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Goniometer

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Introduction

A goniometer is a device that measures an angle or permits the rotation of an object to a definite position. In orthopedics, the former description applies more. The art and science of measuring the joint ranges in each plane of the joint are called goniometry. The term ‘goniometry’ has its origin from two Greek words, gonia, which means angle, and metron, which means to measure. The first known use of a primitive version of the modern-day goniometer was by a Dutch physician and mathematician named Gemma Frisius, who used it to calculate and record the position of celestial bodies with respect to Earth.

Anatomy and Physiology

The range of motion is the measurement of movement around a specific joint or body part. To measure the range of motion, doctors, osteopaths, physical therapists, or other health professionals most commonly use a goniometer, which is an instrument that measures angle motion at a joint.[1][2]

There are three types of range of motion, dependent on the purpose of the assessment:

1. Passive
2. Active
3. Active assistive

Types of Goniometers

1. Universal Goniometer - comes in two forms: short arm and long arm.
    - The short arm goniometer is used for smaller joints like the wrist, elbow, or ankle,
    - The long arm goniometers are more accurate for joints with long levers like the knee and hip joints.[3]
2. Twin Axis Electrogoniometer -
    - The inter-rater and intra-rater reliability of the electrogoniometer is higher than the universal goniometer but challenging to apply in patients' clinical evaluation, hence used more often for research purposes.[4]
3. Gravity Goniometer/Inclinometer
    - One arm has a weighted pointer that remains vertical under the influence of gravity.
4. Software/Smartphone-based Goniometer
    - A smartphone as a digital goniometer has several benefits like availability, ease of measurement,

application-based tracking of measurements, and one-hand use. These applications use the accelerometers in phones to calculate the joint angles.[5][6][7][8]

5. Arthrodial Goniometer
    - Ideal for measuring cervical rotation, anteroposterior flexion, and lateral flexion of the cervical spine.

Of all the types, a universal goniometer is most widely used.[9]

Indications

The goniometer is used in the following:

1. Presence of dysfunction related to muscles, tendons, or joints.
2. Establishing a diagnosis
3. Developing treatment goals
4. Evaluating progress or the lack of it
5. Modify treatment based on the progress
6. Fabricating orthoses
7. Measurement for research purpose

Contraindications

Conditions for which a goniometer ought not to be used include the following:

1. Joint dislocation
2. Unhealed fracture
3. Post-surgery if movement disrupts the healing process
4. Regions of osteoporosis or bone fragility, as forced measurements may cause iatrogenic injury
5. Immediately following an injury where disruption of soft tissue is likely

Conditions where goniometer use is appropriate with added precautions

1. Infection or inflammation around a joint
2. Severe pain aggravated by movement
3. Hypermobility or instability

Equipment

A universal goniometer has three parts.

A body- It is designed like a protractor and may form a full or a half-circle. It has a scale for the measurement of the angle. The scale can extend either from 0 to 180 degrees or 180 to 0 degrees for half circle models or 0 to 360 degrees on full circle models. The intervals on the scales can vary from 1 to 10 degrees.

The fulcrum – It a screw at the center of the body that allows the moving arm to move freely in the body of the device. The screw-like device can be tightened to fix the moving arm in a particular position or loosened to permit free movement.

The fulcrum and the body are placed over the joint being measured.

The stationary arm is the arm of the goniometer that aligns with the inactive part of the joint measured. It is structurally a part of the body and is not movable independently of the body.

The moving arm is the arm of the goniometer, which aligns with the mobile part of the joint measured.

Personnel

Only trained doctors, physical therapists, occupational therapists, or other personnel with prior training should perform evaluations using goniometers.[10]

The skilled person must know how to:

1. Position and stabilize the joint correctly.
2. Move a body part through its appropriate range of motion (ROM).
3. Determine the joint's end of the range of motion and end-feel.
4. Palpate the appropriate bony landmarks.
5. Align the goniometer with the landmarks.
6. Read the measuring instrument properly.
7. Record measurements correctly.

Preparation

The use of a goniometer does not require elaborate preparation. The patient should be counseled well in advance, and consent for examination is a must. The examination must be carried out in broad daylight with the joint undergoing evaluation and the surrounding area well exposed. An assistant, if needed, should be called in advance.

Technique

A goniometer can evaluate both active as well as passive range of motion.

Positioning plays a vital part in goniometry because it helps to place the joints in a zero starting position or a neutral position and helps to stabilize the proximal joint segment. The examiner stabilizes the proximal joint component and then carefully moves the distal component of the joint through its entire available range of motion until reaching the end feel.

- After estimating the available range of motion and the examiner returns the distal component to the starting position. The examiner palpates the relevant bony landmarks and aligns the goniometer.
- The examiner records the starting measurement and removes the goniometer, and the patient moves the joint through the available range of motion.
- Once the joint has run through the available range of motion, the examiner replaces and realigns the goniometer and reads and records the measurement.
- The examiner repeats the measurement three times and calculates the average; this is the active range of motion measurement.
- The examiner compares the reading with the contralateral side.
- The joint is then moved passively through its passive range of motion (PROM), and the steps mentioned above

are repeated to measure PROM accurately.

- Care is necessary to make sure the patient does not move his body while moving the joint, thereby ensuring accurate measurement.

Positioning significantly influences the tension in soft tissue structures like capsules, muscles, and ligaments, which envelope a joint. Any position which tenses the soft tissue structures will lead to a limited range of motion compared to a position where the structures are lax.

