

3

Goniometer

LEARNING OBJECTIVES

After the completion of the chapter, the readers will be able to:

- Identify different types of goniometers.
- Describe the main parts of a goniometer.
- Explain proper care and handling techniques.
- Discuss routine maintenance procedures.
- Explain the importance of calibration and calibration procedures.
- Discuss how to verify measurement accuracy.
- Identify common errors during goniometric assessments and evaluate their impact on measurements.

CHAPTER OUTLINE

- Introduction
- Types of Goniometers
- Parts of a Goniometer
- Calibration and Accuracy of a Goniometer
- Common Errors in Goniometry due to Faulty Instrument
- Care and Maintenance of a Goniometer
- Clinical Relevance

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Series

INTRODUCTION

In physiotherapy practice, precise measurement of joint angles is fundamental to accurate assessment, diagnosis, and treatment planning. The goniometer—a specialized instrument for quantifying joint range of motion such as at the knee or elbow—plays a pivotal role in this process. This chapter provides an overview of the various types of goniometers, their structural components, and the principles of their proper care, maintenance, and application in clinical settings.

TYPES OF GONIOMETERS

Goniometers come in various forms, each designed for specific applications and levels of precision. Understanding different types of goniometers will help the therapist select the most appropriate one for each assessment and patient.

Universal Goniometer

Universal goniometer is the most common type found in clinical settings. It is used for a wide range of joints, including the shoulder, hip, knee, elbow, wrist, and ankle.

Structure

Universal goniometer typically consists of a central circular disc or protractor marked in degrees from 0° to 360° and two arms—one stationary and one moving. The arms can be made of plastic, metal or a combination of materials (Fig. 3.1).



Figure 3.1: Different sizes and shapes of metal body goniometers



Figure 3.2: Digital goniometer

Uses

Universal goniometer is versatile and can be used for most joints. It requires proper alignment of the stationary arm with the body part remaining still and the moving arm with the part of the body that moves during the joint's range of motion (ROM).

Digital Goniometer

Digital goniometers provide a modern approach to measuring joint angles, offering digital displays that show the angle measurement electronically.

Structure

Digital goniometers consist of two arms connected by a digital protractor. The protractor displays the angle measurements on a digital screen, eliminating the need for manual reading (Fig. 3.2).

Uses

Digital goniometers are used similarly to universal goniometers but offer easier readability and potentially greater accuracy. They are particularly useful in research settings or when documenting precise angle measurements is essential.

Gravity-Dependent Goniometer (Inclinometer)

Gravity-dependent goniometers or inclinometers are specifically designed to measure the ROM of spinal joints and other areas where traditional goniometers may be less effective.

Structure

Inclinometers usually consist of a single arm and a gravity-sensitive mechanism that measures the tilt from the vertical or horizontal planes. Some models are digital, while others use a spirit level or a weighted dial (Fig. 3.3).

Uses

Inclinometers are placed on the skin over a spine segment or other body parts. They measure the angle of tilt as the patient moves, using gravity as a reference point. This type is especially useful for measuring spinal flexion, extension, and lateral bending.



Figure 3.3: Inclinometer

Telescopio Goniometer

Telescopio goniometers are designed for measuring larger joints and limbs, such as the hip or shoulder or for assessing the ROM in patients with significant deformity or obesity where a standard goniometer may not reach.

Structure

Telescopio goniometers have extendable arms that can be adjusted to the size of the limb or joint being measured. They typically feature a central protractor and can be made from various materials (Fig. 3.4).

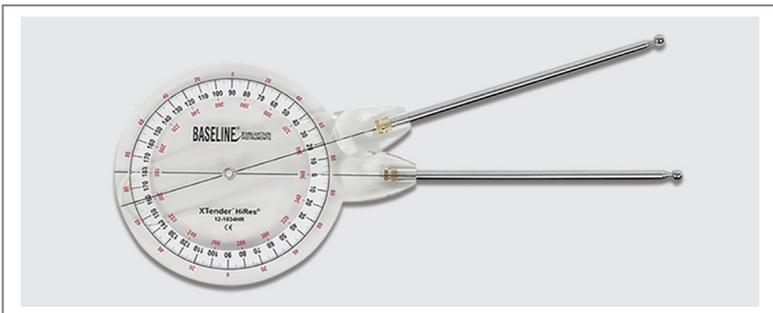


Figure 3.4: Telescopio goniometer



Figure 3.5: Finger goniometer

Uses

Telescopic goniometer is used by extending the arms to fit the length of the segment being measured, allowing for accurate measurement of larger limbs or joints.

Finger Goniometer

Finger goniometers are smaller goniometers specifically designed for measuring the ROM of finger joints.

