Lesson 10 Basic biomechanical measurements in the physiotherapy

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This lesson contains 10 screens teaching text, 1 zoomable figure and 15 short videos. This lesson requires approximately 2 - 4 hours of study but can vary depending on the student.

Biomechanical analysis is concerned with objective parameters of the human posture and motions and describes the forces and patterns involved in the movement. Biomechanical analyses contribute to enhancing our knowledge of the underlying causes of movement (3). For example, in order to the appropriate treatment, we need to know about the displacements and forces produced at various joints. There are many different technical ways to make biomechanical measurements. In this lesson, some of the assessment method of human posture and motion are introduced.

During a biomechanical analysis, data are collected through qualitative and quantitative analysis (3).

Qualitative analysis methods are also referred to as subjective methods involving a non-numerical evaluation of a skill and is most frequently performed during direct observation of movement. As you remember, this is the description of quality without the use of number.

Quantitative evaluation of movement requires that a record is collected for a number of trials so that each can be viewed and analyzed. This method is otherwise known as objective technique in biomechanical analysis. This is the collection, measurement, and evaluation of data from the activity of interest. Quantitative analysis implies that numbers are involved (6).

Before data collection we have to develop a detailed assessment plan or protocol. The main five steps of the measuring process are the goal setting, planning, implementation, analysis, and feedback (Fig. 1).

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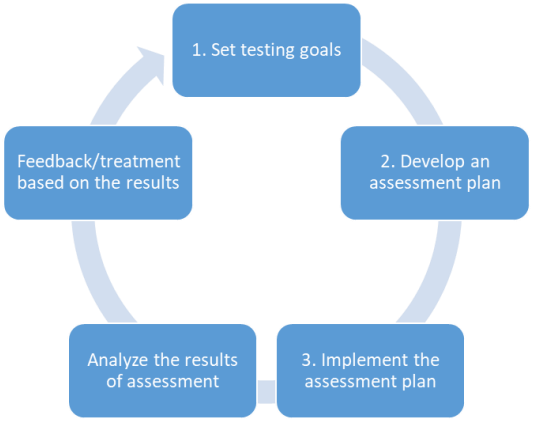

Fig. 1 General steps of the measuring process

Let's see the some example of the biomechanical assessment and equipment for biomechanical analysis.

Methods and instruments for biomechanical assessments

Impairments are defined as a dysfunction or a significant structural abnormality in a part of the body.

Assessment of the state or impairments of the patient, the effect of the therapy and the evaluation of changes in signs and symptoms can take many forms. The physiotherapist has to use different methods for accurate measuring of different parameters and have to be able to analyze and evaluate data.

At first, we need to collect anthropometric data, for example age, height, body mass, waist and hip circumference. For anthropometric evaluation we can use measuring tape, weighing scale. The self-reported data may be inaccurate.

Some parameters of the musculoskeletal system functioning are measurable in a relatively simple way. For example, we can measure the range of motion with a goniometer, the length of a limb with a measuring tape. There are different clinical tests which are used to determine the tissue source of pain or presence of musculoskeletal dysfunction. **Functional performance testing** means using a set of tests to determine performance abilities or functional limitations. This method measures the specific characteristics of function (6).

The following video shows an example of a functional performance test:

https://www.youtube.com/watch?v=GBT9V78d6E0

Another part of the biomechanical parameters which are necessary for the effective therapy of the patient are measurable with some kind of biomechanical analysis equipment. The instrumental recording of movement or posture data may take a number of forms; for example videography, electromyography, accelerometer, dynamometry, stabilometry. Let's see some example for this.

Dynamometry

The term **dynamometer** refers to an instrument used to measure a force.

There are several type of hand-held dynamometers that allow the user to quantify the force applied during manual muscle testing.

Please watch the following video about the use of a hand-held dynamometer:

https://www.youtube.com/watch?v=zrr3zpjHyFI

There are computerized dynamometer devices which evaluate strength, endurance, power and range of motion of all major joints and muscles, and provides highly detailed objective data results of their performance.

The next video shows an example of high tech dynamometers:

https://www.youtube.com/watch?v=G8zkeHTWqZ0

Body pressure distribution measurement

Measurement of ground contact forces can be used to assess the loads to which the human body is subjected to normal activities, like walking, or in more demanding situations such as in sports. **Pressure distribution** measurements are used to monitor the local loading on the tissue. One of the most used fields of the body pressure distribution measurement is the examination of plantar pressure distribution which can be performed during standing or walking. The examination of plantar pressure distribution is useable for evaluation of foot deformities or the effect of different surgical or conservative management. This measurement tool can be applied in other variety of areas including testing of athletic shoe design and effect of orthotics on foot function (4).

