Erasmus+

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TEACH

MODULE BIOMECHANICS OF GAIT

Didactic Unit C: How Do I Assess Gait?

C.3 What are the advantages of the use of instrumental techniques versus scales and physical examination to assess gait?

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AMSE THE ASSOCIATION OF MEDICAL SCHOOLS IN EUROPE

C.3 WHAT ARE THE ADVANTAGES OF THE USE OF INSTRUMENTAL TECHNIQUES VERSUS SCALES AND PHYSICAL EXAMINATION TO ASSESS GAIT?

INDEX

C.3 What are the advantages of the use of instrumental techniques versus scales and physical examination to assess gait?

1.Introduction and objectives

1. INTRODUCTION AND OBJECTIVES

EVALUATION OF GAIT

- Observation
- Clinical scales /test and questionnaires
- Instrumental techniques

FUNDAMENTAL DIFFERENCES

- Choose between evaluation types
- Combination of evaluation types

1. INTRODUCTION AND OBJECTIVES

OBJECTIVES

1. To review the advantages and disadvantages of valuation methodologies for human gait.

2. To know the statistical properties of the gait assessment methodologies available.

3. To establish the technical knowledge that allow healthcare professionals to choose the most appropriate gait assessment technique for their clinical or research context.

C.3 What are the advantages of the use of instrumental techniques versus scales and physical examination to assess gait?

2. Features and properties of gait assessment tools: comparison between available techniques

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.1 Usability

The ease which people can use a particular tool

To achieve an specific goal

- Is it easy to use?
- Does it take a long time?
- Is it feasible to use it in my work area?

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.1 Usability

Instrumental techniques

- Strict protocol framed
- Manage correctly the instrumentation of the subject
- Post-treatment of data after measurement
- Long time spent

Clinical scales / Test and questionnaires

- Protocol biased by subjectivity
- No instrumentation
- No data treatment after measurement
- Short time spent

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.1 Usability

Gait cycle

Gait velocity, stride lenght, step lenght, cadence, double support time, support and swing phase time

	Instrumented walkway	*Photogrammetry system*
		
Subject instrumentation:	NO	YES
Data processing after measurement:	NO	YES
Training evaluator :	NO	YES
Approximate assessment time:	5 minutes	1 hour

Table 1. Comparation of features between Instrumented walkway and photogrammetry system.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.1 Usability

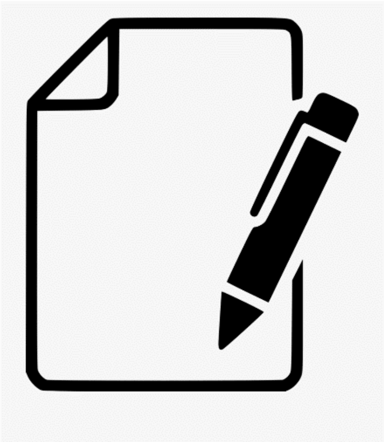
Characteristic	Observation gait analysis	Questionnaire, Scales and clinical Test	Instrumental techniques
Time cost	+	+	+ / ++/ +++ (depending on the system used)
Evaluator training	+	+	++ / +++ (depending on the system used)
Context of use	Clinical	Clinical and research	Research
Usability	+	++	+++

Table 2. Comparation of features between observation analysus, questionnaire, scales and clinical tests and instrumental techniques.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.2 Equipment requirements

Evaluation scale or questionnaire



Clinical tests

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.2 Equipment requirements

6-minutes walking test

Figure 1. 6-minutes walking test set up

- Measures the distance a patient can quikly walk in a 6-minute period.
- 100-ft hallway.
- Evaluates the global an integrated resposes of all systems involved during exercise.
- No exercise equipment.
- No advanced training for technicians.
- Assess the submaximal level of functional capacity.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.2 Equipment requirements

6-minutes walking test

Image 1. 6-minutes walking test set up

1. Countdown timer.
2. Mechanical lap counter.
3. Two small cones.
4. A chair that can be easily moved along the walking course.
5. Worksheets on a clipboard.
6. Adhesive tape or colored stickers.
7. Borg scale.
8. Pulse oximeter.
9. Sphygmomanometer and stethoscope.
10. Telephone.
11. A source of oxygen.
12. Automated electronic defibrillator.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.2 Equipment requirements

