Erasmus+

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

MODULE BIOMECHANICS SPINE

Didactic Unit D: INSTRUMENTED ANALYSIS OF THE SPINE

D.2. Which dorsal and lumbar biomechanical instrumented evaluation protocols exist?

Politechnika Śląska

IBV INSTITUTO DE BIOMECÁNICA DE VALENCIA

VNIVERSITAT DE VALÈNCIA

AMSE THE ASSOCIATION OF MEDICAL SCHOOLS IN EUROPE

D.2. Which dorsal and lumbar biomechanical instrumented evaluation protocols exist?

OBJECTIVES

- To recall the main features that make up a biomechanical evaluation test.
- To learn some of the protocols used for kinematic evaluation of the dorsal and lumbar spine.
- To learn some of the protocols used to evaluate strength and muscular activity in the dorsolumbar spine.

D.2. Which dorsal and lumbar biomechanical instrumented evaluation protocols exist?

INDEX

- **Remember: What is a biomechanical test? What does it involve?**
- **Protocols for evaluating motion**
- **Protocols to evaluate strength**
- **Assessment of muscular activity: Surface EMG**

D.2. Which dorsal and lumbar biomechanical instrumented evaluation protocols exist?

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- **Remember: What is a biomechanical test? What does it involve?**
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- Assessment of muscular activity: Surface EMG

What is a biomechanical test? What does it involve?

A biomechanical assessment test is a **complementary test** done by means of biomechanical techniques.

What is a biomechanical test? What does it involve?

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

- What function is being assessed.
- What instrument and technique it is based on.
- **What assessment protocol has been used.**
- What results it provides, in what units and with what data analysis techniques they have been obtained.
- Standardised criteria for interpretation.

D.2. Which dorsal and lumbar biomechanical instrumented evaluation protocols exist?

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Protocols for evaluating motion

Dorsolumbar spine: protocols?

We could decide to measure any other gesture provided that:

- We know how to choose the right instrument and technique;
- Suitable biomechanical model;
- Correct, well-defined and standardised protocol;
- Proper data processing;
- Valid, reliable results obtained;
- Standardised interpretation of the results.

Protocols for evaluating motion

INCLINOMETRY

NedRangos/IBV

Electronic inclinometry system using two inclinometers:

The inclinometers are placed to assess the axes of motion for dorsal flexion-extension and rotation.

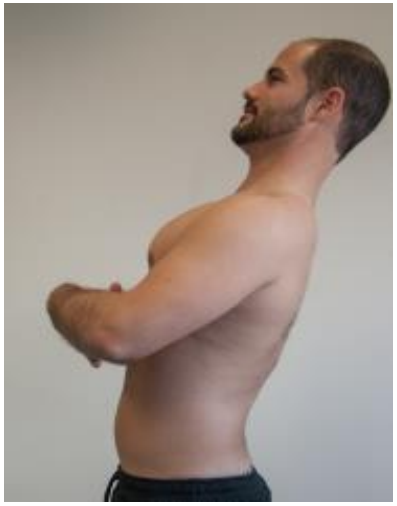
Protocol based on the **American Medical Association**'s guide.

The neutral position is measured, then the active or passive motion to be assessed (flexion and rotation) is performed.

A minimum of three valid measurements according to the AMA's repeatability criterion, differing by less than 10% or 5°.

Protocols for evaluating motion

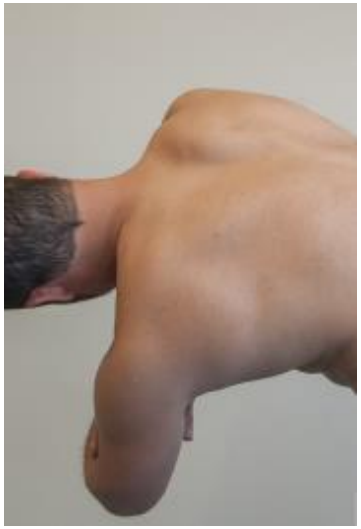
INCLINOMETRY: Dorsal flexion and extension



1. Neutral position
2. Maximum flexion motion (increase in kyphosis).
3. Maximum extension motion (reduction of kyphosis, opening of chest).