Next videos show examples of static (standing) and dynamic (walking) plantar pressure evaluation:

https://www.youtube.com/watch?v=2FWZ37JTk5I

https://www.youtube.com/watch?v=QuaEdhgLdKM

Force platforms

Force platform, in other words force plate measures the ground reaction forces generated by a body standing on or moving across them. Force platforms are usable to quantify biomechanics parameters during quiet standing or walking. Static posturography means the ability to maintain balance on a fixed platform, while

dynamic posturograph evaluates postural reactions in response to a translation or rotation of the support surface. It is a validated method of evaluating balance and postural stability under dynamic test conditions (1).

Please, watch the following videos about posturograpy:

https://www.youtube.com/watch?v=HT1xe4JaV7w&list=PL64AF0A03CE0A0A42

https://www.youtube.com/watch?v=AfNzm1Mcr_o

https://www.youtube.com/watch?v=HT1xe4JaV7w&list=PL64AF0A03CE0A0A42

https://www.youtube.com/watch?v=l_we1k_Okeo

Video motion analysis

Video motion analysis is a technique used to get information about moving objects from video. This technique uses multiple digital cameras and wearable markers or sensors for the detailed, real-time movement analysis. Video gait analysis is utilized for assessing the walk biomechanics.

Analysis of human motion via video provide opportunity for the objective assessment of a patient's condition, movement ability and motion patterns. Due to the feedback and motivational effect the video motion analysis can be a direct help for the treatment.

Please, watch the following videos about video motion analysis:

https://www.youtube.com/watch?v=1LBx5vZR_EY

There are different measuring systems which use specialized ultrasonic markers attached to the subject. This systems provide ultrasound-based motion analysis and are able to calculate the transient motion of the head, neck and lumbar, as well as a subject's posture and balance.

Electromyography (EMG)

Electrical activity produced by skeletal muscles can be evaluated with **electromyography**. This method uses a device is called electromyograph which helps detect neuromuscular abnormalities. EMG activity (measured in microvolts) is linearly related to the amount of muscle contraction. The electrical activity picked up by the electrodes is then displayed on a monitor that displays electrical activity in the form of waves. Surface

electrodes can be used for superficial muscles. Surface electrodes should clearly be used for the study of the gross function of muscle. A primary advantage of using surface electrodes is that they can be easily applied in a standardized manner without discomfort.

The following video shows surface electromyography which measures the electrical activity of the lower limb muscles:

https://www.youtube.com/watch?v=3WS9T8SzE98

Electromyography often carried out with fine wire electrodes which are inserted through the skin into the muscle.

Please, watch the video about needle electromyography:

https://www.youtube.com/watch?v=fr3bDpzeKkQ

Ultrasonography (US)

Ultrasonography uses ultrasound for diagnostic purposes. Ultrasound images of the musculoskeletal system provide pictures of muscles, tendons, ligaments, joints and soft tissue throughout the body.

Ultrasonography may be useful for detecting the joint abnormality. Superficial joints including those of the knee, ankle, elbow, and wrist can be visualized easily. Ultrasonography can evaluate for soft tissue infection or abnormalities in the tendon, ligaments and articular capsule (2).

The following video shows the examination of the elbow joint with ultrasound:

https://www.youtube.com/watch?v=H0NfwMubzSw

Ultrasonography of muscles provides information about structure and function of muscles, such as architecture, atrophy and hypertrophy. Ultrasound is a dynamic technique and therefore capable of visualizing normal and pathological muscle movements as well (2).

The following video shows the evaluation of deep muscles of the lumbar spine with ultrasonography:

https://www.youtube.com/watch?v=H63RYjqBxBk

This video presents the contraction of the pelvic floor muscles in ultrasound:

https://www.youtube.com/watch?v=4umq_GHvvPg

Study questions:

TRUE/FALSE questions

Read each statement below carefully. Choose T if you think a statement is TRUE. Choose F if you think the statement is FALSE.

1. Electromyography often carried out with surface electrodes which are inserted through the skin into the muscle.

   T or F
2. Hand-held dynamometer picks up the electrical activity from the muscles.

   T or F
3. Ultrasonography of muscles can provide information about structure and function of muscles.

   T or F
4. During electromyography, surface electrodes should clearly be used for the study of the gross function of deep muscles.

   T or F
5. A video motion analysis system evaluates the strength and endurance of muscles.

   T or F

Matching questions

In this exercise, you have to match each word with a definition.

1. Static posturography	**A. It evaluates the electrical activity produced by skeletal muscles.**
2. Electromyography	**B. It is defined as a dysfunction or a significant structural abnormality in a part the body.**
3. Functional performance testing	**C. It evaluates the postural reactions in response to a translation or rotation of the support surface.**
4. Impairment	**D. It measures the ability to maintain balance on a fixed platform.**
5. Dynamic posturograph	**E. It means using a set of tests to determine performance abilities or functional limitations.**

References

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