It is vital to make sure that the same testing position during successive measurements to ensure that the amounts of tension remain constant in the soft tissue as compared to past measurements. This approach assures the obtaining of similar results. Any change in position will lead to erroneous readings.

The range of motion differs from person to person and also by age and joint. Please see the table.[11]

Complications

Complications related to goniometry are limited and mainly due to faulty techniques. They are as follows:

1. The error of measurement - inaccurate measurements due to faulty technique can have a drastic effect on the patient's treatment.
2. Iatrogenic injuries

Forceful joint range of motion during goniometry may cause an iatrogenic fracture in weak osteoporotic bones.

Clinical Significance

Goniometric measurements can be useful in a variety of clinical scenarios. They range from mapping the spine mobility in cases of ankylosing spondylitis to checking the range of motion of the spine after fusion surgeries for scoliosis. Improvements in the range of motion of the extremity joints can be easily noted with goniometric testing.

The overall consensus is still unsure whether or not the goniometer is a sufficiently valid and reliable device to know the effectiveness of an intervention.[12]

The reliability of the results obtained from the goniometer might have a bearing on the type of goniometer used. There are also cases where a statistically significant difference is not observed.[13]

Enhancing Healthcare Team Outcomes

Goniometer can help in clinical decision making regarding the management, outcome analysis after a particular intervention has been applied, and compare the efficacies of different treatments. This methodology helps health care professionals to identify the most efficacious treatment modality for a specific disease, thus maximizing and enhancing health care outcomes in conditions where this information is valuable and measurable.[14]

Review Questions

- Access free multiple choice questions on this topic.
- Comment on this article.

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Figures

Joint motion	Age 2–8*	Age 9–19*	Age 20–44*	Age 45–69*
Females (*N*)	39	56	143	123
Hip extension	26.2 (23.9–28.5)	20.5 (18.6–22.4)	18.1 (17.0–19.2)	16.7 (15.5–17.9)
Hip flexion	140.8 (139.2–142.4)	134.9 (133.0–136.8)	133.8 (132.5–135.1)	130.8 (129.2–132.4)
Knee flexion	152.6 (151.2–154.0)	142.3 (140.8–143.8)	141.9 (140.9–142.9)	137.8 (136.5–139.1)
Knee extension	5.4 (3.9–6.9)	2.4 (1.5–3.3)	1.6 (1.1–2.1)	1.2 (0.7–1.7)
Ankle dorsiflexion	24.8 (22.5–27.1)	17.3 (15.6–19.0)	13.8 (12.9–14.7)	11.6 (10.6–12.6)
Ankle plantar flexion	67.1 (64.8–69.4)	57.3 (54.8–59.8)	62.1 (60.6–63.6)	56.5 (55.0–58.0)
Shoulder flexion	178.6 (176.9–180.3)	171.8 (169.8–173.8)	172.0 (170.9–173.1)	168.1 (166.7–169.5)
Elbow flexion	152.9 (151.5–154.3)	149.7 (148.5–150.9)	150.0 (149.1–150.9)	148.3 (147.3–149.3)
Elbow extension	6.8 (5.2–8.4)	6.4 (4.7–8.1)	4.7 (3.9–5.5)	3.6 (2.6–4.6)
Elbow pronation	84.6 (82.8–86.4)	81.2 (79.6–82.8)	82.0 (81.0–83.0)	80.8 (79.7–81.9)
Elbow supination	93.7 (91.4–96.0)	90.0 (88.0–92.0)	90.6 (89.2–92.0)	87.2 (86.0–88.4)
Males (*N*)	55	48	114	96
Hip extension	28.3 (27.2–29.4)	18.2 (16.6–19.8)	17.4 (16.3–18.5)	13.5 (12.5–14.5)
Hip flexion	131.1 (129.4–132.8)	135.2 (133.0–137.4)	130.4 (129.0–131.8)	127.2 (125.7–128.7)
Knee flexion	147.8 (146.6–149.0)	142.2 (140.4–144.0)	137.7 (136.5–138.9)	132.9 (131.6–134.2)
Knee extension	1.6 (0.9–2.3)	1.8 (0.9–2.7)	1.0 (0.6–1.4)	0.5 (0.1–0.9)
Ankle dorsiflexion	22.8 (21.3–24.3)	16.3 (14.9–17.7)	12.7 (11.6–13.8)	11.9 (10.9–12.9)
Ankle plantar flexion	55.8 (54.4–57.2)	52.8 (50.8–54.8)	54.6 (53.2–56.0)	49.4 (47.7–51.1)
Shoulder flexion	177.8 (176.7–178.9)	170.9 (169.1–172.7)	168.8 (167.3–170.3)	164.0 (162.3–165.7)
Elbow flexion	151.4 (150.8–152.0)	148.3 (146.8–149.8)	144.6 (143.6–145.6)	143.5 (142.3–144.7)
Elbow extension	2.2 (0.9–3.5)	5.3 (3.6–7.0)	0.8 (0.1–1.5)	−0.7 (−1.5 to 0.1)
Elbow pronation	79.6 (78.8–80.4)	79.8 (77.8–81.8)	76.9 (75.6–78.2)	77.7 (76.5–78.9)
Elbow supination	86.4 (85.3–87.5)	87.8 (85.7–89.9)	85.0 (83.8–86.2)	82.4 (80.9–83.9)

Range of motion according to age and joint. Contributed by J. M. Soucie, MD

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