Protocols for evaluating motion

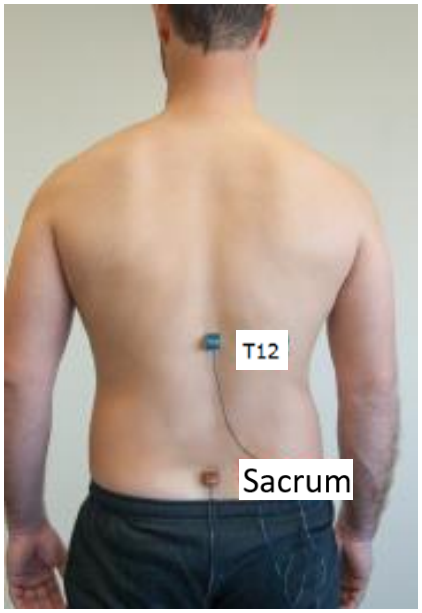
INCLINOMETRY: Dorsal rotation



1. Neutral position (trunk in flexion, arms crossed, no rotation).
2. Maximum left and right rotation motion (rotation with the trunk in flexion, lifting an elbow towards the ceiling).

Protocols for evaluating motion

INCLINOMETRY



NedRangos/IBV

Electronic inclinometry system using two inclinometers:

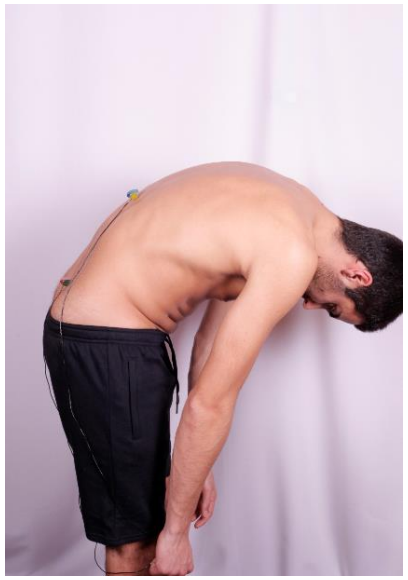
The inclinometers are placed to assess the axes of motion for lumbar flexion-extension and lateral flexion.

Protocol based on the American Medical Association's guide. The neutral position is measured, then the maximum active or passive motion to be assessed.

A minimum of three valid measurements according to the AMA's repeatability criterion, differing by less than 10% or less than 5°.

Protocols for evaluating motion

INCLINOMETRY: Lumbar flexion and extension



1. Neutral position
2. Maximum flexion motion (fingertips towards the ground).
3. Maximum extension motion

Protocols for evaluating motion

INCLINOMETRY and lumbar flexion-extension LUMBAR VALIDITY TEST

Additional confirmation of AMA repeatability: a lumbosacral flexion-extension test takes into account the motion of the hips at the sacrum:

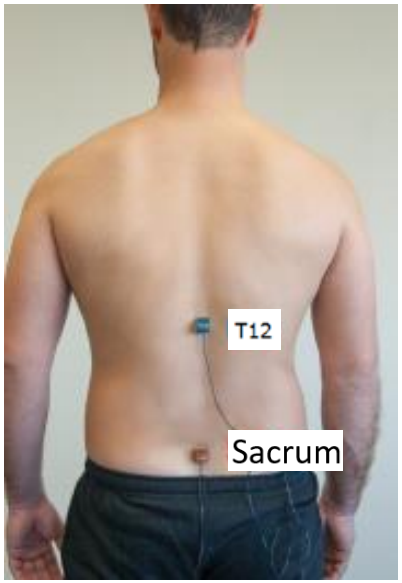
- ♂ Sacrum flexion-extension range > 55º.
- ♀ Sacrum flexion-extension range > 65º.

If this is not met, a validity test is advisable:

✔ Valid test: lowest passive elevation angle is no more than 15º greater than the sacral flexion-extension.

