs of a normal movement (a person without pain or lumbar pathology, whose characteristics are similar to those of the patient) so that you can compare them.

Time, in seconds, needed to perform the recorded movements:

RISING FROM A CHAIR



LIFTING A WEIGHT

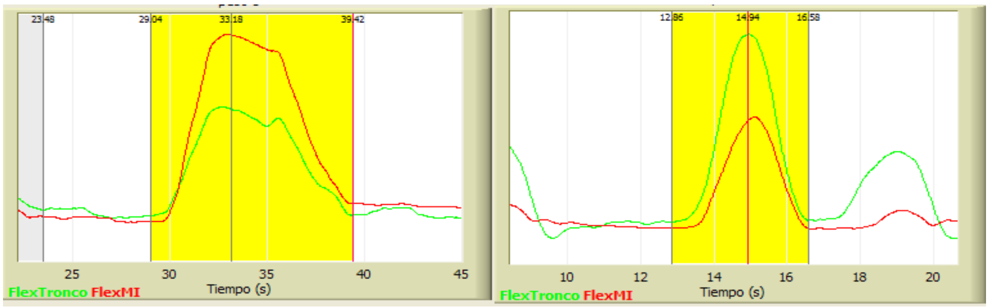


Figure 20. The yellow stripe represents the total time in seconds (abscissa axis) needed to completely perform the movement. The image on the left shows the patient's record, whereas that on the right shows a person without pathology or pain.

In this first assessment, the patient needs much time to perform the different movements analysed. You can see that in the image on the left the yellow stripe is wider than in the image on the right (the graph of a normal movement). This finding means that the patient performs a slow movement both to rise from the chair (top graphs) and to bend over, pick up a weight and lift it (bottoms graphs). These data are compatible with pain.

With regard to the **speed and acceleration of the movement in these two activities**:

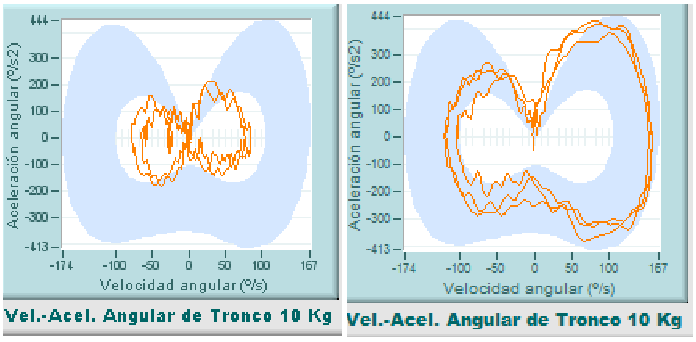


Figure 21. Representation of the angular speed/acceleration of the trunk for the three repetitions of the movement of lifting 10 kg, along with the normality bands (blue band). The image on the left shows the patient's record, and that on the right, the record of a person without pathology or pain.

Both speeds and accelerations reduce when the patient bends over, picks up the weight and lifts it. In the graphs, you can see the velocity values represented on the abscissa axis and the accelerations on the ordinate axis. The important thing about this graph is that the blue band representing normality takes into account the movement of people without pathology, who are the same gender and age as the patient. This movement pattern was calculated with the same assessment equipment that was used for this patient. In the left graph, you can see that the trace is drawn in the central (white) area. This zone represents the pathological or functionally altered movements. The graph on the right shows a normal movement: you can see that the orange lines which represent the repetitions are within the blue band representing the movement of a normal population or people without any limitations. This finding means that the patient performs a slow movement both when bending his trunk to reach the weight and when lifting it. These data are also compatible with pain during the movement, in which case the speed and acceleration of the movements decrease.