Appraisal with Instrumental techniques →

- More quantity of material required
- Higher specialized material required

Sensor or measurement equipment

Software and computer

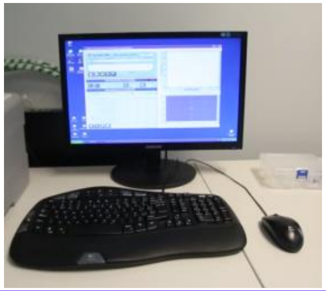
Supplies

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.2 Equipment requirements

Materials needed to do a gait evaluation with a photogrammetry system

Multi-camera system



Software and computer

Landmarks

Figure 2. Photogrammetry system and its components

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.2 Equipment requirements

Characteristic	Observation gait analysis	Questionnaire, Scales and clinical Test	Instrumental techniques
Equipment	+	+	+++
Supplies	-	+	++
Economic cost	+	+	+++

Table 3. Requirements of gait assessment tools

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.3 Objectivity of the results and statistical analysis

Instrumented assessment tools → Objective data obtained. No interpretation of the evaluator.

- Analysis trough observation
- Analysis trough questionnaires
- Analysis trough clinical scales

•Subjective data obtained.

•Results subject to interpretation.

•Clinical scales are very useful instruments, but are subject to double subjectivity (patient and evaluator).

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.3 Objectivity of the results and statistical analysis

Subjective and objective measure of step legth

Step length and height	
The left foot does not pass right stance foot	0
The left foot passes right stance foot with step	1

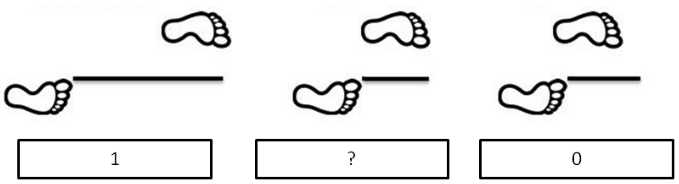


Figure 3. Step length and height ítem from the Tinetti Mobility Test, Gait section.

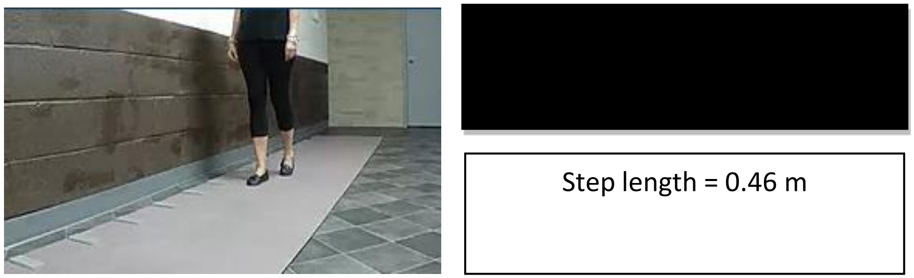


Figure 4. Step length assessment with an instrumented walkway (GAITrite).

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.3 Objectivity of the results and statistical analysis

Objective results measured with instrumental techniques

- Data can be comparable with other data from the same patient.
- Data can be comparable with other results between patients.
- Objective data between subjects should be normalized to be compared.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.3 Objectivity of the results and statistical analysis

Subjective data measured with scales and questionnaires

- Subjective measures can be highly correlated with objective measures.
- Value added to assessment scales used in clinical settings.
- If they are highly correlated with the results of the assessment using an instrumental technique, the subjective data measure will be valid.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.3 Objectivity of the results and statistical analysis

Subjective data obtained trough scales and questionnaires

(scored as a number)

Objective data obtained from an instrumental technique

→

Both capable of being stadistically analysed ✓

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.3 Objectivity of the results and statistical analysis