Protocols for evaluating motion

INCLINOMETRY: Lateral flexions



1. Neutral position
2. Maximum left and right lateral flexion motion (arm at body's side).

Protocols for evaluating motion

PHOTOGRAMMETRY

Segments

Cervical

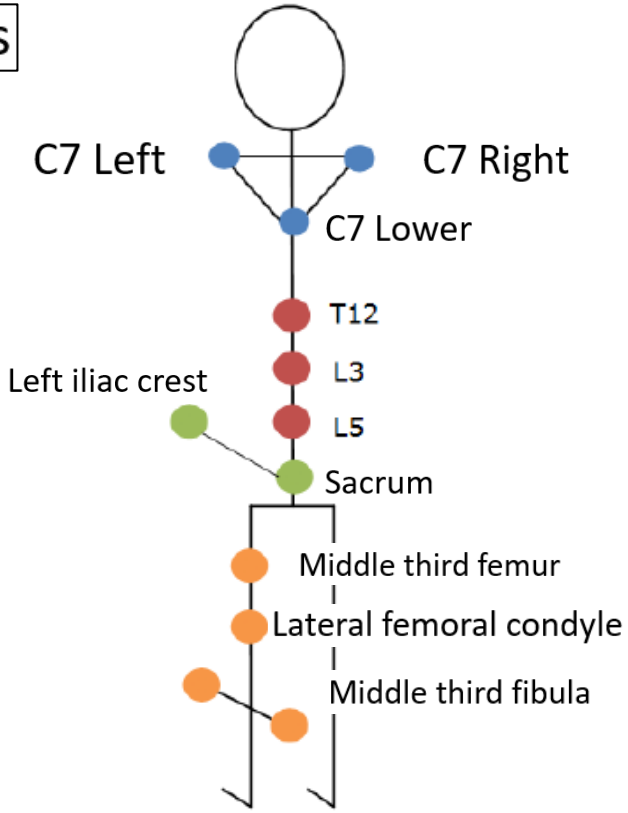
Thoracic

Lumbar

Pelvic

Thigh

Leg



Protocols for evaluating motion

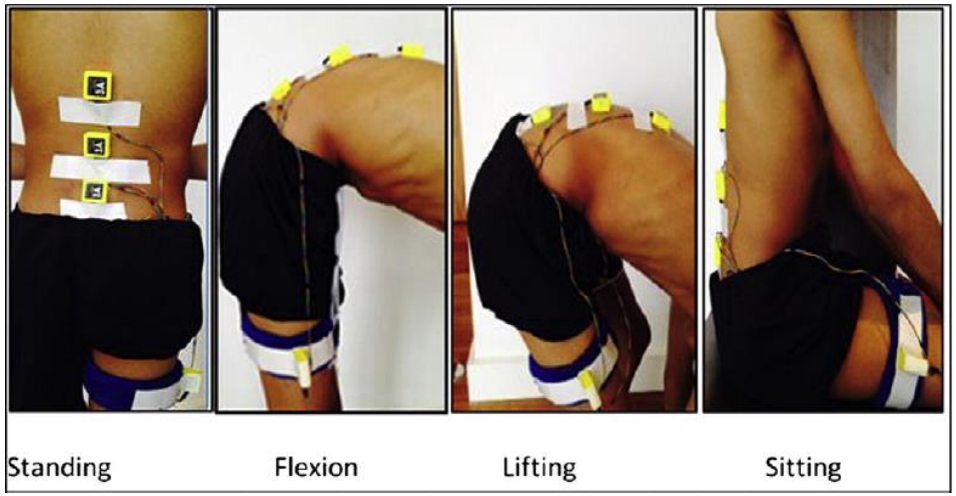
PHOTOGRAMMETRY: Getting up from a chair

Protocols for evaluating motion

PHOTOGRAMMETRY: Lifting a weight

Protocols for evaluating motion

Alqhtani R.S. et al. also evaluated ADL: standing, flexion, lifting an object and sitting.



Accelerometry system: four sensors at S1, L3, T12 and lateral thigh.
Measurement of relative motion between sensors: hip angle, lower and upper lumbar region.

Prior warm-up (trunk flexion-extension and rotation).

Gestures measured:

Starting with feet over marks on the floor, upright position staring at a predetermined mark on the wall at a height of 2 m. Arms relaxed at the side of the body.

Motions: maximum anterior flexion, lifting an object from the ground (such as a wooden box with handles), and sitting down and getting up from a stool.