Regarding the vertical reaction force of each foot recorded by each platform:

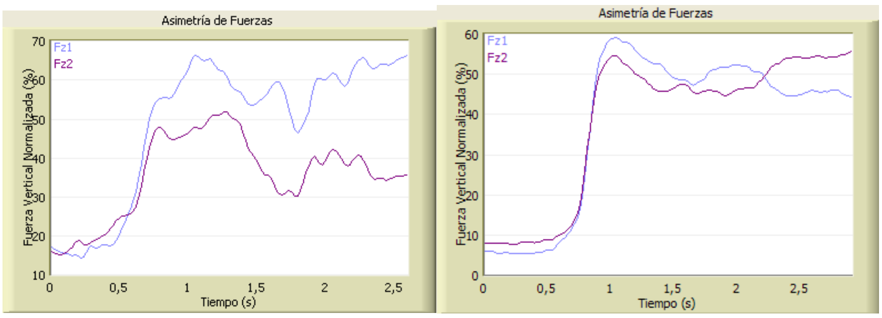


Figure 22. Total normalised vertical force performed by the **right** foot **(Fz1)** and by the **left** foot **(Fz2)** while performing the sit-to-stand movement in one of the repetitions. The image on the left shows the record of the patient who was assessed, whereas the image on the right shows a person without pathology or pain.

Observe in this graph that force Fz1 (light blue), which corresponds with the force exerted by the right foot when rising, reaches higher values (around 60%), whereas force Fz2, exerted by the left foot, reaches values around 50%. Normally, the values of these forces are similar, that is, we stand up supporting and stabilizing our body evenly on both legs; when the support of one of the limbs causes pain, the patient avoids such support. The presence of an asymmetry of forces, with the maximum vertical force being higher in the right lower limb (light blue in the graph) when compared to the opposite lower limb, could be interpreted as a result of the possible radiculopathy of the patient due to the spinal disc herniation latelarized to the left side.

Additionally, a muscle activity assessment test was performed by measuring the flexion-relaxation phenomenon. The result is shown below:

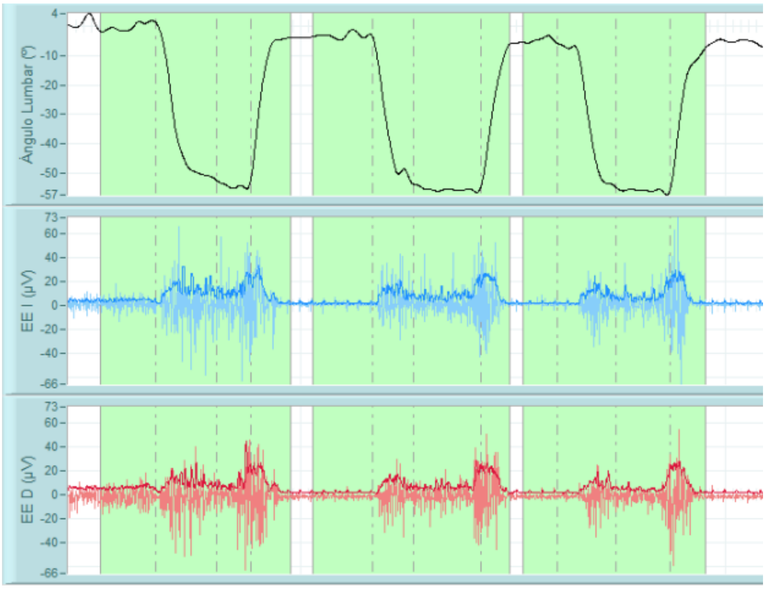


Figure 23. Kinematic and sEMG results during the lumbar spinal flexion-relaxation test.

An absence of myoelectric silence was recorded in the biomechanical test of the flexion-relaxation phenomenon, which is compatible with the lack of relaxation of the spinal erectors in low back pain. This result is consistent with the rest of the results obtained in the biomechanical assessment and indicates an alteration of the movement due to low back pain.

Final decision after the biomechanical assessment

In light of the results obtained in the lumbar functional assessment, we can conclude that the pathology or the symptoms reported have a current impact on the functional capacity of this patient based on the objective values obtained for the different parameters analysed, which confirms the existence of an altered functional level.

Given these results, and together with the physical examination data, the doctor who monitors the temporary disability decides to continue the sick leave.

The patient continued the rehabilitation treatment.

