Exercise & Sports Biomechanics
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Week 09
Lecture 45
Goniometry

[Hello, friends! Welcome to this course].

In this section, we are going to discuss **goniometry**. We all know that biomechanics is the study of the mechanical principles that govern human movement, and it helps in analyzing joint motion, muscle forces, and body mechanics to improve performance and reduce injury risk in sports. A key aspect of biomechanics is measuring joint movement, which is done using goniometry.

We will also be talking about the three kinds of goniometry here: **manual goniometry**, **digital goniometry**, and **electro goniometry**.

Goniometry:

Goniometry is the science of measuring joint angles to assess movement efficiency and range of motion.

Key differences between goniometry, digital goniometry, and electro goniometry:

Digital goniometry is an advanced version that uses electronic displays and sensors for more accurate joint angle readings. On the other hand, **electro goniometry** is an advanced form of goniometry that uses electronic sensors to measure joint motion in real time. All these techniques are widely used in sports science, rehabilitation, physiotherapy, and biomechanical research. These are the key differences between goniometry, digital goniometry, and electro goniometry.

Now, talking about **the measurement types**, **manual goniometry** is good for static movement. On the other hand, electro-goniometry is good for dynamic movement. But digital goniometry is good for both static and dynamic movements. **The device used** in goniometry is the manual goniometer, while in digital goniometry, it is the electronic goniometer with a digital display, and in electro goniometry, and it is the sensor-based goniometer, which works on electronic signals.

The precision level is basically it depends on the human error and expertise in case of the goniometry. In the digital goniometry it is high accurate due to the digital sensor and the electro goniometry are they are very good in real time tracking with the high precision. The manual goniometer can be applied in the clinical uses the basic motion analysis, the digital goniometer can be applied in the rehab clinical analysis and the sports training on the other hand the electro goniometry can be applied for the advanced motion tracking in sports and the rehab. **The data recording** is like there is no real time recording in goniometry manual goniometry we need to do it manually. In the digital one it is like the digital display is there and there is a storage in the device, so you can measure for that particular the storage

capacity available and in the electro-gomiometry it is like the continuous real-time analysis can be done.

The importance of measuring joint motion in sports:

1. **Optimizes the athlete's performance** by analyzing movement efficiency.
2. **Prevent injuries** by detecting abnormal joint mechanics.
3. **Aids rehabilitation** by tracking recovery progress after the injury.
4. **Enhances the sports equipment design** by studying the biomechanical movement.

What is goniometry?

The goniometry measures the joint angle and the range of motion. Goniometry is the art of measuring the range of motion in a joint using a goniometer.

So, it comes from a Greek word called **Gonia** and **Metron**. So, Gonia meaning the angles and the Metron meaning to measure. And it is used to evaluate the joint flexibility, mobility and the movement efficiency.

Types of Goniometry:

So, there are many types of goniometers available but prominently we are discussing here the three types that is,

1. Manual goniometry.
2. Digital goniometry.
3. Electro goniometry.

T**he manual goniometer** it uses a protector like tool with two arms to measure joint angle commonly used in clinical settings for range of motion assessment.

The digital goniometry they uses the electronic sensors for more precise reading and often used in the sports training and the researches while the **electro goniometry** they uses the electronic sensors for real time dynamic joint motion and the tracking. They are basically used in the biomechanics research, sports performance analysis and the rehabilitation.

Manual Goniometry:

Talking about the manual goniometer, the manual goniometer consists of the following components like the body, which is **the protractor scale**. So, the main circular or the semi-circular part of the goniometer and it marked with the degree measurement like 0 to 180 degrees in the semi-circular, while 0 to 360 degrees in the circular protector. The second part is the stationary arm.

So, this is a fixed or **the straight arm** attached to the body part of the goniometer and it remained aligned with the body segment that remains stationary during the movement. The

third one is **the movable arm**. So, the movable arm is basically the rotating arm and it attached to the center of the body and it follows the moving body segment allowing the angle measurement. The last one is **the fulcrum** that is the pivot point. So, the center of the rotation where the stationary and the movable arms meet, and placed over the joint axis of motion during measurement.

Digital Goniometry:

Talking about the digital goniometry. So, it is a modern version of manual goniometry that incorporate digital sensors and display screens. It provides immediate, more precise reading of joint angles and used in rehabilitation, physiotherapy, sports training and clinical biomechanics. The component of electrogoniometry includes **the digital display screen**, which shows the joint angle in real time, **the electronic sensors** that detect the movement and convert it into the digital readings, **the memory and the data storage**. So, the sub models can store previous recording for the progress tracking and **the Bluetooth and the wireless connectivity** like they are available in the advanced model. So, the transfer the data to computers or the mobile application for the analysis.