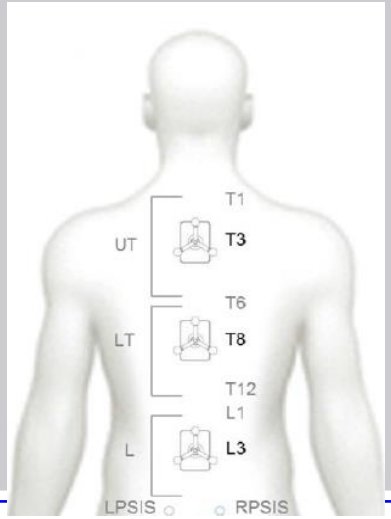
A complete gesture is performed as a test before measuring.

Protocols for evaluating motion

Other protocols:

Needham R. et al. and Steele J. et al. concentrated on kinematic evaluation of the spine while carrying out a habitual activity: walking.

Author(s)	Objective of study
Needham R. et al.	To develop and validate a multi-segmented kinematic model to evaluate lumbar and dorsal spine motion while walking.

Protocol used		
Kinematic model of the spine: model of Markers. Validated with mechanical model. Measurements compared with electrogoniometer and torsiometer. Enables 3D angular Measurement (XZY axes).		Walking barefoot in a walkway at a self-chosen speed. The Wireless Timing Gates system was used (Brower Timing Systems, Draper, UT, USA) to ensure said speed was reached. Five measurements or walks in the walkway are performed, ensuring tread upon two dynamometric platforms. The entire process is repeated a week later (test-retest repeatability study).

Protocols for evaluating motion

Other protocols:

Kinematic evaluation of the spine while carrying out a habitual activity: walking.

Author(s)	Objective of study
Steele et al.	To study the relationship between the spine's kinematics while walking with pain and the lumbar spine's extensor strength in subjects with lumbalgia.

Protocol used	
Pelvic and thoracolumbar markers model. This enables lumbar motion to be measured with respect to the pelvis in 3D. 	The subject walks at a self-chosen speed along a marked walkway of 8 m in length. At least five walks or attempts are gathered.

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Protocols to evaluate strength

ISOMETRIC DYNAMOMETRY

- These devices are for measuring resistance force without changing the length of the muscle fibres and with no movement of the joints.
- Different protocols.

MicroFET2 manual dynamometer for musculoskeletal evaluation

Evaluation of isometric force in each arc, including force from the trunk, especially in **extension**. Maximum force peak determined and force curves and graphs generated.

Information and images from:
https://tienda.fisaude.com/dinamometro-evaluacion-musculo-esqueletica-microfet2-p-39680.html

Protocols to evaluate strength

ISOMETRIC DYNAMOMETER: Some protocols to assess dorsolumbar spinal strength in the bibliography.

Author(s)	Objective of study
Pranata A. et al.	To study the ability to check on the lumbar extensor strength in subjects with chronic lumbar pain, and to analyse whether it is related to the perceived level of disability.

Protocol used

Lumbar extensor maximum voluntary isometric contraction (MVIC) was measured to derive sub-maximum values (20-50% of MVIC) for the target-matching task in a supported seated position using a lumbar extensor dynamometer (MedX).
The MedX stabilises the pelvis via a restraint system which prevents pelvic rotation by isolating the lumbar extensor muscle group.

Previous 30-second warm-up: lumbar flexion and extension (pain-free range of motion).
Posture: neutral spine position (12° flexion, 0° at full extension) with their back supported by the backrest. Subjects should press their back against the backrest, increasing the isometric force to MVIC over a 4-second period.

Protocols to evaluate strength

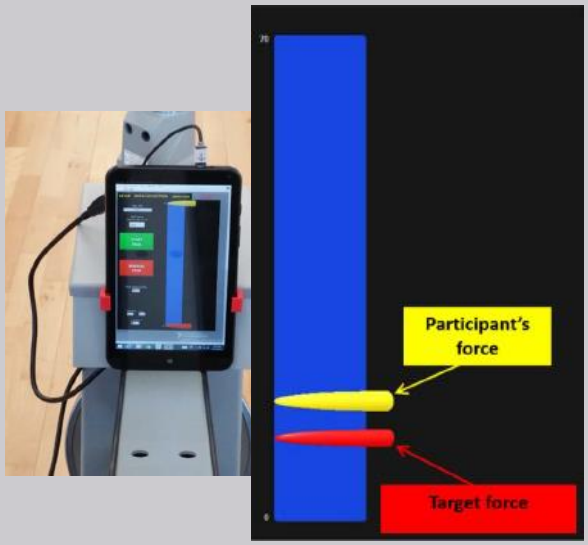
ISOMETRIC DYNAMOMETER: Some protocols to assess dorsolumbar spinal strength in the bibliography.