Structure

Finger goniometers are typically smaller than universal goniometers, with shorter arms suitable for the small size of finger joints. They often have a simpler design, sometimes with a single fixed axis (Fig. 3.5).

Uses

Finger goniometers are used to assess the flexion, extension, abduction, and adduction of finger joints. They are particularly useful in hand therapy and for patients recovering from hand injuries.

Smartphone Goniometer Apps

With advances in technology, smartphone apps have been developed to function as goniometers. These apps use the built-in accelerometer and gyroscope of the phone to measure angles.

Structure

Smartphone goniometer apps are not physical goniometers but software applications designed to be used on smartphones or tablets (Fig. 3.6).

Uses

The user places the smartphone on the body part being measured or aligns it with the limb's movement. The app then calculates and displays the angle of movement. While convenient, the accuracy of smartphone goniometer apps can vary and may not be suitable for all clinical measurements.



Figure 3.6: Clinometer application on the iPhone

CBS PARTS OF A GONIOMETER

Understanding the different parts of a goniometer is crucial for its proper use and ensuring accurate measurements. Figure 3.7 presents a detailed look at the components of a typical goniometer.

Body (Protractor)

The body of the goniometer, often referred to as the protractor, is the central part of the instrument. It is typically circular or semi-circular in shape and marked with degree measurements ranging from 0° to 360° .

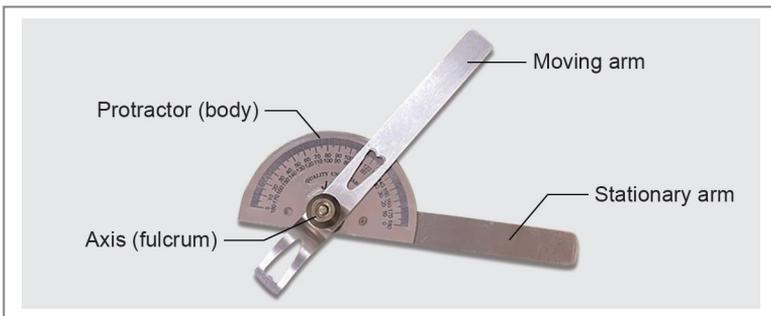


Figure 3.7: Parts of goniometer

Characteristics

- **Material:** Can be made of plastic, metal or a transparent material for easy reading against the skin.
- **Degree markings:** The degrees are marked around the edge of the protractor to allow for precise measurement. They are usually in increments of one degree for accuracy.
- **Visibility:** Many goniometers have a clear, transparent body to easily align the device with the patient's anatomical landmarks.

Arms

A goniometer has two arms; (1) The stationary (fixed) arm, and (2) The moving (adjustable) arm. These arms are attached to the body of the goniometer and are used to measure the angle between two points of a limb or joint.

Stationary Arm

- **Purpose:** This arm remains fixed and is usually aligned with the proximal or stationary part of the body segment being measured.
- **Length:** It can vary in length depending on the type of goniometer but is typically long enough to accurately align with body landmarks.

Moving Arm

- **Purpose:** This arm moves with the part of the body that is being measured, typically the distal or moving part of the limb.
- **Adjustability:** It can be rotated around the protractor to measure the angle of joint movement.

Axis (Fulcrum)

The axis or fulcrum is the central point around which the moving arm of the goniometer rotates. It is located at the center of the protractor body and corresponds to the pivot point of the joint being measured.

Characteristics

- **Position:** It should be correctly positioned at the joint's axis of rotation for accurate measurements.
- **Identification:** On most goniometers, the axis is marked with a small circle or crosshair on the body of the protractor for precise alignment.

Locking Mechanism

Some advanced or specialized goniometers come with a locking mechanism that allows the moving arm to be fixed at a certain angle. This feature is particularly useful for recording measurements or maintaining an angle for comparison.

Functionality

- **Use:** Allows the physiotherapist to lock the arms in place after measuring an angle, which helps in documenting or explaining the results to the patient without losing the measurement.
- **Types:** The locking mechanism can be a simple screw, a lever or a button, depending on the goniometer's design.

Handle

Some larger goniometers, such as those used for measuring spinal motion or for educational purposes, may include a handle. The handle aids in positioning and stabilizing the goniometer during measurement, especially in hard-to-reach areas.

Characteristics

- **Ergonomics:** Designed to fit comfortably in the hand, making it easier to hold the goniometer steady during use.
- **Material:** Usually made from the same material as the arms, ensuring durability and ease of cleaning.