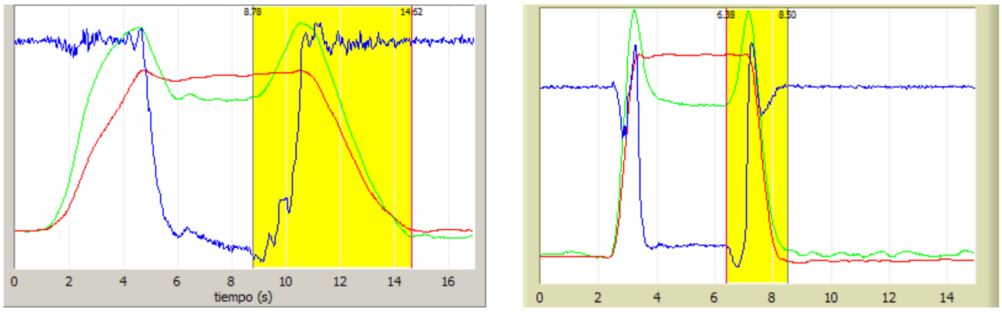
Six and a half weeks later, a new biomechanical assessment was performed. On physical examination of the lumbar spine at that time, the joint range of motion is 80º of flexion and full extension. Discomfort on palmation of the lumbar spinous processes and right sacroiliac joint. Bilaterally negative Lasègue’s sign.

2. Results of the lumbar assessment in subsequent monitoring

The graphs below represent the movement performed by the patient. This information is completed by the graphs from the previous session so that it is easier for you to compare them.

Time, in seconds, needed to perform the movements recorded.

ACTIVITY: RISING FROM A CHAIR



ACTIVITY: LIFTING A WEIGHT

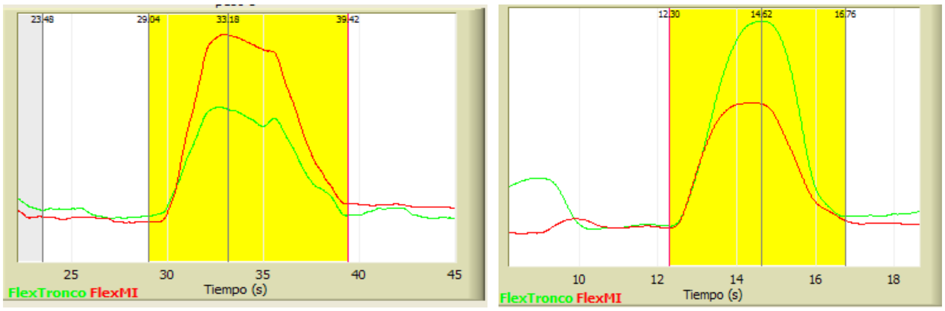


Figure 24. The yellow stripe represents the total time in seconds (abscissa axis) needed to perform the complete movements. The image on the left shows the record of the patient in the previous session (functional alteration), and the image on the right, the same patient during the current assessment session.

The time that the patient needs to perform the complete movement has significantly improved. On the left side, you can see that the yellow stripe is wider, whereas on the right side it is substantially reduced; therefore, the patient has performed the movement faster, which is related to improvement and less pain. This improvement was objectified both in the activity of rising from a chair and in the activity of bending over, picking up a weight and lifting it.

With regard to the **speed and acceleration of the movement in these two activities**:

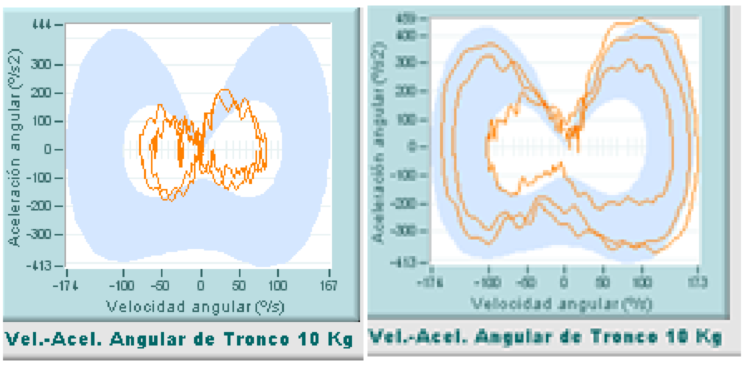


Figure 25. Representation of the angular speed/acceleration of the trunk for the three repetitions of the movement performed by the patient to lift 10 kg, along with its normality bands. The image on the left shows the patient's record from the previous session, and the image on the right, the same patient during the current session.

Another finding indicating improvement is the fact that the patient is now able to perform the movements at speeds and accelerations that are practically within normality. In the graph on the left, we saw that the graphic representation was away from the blue band (slow movement); however, in the right image these lines are within the blue band, which means that the movement has normalised in relation to its speed components. These data also support the conclusion that the patient has adequately progressed and improved after the treatment.