Dynamic Parkinson Gait Scale (DYPAGS) → Semi-quantitative variable

Tinetti Mobility Test (TMT) → Qualitative categorical variable

Naked-eye analysis obtaining characteristics of human gait → Subjective

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.4 Validity

- Validity refers to the accuracy of the measurement.
- A valid instrument must offer accurate and valid interpretable data.
- Validity refers to an specific matter and on a defined population.
- Reliability and validity are not totally independent:

A non reliable instrument ↛ Valid

A reliable instrument → Can be Invalid

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.4 Validity

Procedure to measure the validity of a tool

- New techniques or tools need to be compared with a “Gold Standard”.
- ¿Does tool A measure as precisely as tool B does in human gait?
- Usually analyzed with Pearson or Spearman Correlation Coefficient (r).
- Level of validity considered as:

Excellent: > 0.6	Adequate: 0.59 – 0.31	Poor: < 0.6

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.4 Validity

¿What type of tools have the most validity to measure gait or a specific characteristic of gait?

Instrumental measurement techniques **>** Valid Scales and clinical tests

- More precise instruments to measure a certain variable of the gait.
- Not all the instrumental techniques are equally precise.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.4 Validity

Devices	Precision	Cost
Chronometer	+	+
Pedometer	+	+
GPS	++	++
Radar speed	+++	++++
Cross line detector	+++	++
Inertial measurement unit	++	+++
Footswitch	+++	++
Instrumented walkway	+++	++++
Optoelectronic cameras	++++	+++++

Figure 4. Comparison of the common technologies used to measured spatiotemporal gait parameters (Moissenet F. and Armand S. 2016). For each instrumental technique, the degree of precision and the cost of the technique are mentioned.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.5 Reliability

- Reliability is the ability to reproduce a consent result in time and space or with diffferent observers.

- It is one of the quality criteria of an instrument.

- An instrument may not be considered reliable under different conditions.

- Reliability refers to whether an assessment instrument gives the same results each time it is used in:

The same settings | The same type of subjects

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.5 Reliability

Procedure to measure the validity of an instrument

It depends on what is intended to measure:

Stability	Internal consistency	Equivalence
It estimates the consistency of measurement repetition	(Homogeneity) All the subparts of an instrument measure the same characteristic	The concordance degree of several observers

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.6 Sensitivity to change and Responsiveness

Sensitivity to change

• It is defined as the ability of an instument to **measure change in state**, regardless of whether the change is relevant or meaningful to the decisión-maker.

•It is related to the **evaluation of the impacts** of programs and treatments in clinical science.

•It is specially relevant in applied settings where **program or treatment effects are often not particularly strong**, and measurement conditions can be quite variable.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.6 Sensitivity to change and Responsiveness

Responsiveness

• It is defined as the ability of an instrument to **measure a meaningful or clinically important change** in a clinical state.

•It is not considered a generalizable property and **should be assessd for each population and purpose** for which the measure is used.

•A change score on a measure should **equal of exceed its minimally important difference (MID)** estimate to be considered important.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.6 Sensitivity to change and Responsiveness

Related to sensitivity

Biomechanical assessment techniques **>** Clinical assessment scales

Sensitivity to detect changes on gait features

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.6 Sensitivity to change and Responsiveness

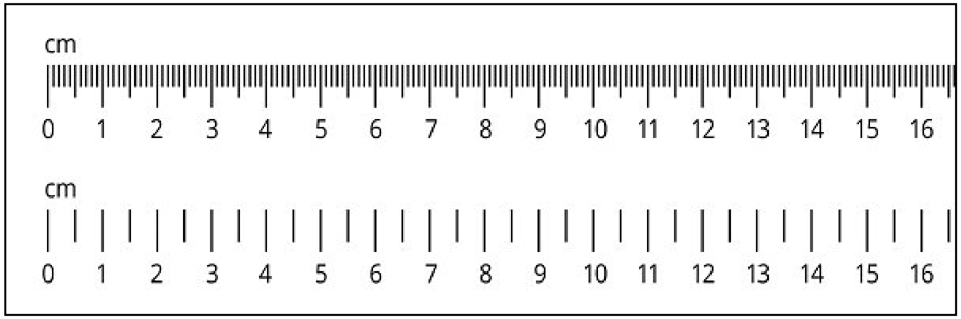


Figure 5. The image shows two rulers.