CALIBRATION AND ACCURACY OF A GONIOMETER

Ensuring the calibration and accuracy of a goniometer is essential for effective and reliable measurements in physiotherapy practice. Calibration refers to the process of verifying and adjusting the readings of a goniometer to ensure they reflect the true angle of joint movement. Accuracy, on the other hand, refers to the closeness of the goniometer's readings to the true value. Methods to maintain calibration and accuracy of a goniometer are given as follows:

Calibration Process

Regular calibration is key to ensuring that the goniometer provides accurate measurements:

- **Reference check:** Use a known standard such as a protractor or another calibrated goniometer to compare readings. This could involve measuring a fixed object with a known angle to ensure the goniometer reads the angle correctly.
- **Zero degree check:** Ensure that when the arms of the goniometer are closed, the reading is at 0° . If there is any deviation, the goniometer may need adjustment or replacement.
- **Full range check:** Open the arms of the goniometer fully to ensure the device reads 180° (or 360° for a full circle protractor) accurately. This checks for any errors across the range of motion.
- **Consistency check:** Measure the same angle multiple times to check for consistency in the readings. Inconsistent readings can indicate a problem with the goniometer's mechanism.
- **Professional calibration:** For digital goniometers or if the therapist notices any discrepancies, professional calibration may be required. Some manufacturers offer calibration services or the therapist may need to consult a specialist.

Maintaining Accuracy

To maintain the accuracy of the goniometer, follow these guidelines:

- **Proper use:** Always ensure correct placement of the goniometer's axis at the joint's center of rotation, alignment of the stationary arm with the body part that remains stationary, and the moving arm with the part that moves during motion.
- **Environmental factors:** Be aware of environmental factors that could affect measurements, such as patient positioning, muscle relaxation, and the therapist's viewpoint relative to the goniometer.
- **Training:** Regular training and practice using goniometer can help reduce user error and increase measurement reliability. Therapists must familiarize themselves with the correct techniques for measuring different joints.
- **Documentation:** Record the methods and positions used for measurements to ensure consistency between sessions and among different therapists. Numerical tables are structured with joint motions listed centrally, flanked by columns for left and right side

measurements. Examiner initials and test dates are recorded at the top of each column. The instrument used and any relevant clinical observations (e.g., pain or discomfort) are noted in the comments section. Initial measurements may be entered on either side of the central column, with subsequent entries progressing outward. This format facilitates clear comparison across sessions, aiding in the identification of restricted motions and monitoring of rehabilitation progress (*Appendix 1*).

- **Patient cooperation:** Ensure that the patient is relaxed and understands the procedure to prevent involuntary movements that could affect the readings.
- **Periodic rechecks:** Even with careful handling, goniometers can become inaccurate over time due to wear and tear, especially plastic ones. Regularly recheck and recalibrate the tools.

Troubleshooting Common Issues

If a therapist encounters problems with accuracy, consider the following:

- **Damaged equipment:** Inspect the goniometer for any physical damage such as bent arms or a loose axis, which can affect readings.
- **Reading errors:** The therapist must ensure correct reading of the scale. Misreading the scale, especially in poorly lit areas or when the scale has become worn, is a common source of error.
- **Patient factors:** Consider anatomical variations, swelling or skin folds, which can interfere with proper landmark identification and arm placement.
- **Method consistency:** Use the same method and procedure each time to reduce variability in measurements.

COMMON ERRORS IN GONIOMETRY DUE TO FAULTY INSTRUMENT

Accurate goniometric assessment of joint ROM depends on the integrity of the measuring instrument. Faulty equipment introduces systematic and observational errors that compromise data validity. Key issues include:

- **Mechanical deformities:** Bent or misaligned arms distort angle readings.

- **Unstable fulcrum:** A loose hinge shifts during use, altering measurements.
- **Illegible scale markings:** Faded or obstructed scales hinder precise readings.
- **Calibration drift:** Instruments may lose accuracy over time without recalibration.
- **Improper zeroing:** Inconsistent alignment at baseline affects reliability.
- **Device variability:** Differences across goniometer types impact consistency.

Routine inspection, calibration, and adherence to standardized protocols are essential to minimize equipment-related errors and ensure reliable ROM evaluation.

CARE AND MAINTENANCE OF A GONIOMETER

Proper care and maintenance of a goniometer are essential to ensure its longevity and the accuracy of measurements it provides. Since a goniometer is a precision instrument used in physiotherapy assessments, handling it with care is crucial. The following are the detailed guidelines for the care and maintenance of a goniometer:

- **Cleaning:** Regular cleaning is vital to maintain the goniometer's hygiene and functionality, especially since it comes in contact with different patients.
 - **After each use:** Wipe the goniometer with a clean dry cloth/tissue paper to remove any skin oils, sweat or dirt.
 - **Disinfection:** Use a mild disinfectant or alcohol wipes for cleaning, especially during flu seasons or when used between patients in a clinical setting. Avoid using harsh chemicals that could damage the material or erase the markings.
 - **Drying:** Ensure the goniometer is completely dry before storing it. Moisture can lead to rust on metal parts or degradation of plastic materials.
- **Storage:** Proper storage is key to protecting the goniometer from damage and environmental factors.
 - **Temperature and humidity:** Store the goniometer in a cool, dry place to prevent warping or rusting. Avoid leaving it in direct sunlight or in high-humidity areas like washrooms.