Author(s)	Objective of study
Pranata A. et al.	To study the ability to check on the lumbar extensor strength in subjects with chronic lumbar pain, and to analyse whether it is related to the perceived level of disability.

Protocol used

Lumbar extensor force matching task:
Subjects should match the force target as accurately as possible by increasing and decreasing their isometric force from 20 to 50% of MVIC at a frequency of 0.16 Hz.
The lower and upper force target limits (i.e., 20% and 50% MVIC) were selected based on lumbar extensor contraction intensities used in activities of daily living.

Two trials of 60 s duration with a 30-second rest between them. Trials were performed. Visual feedback was provided. No verbal encouragement was provided and the testing and environment were kept silent.



Protocols to evaluate strength

ISOKINETIC DYNAMOMETRY

This evaluates the moment of force (Fxd) or torque generated in a joint or body segment at a predetermined speed and within a predetermined range of motion.

Different positions: sitting, standing, prone, supine and decubitus lateral. The sitting position seems to be the most suitable, since it allows the pelvis to be stabilised, thus minimising muscular activity from the hip.

In this case, the protocol includes choosing the total range and velocity (º/s) at which the measurement of force is to be taken:

- Depending on the pathology being assessed, different ranges and velocities can cause limitations. For example, in subjects with a facet joint pathology, pain appears on extending the trunk at a low speed and maximum range, reducing the maximum moment (torque) generated.

Ferreira Quintino L. et al.

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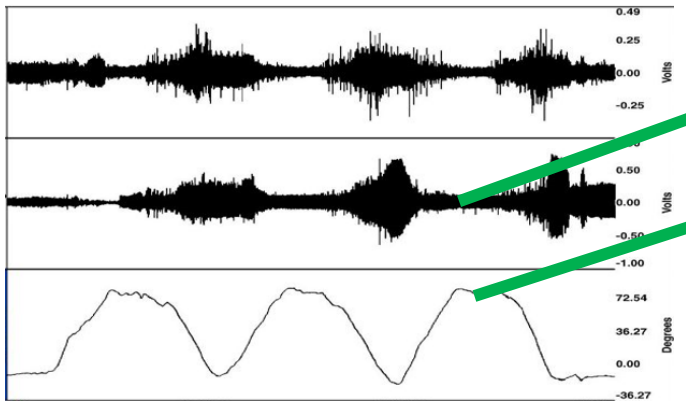
Assessment of muscular activity: Surface EMG

SURFACE EMG

There are many evaluation protocols for muscular activity that use surface EMG:

- **Measurement of the flexion-relaxation phenomenon in the lumbar spine:**
  - ✓ Relaxation of the musculature at maximum flexion (healthy subjects).
  - ✓ There are different protocols as regards the instruments and requirements for the gesture that is to be performed in order to evaluate this phenomenon. Many of them specify the minimum flexion required of the lumbar spine for the evaluation of the phenomenon to be valid.



Decrease in EMG activity.

Maximum flexion.

You can see an example of the protocol for performing this type of test via the following link: https://www.youtube.com/watch?v=rrMUmVgEOWg

Protocols for evaluating the lumbar spine

SURFACE EMG

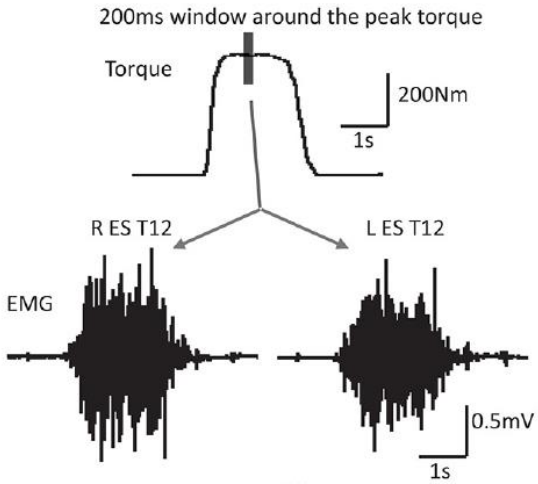
Chiou Sy et al.