With regard to the **vertical reaction force** recorded with two dynamometric platforms:

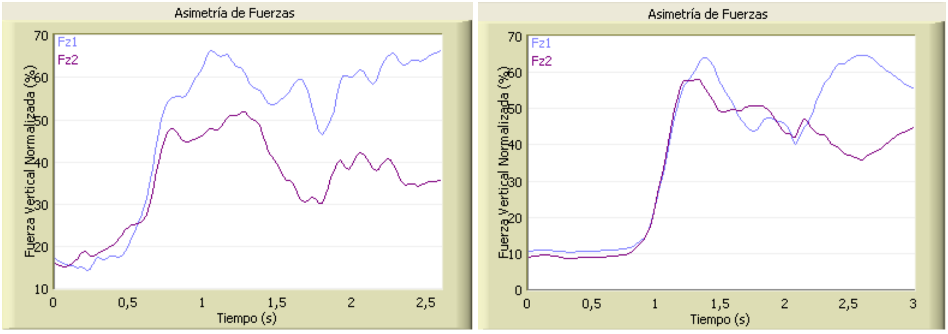


Figure 26. Total normalised vertical force exerted by the **right** foot **(Fz1)** and by the **left** foot **(Fz2)** while performing the sit-to-stand movement in one of the repetitions. The image on the left shows the patient's record from the previous session, whereas the image on the right shows the same patient during the current session.

The support has also stabilized on both lower limbs. In the previous assessment, there was a difference in the support when getting up from the chair, with more weight supported by the right limb (light blue line Fz1), whereas in the current assessment, the weight supported by each foot is practically equal.

The global assessment of this test was 97% of normality, which means that the current movement pattern is similar to that of people of his age and gender without any pathology or pain. Therefore, this movement pattern indicates that the patient is not functionally limited (with the applied protocol, NedLumbar/IBV considers the overall result functionally normal when it is greater than 90%.)

The spine flexion-relaxation assessment test was performed again, and the result obtained was as follows:

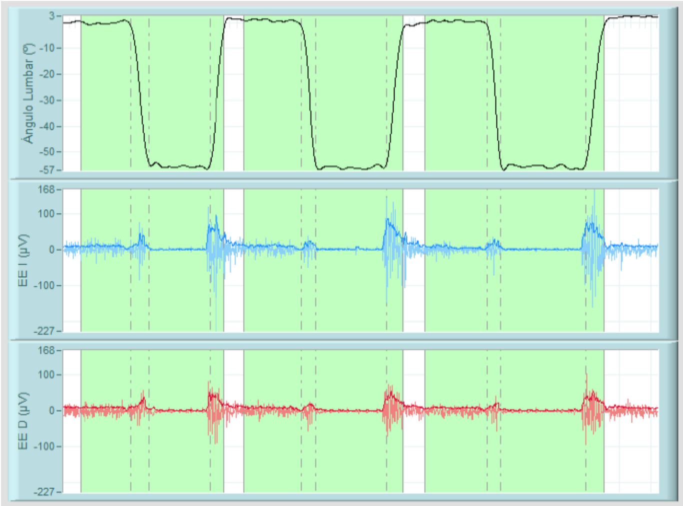


Figure 27. Kinematic and sEMG results during the flexion-relaxation test of the lumbar spine.

In light of the results obtained in the lumbar functional assessment, we can conclude that the pathology or the symptoms reported do not have a current impact on the functional capacity of this patient based on the objective values obtained for the different parameters analysed, which confirms the existence of a normal functional level.

Progress: In the first consultation, the patient reported pain and limited movement. After the therapy prescribed and the new assessment, he reported improvement, though the pain on palpation of the lumbar area persists but does not limit his movements. At the end of the treatment, the patient reported mild pain on palpation of the lumbar spinous processes; however, the sacroiliac joint and the paravertebral muscles are not painful on palpation. Active lumbar flexion is 60º and full extension. Normal lateral flexion and negative Lasègue’s sign.

Given that the results have normalised and that the patient is progressing favourably, the doctor decided that he could return to work.

6. Key ideas

- Spinal pain has a high prevalence in the clinical setting and frequently causes an alteration in the mobility of the spine.
- 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.

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