- **Separate storage:** Keep it in a protective case or drawer where it will not get crushed or bent by heavier objects. If storing multiple goniometers together, avoid stacking them directly on top of each other without cushioning.
- **Accessibility:** Keep it in a location where it is easily accessible but safe from potential harm.
- **Handling:** Correct handling will prevent damage and maintain the goniometer's accuracy.
 - **Gentle use:** Avoid dropping the goniometer or using excessive force when opening and closing the arms. Mishandling can lead to bending or misalignment, affecting measurement accuracy.
 - **Avoid overextension:** Do not extend the arms beyond their capacity or use them for purposes other than measuring joint angles, as this can damage the instrument.
- **Regular inspection:** Routine checks will help identify any issues before they impact the goniometer's performance.
 - **Check for damage:** Regularly inspect the goniometer for any signs of wear and tear, such as loose, bent or rusted parts.
 - **Arm alignment:** Ensure that the arms align correctly and the measurement starts at 0° when the arms are closed.
 - **Legibility:** Make sure the degree markings are still clear and legible. Faded or worn-out markings can lead to inaccurate readings.
- **Calibration:** While goniometers typically do not require frequent calibration like some electronic devices, it is good practice to check their accuracy periodically.
 - **Comparison:** Compare the measurements with a known angle or another goniometer to ensure accuracy.
 - **Professional calibration:** If available, consider professional calibration services, especially for digital goniometers, to ensure they maintain their precision over time.
- **Repairs:** If the goniometer is damaged or malfunctioning, assess whether it can be repaired or needs to be replaced.
 - **Manufacturer's instructions:** Refer to the manufacturer's guidelines for maintenance and repairs.
 - **Professional repairs:** For complex issues, especially with digital goniometers, consult a professional or the manufacturer for repairs.
 - **Replacement:** If a goniometer is extensively damaged or consistently provides inaccurate readings, it may be more prudent to replace it rather than attempting repairs.

Clinical Insight

- **Accurate ROM assessment:** Goniometers are essential tools for measuring joint angles, allowing for precise ROM assessments in conditions, such as arthritis, postsurgical rehabilitation, and musculoskeletal disorders. Accurate measurements guide treatment planning and track progress.
- **Differentiating joint pathologies:** The type of goniometer used (e.g., universal, digital or inclinometer) can help identify specific joint limitations. For example, a digital goniometer may provide more precise data for subtle joint restrictions in conditions like early-stage osteoarthritis, aiding in early intervention and customized therapy plans.

CLINICAL RELEVANCE

- **Upper limb:** In adhesive capsulitis (frozen shoulder), serial goniometric measurements of external rotation and abduction help monitor capsular tightness and guide joint mobilization intensity. In tennis elbow rehabilitation, tracking wrist extension range informs readiness for eccentric loading and return-to-sport timelines. For brachial plexus injuries, measurement of shoulder flexion and elbow extension helps evaluate motor recovery stages.
- **Lower limb:** In postoperative total hip replacement, goniometry helps in assessing adherence to hip precautions by measuring safe limits of flexion and internal rotation. In anterior knee pain syndromes, measuring quadriceps length through prone knee flexion helps identify muscle tightness contributing to patellofemoral dysfunction. Goniometric assessment of ankle dorsiflexion in runners is essential to prevent overuse injuries such as Achilles tendinopathy and plantar fasciitis.
- **Spine:** In mechanical low back pain, goniometric tools (including inclinometers) quantify limitations in lumbar flexion and extension—key to tracking response to core stabilization programs. In scoliosis management, measuring trunk rotation and lateral flexion assists in evaluating structural versus functional limitations and the impact of orthotic bracing.

Points to Remember

- Goniometers are essential for accurately measuring joint angles and are crucial for assessing and tracking patient progress in physiotherapy.
- Types of goniometers include universal, digital, gravity-dependent (inclinometer), telescopic, and finger goniometers, each designed for specific joints and applications.
- Goniometer comprises a protractor (body), stationary arm, moving arm, axis (fulcrum), and sometimes a locking mechanism or handle.
- Regular cleaning, proper storage, gentle handling, routine inspection, and calibration are necessary to ensure accuracy and longevity of goniometers.