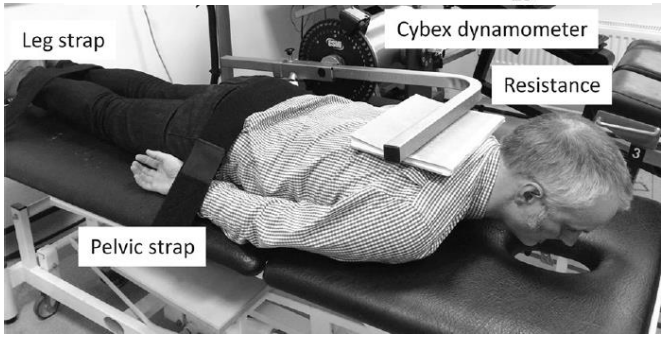
Objective of study

To study the ability to check on the lumbar extensor strength (EMG in terms of frequency) in subjects with lumbar pain, and to analyse whether it is related to the perceived disability.

Protocol used

Bilateral electrodes in erector spinae L4 and T12 (EMG).
Subjects performed three brief maximum voluntary isometric contractions (MVICs) of the back extensors and the torque was measured using a dynamometer.
The frequency of the EMG signal is studied at the moment of peak torque, obtaining: a ratio (low/high frequencies) of the energy, peak power and the frequency of the peak power for each recording site, averaged and correlated.





Protocols for assessment of muscular activity

SURFACE EMG: Other protocols

SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) includes a series of proposals to evaluate muscle activity in the trunk, including recommendations for the action or motion to be carried out during the measurement. These include:

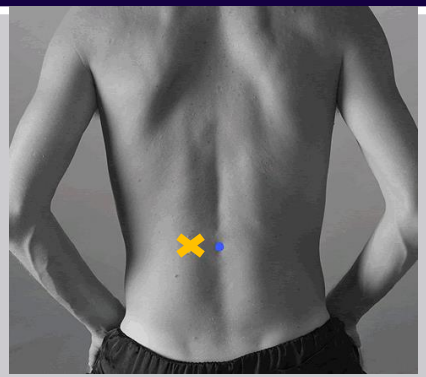
http://www.seniam.org/

Muscle	EMG sensors (X)	Activity/Test
Multifidus		Clinical testing would consist of lifting the trunk from a prone position.

Protocols for assessment of muscular activity

SURFACE EMG: Other protocols

http://www.seniam.org/

Muscle	EMG sensors (X)	Activity/Test
Erector spinae longissimus		Clinical testing would consist of lifting the trunk from a prone position.
Erector spinae iliocostalis		

IMPORTANT ASPECTS OF SPINAL EVALUATION USING TECHNIQUES WITH INSTRUMENTS

- There are many protocols to evaluate the dorsolumbar spine with techniques using instruments, whether it is to measure strength, motion, muscular activity or something else.
- In theory, any gesture can be evaluated with instrumental techniques provided we choose the correct one, a suitable protocol, proper data processing and we have standardised criteria to interpret the results.
- The protocol for measuring in any case must include: the instruments (if required), the gesture we are measuring, the number of repetitions, the prior instructions and the orders given to the patient during the test, the subject's posture before and after the measurement, the timing (rests, trials), and the greatest amount of detail possible to enable anybody to follow the same protocol.
- The definition of a measuring protocol must take into account all possible factors that may alter the results' validity (we measure what we intend to measure) and reliability (if the protocol is repeated by the same or different evaluator under the same conditions, the results will be similar).

Class activity (30')

You are going to work in groups:

1. Read the article by S. Alqhtani et al. carefully.
2. Look at the protocol for measuring, including the instruments, gestures, conditions and instructions/orders.
3. Could you reproduce the experiment exactly?
4. Do you think there is anything missing in the description of the experiment in order to be able to reproduce it? What? Why is it important and how do you think it could affect the results obtained?

Share your conclusions with your colleagues.

References

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- Quintino, L. F., Franco, J., Gusmão, A. F. M., Silva, P. F. D. S., & Faria, C. D. C. D. M. (2018). Trunk flexor and extensor muscle performance in chronic stroke patients: a case–control study. *Brazilian journal of physical therapy*, 22(3), 231-237.

Websites:

https://tienda.fisaude.com/dinamometro-evaluacion-musculo-esqueletica-microfet2-p-39680.html

http://www.seniam.org/

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