The upper ruler is more precise tan the lower ruler

→

The upper ruler is more sensitive to length measure than the lower one

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.6 Sensitivity to change and Responsiveness

Devices	Precision	Cost
Chronometer	+	+
Pedometer	+	+
GPS	++	++
Radar speed	+++	++++
Cross line detector	+++	++
Inertial measurement unit	++	+++
Footswitch	+++	++
Instrumented walkway	+++	++++
Optoelectronic cameras	++++	+++++

Figure 4. Comparison of the common technologies used to measured spatiotemporal gait parameters (Moissenet F. and Armand S. 2016).

Most accurate systems

Photogrammetry systems

Optoelectronic cameras

More sensitive to the measurement of spatio-temporal variables

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.7 Floor and ceiling effect

Fenomenon produced when a range of function covered by a measure is less than the range experienced by patientes.

•Meassure may lack responsiveness.

•Spikes at highest or lowest response option is often interpreted as evidence of ceiling or floor effects.

•They are important to assess of the effectiveness of interventions prospective evidence of the performance of a measure.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.7 Floor and ceiling effect

Ceiling effect (Score toward the high end)	Floor effect (Score toward the down end)

↓

Can be biased

Patients could be “worse off” than the measure could capture

Patients could be “better off” than the instrument can mesure

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.7 Floor and ceiling effect

Instrumental gait assessment techniques	Clinical gait assessment scales
↓	↓
Floor effect	Ceiling effect

Reason: the difference of ease or difficulty with which each of them can be performed by patients

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.7 Floor and ceiling effect

Clinical gait assessment scales

- Defined following structured questionnaires.
- They reduce sensitivity with other clinical assessment instruments or technologies.
- Small changes in the functional capacity due to the intervention of the profesional are very difficult to identify.

2. FEATURES AND PROPERTIES OF GAIT ASSESSMENT TOOLS: COMPARISON BETWEEN AVAILABLE TECHNIQUES.

2.7 Floor and ceiling effect

Instrumental gait assessment techniques

- The assessment protocols require the patient to be carried out.
- Gait assessment in patients with severe impairment in ambulation is not possible.
- The floor effect may limit the entry of severely injured individuals.

C.3 What are the advantages of the use of instrumental techniques versus scales and physical examination to assess gait?

3. Key ideas

3. KEY IDEAS

- The medical staff have to know the methodological characteristics and statistical properties at the time of choosing a gait assessment tool. This is necessary to avoid methodological errors and biases in the measured results.
- Regarding usability, clinical scales and tests have the advantage that they are possible to develop in a short time, they do not require specialized training from the rater and they can be used in any context such as in clinical practice.
- The equipment required to use clinical tests and scales is much less and accessible than the equipment needed to perform a gait assessment with biomechanical assessment instruments.
- The most important quality of instrumental biomechanical assessment techniques is that they provide objective data obtained without interpretation of the evaluator (i.e. directly assessment of one or more dimensions of gait pattern), so their use is mainly in the research area. On the contrary, the information obtained through scales and clinical tests is influenced by the interpretation and perception of the evaluator.

3. KEY IDEAS

- The high precision of the instrumental measurement techniques gives them the quality of being more valid to measure a gait characteristic than the scales or clinical tests.
- The reliability is usually better in biomechanical instruments because the repeatability of the measurement does not depend on the observer but on other factors, such as performing the measurement with a standardized protocol.
- The more accurate a measuring instrument is, the more sensitive to change the instrument will be. The sensitivity of equipment must be sufficient to measure minimal clinically important difference in the outcomes that professional intent to observe in a given population.
- The clinical scales and tests have a greater tendency to have a ceiling effect, that is, the participants' scores cluster toward the high end (or best possible score) of the measure / instrument. On the other hand, the instrumental techniques have a greater floor effect, where the participants' scores cluster toward the down end. This is due to patients could be "better off" than the measure could capture or "worse off" than the instrument can measure.

C.3 What are the advantages of the use of instrumental techniques versus scales and physical examination to assess gait?

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