Advantage of digital goniometry:

Advantage of digital goniometry is like they are more accurate than the manual goniometer, obviously they are reducing the human error and but subjected to the placement of the goniometer and easy to use with real time recording and some models store previous measurement also, so they help in tracking the progress the applications of the digital includes they can be applied in the rehabilitation, for tracking the joint range of motion, improvement post injury or the post surgery, performance analysis like measuring flexibility and the mobility for the athletes and assessing in joint recovery and monitoring in the physiotherapy segment.

Electro-goniometry:

Talking about the electro-goniometry, so it is the electronic measurement of joint motion using flexible or the rigid sensors. So, the electro-goniometry is a technology that uses electronic signal to measure joint angle and movement. It is a non-invasive way to measure the range of motion and position of a joint. It provides continuous real-time tracking of joint angles. It is used in sports science, rehabilitation and the biomechanical research.

Even some goniometers allow for measurement of joint angle in two dimensions. For example, take an ankle as a joint. So, we can measure the extent of dorsi and the plantar flexion as well as the inversion and inversion simultaneously from the single sensor.

The electro goniometry have the different parts like it consists of **flexible or the rigid sensor**, so it detects the joint motion and sends signal to the processor. It has an **electronic processing unit** to convert the joint movement into the electronic signals, and the **data acquisition system**, so it stores and analyzes the recorded data.

How does the electro-goniometry work?

The question comes how does the electro-goniometry works? So, there are sensors which can be placed at a joint and as the joint moves the sensor detects the change in the angle. The changes are converted into the electronic signals and this data is recorded and analyzed for motion efficiency and joint function.

The electro-goniometry can be applied in the events like the **gait analysis**, **injury prevention,** and **the rehabilitation** program.

Comparative summary of Goniometer, Digital Goniometer, and Electro-Goniometer:

This table is basically a comparative summary of all the three kind of goniometer that we have discussed now. So, like, talking about the real time data, so in goniometry definitely there are some manual methods, so we cannot track the real time data but we can do that in the digital and the electro goniometer. The uses in the static and the dynamic posture, so the manual goniometry can be used only for the static posture while the digital and the electro goniometry we can use it for both the static and the dynamic thing. But the electro-goniometry is mostly used in the dynamic posture only. But it can be used but mostly it is used in the dynamic posture.

The precision level is moderate in case of the manual, but it is high in the digital goniometry and very high in the electronic goniometry. So, manual goniometry there is no provision for storage and the connectivity but we are having that provision in the digital goniometry and the electro goniometry. So, all the three can be used in the field conditions depends on the usage that can be done and the manual goniometry is best for the basic range of motion assessment.

The digital one is good for rehabilitation and training. For advanced motion analysis, the electronic goniometer would be the best possible tool to work with.

Practical examples in sports:

These are some practical examples in sports where we can use it in running to identify the knee and ankle range of motion, in cycling, swimming, tennis, football, and rehabilitation conditions as well.

Finally, the goniometer is essential for measuring joint motion and flexibility. The digital goniometer enhances accuracy and tracking for rehabilitation and sports performance, while the electronic goniometer provides real-time dynamic movement analysis. All three are valuable in sports performance, injury prevention, and rehabilitation.

[In the upcoming section, I have just uploaded a few videos that demonstrate goniometry. Just have a look at them].

Demonstration of goniometry:

[Hello, friends. Welcome to the demonstration part of goniometry. This is the manual goniometer that I have in my hand].

You can see that there are **three kinds of goniometers** here. This is a universal goniometer. This is a universal goniometer. There is another kind of universal goniometer that I have.

The difference between these two is that the protractor of this goniometer only goes up to 180 degrees, 0 to 180 degree. While for this the protector is 360 degree. You can see the whole protector is there. So, this goniometer we can use only in similar direction because of the 180 degree thing and there is nothing here. And this goniometer we can use in both the direction like it can go this way also, and it can measure this way as well. So, this is the benefit of this kind of goniometer but practically this is very easy to handle this kind of thing the 180 degree and this require the expertise practice as well.

Parts of the Goniometer:

Talking about the parts of the goniometer, as mentioned in the slides, you can see this is the protector.

And if you notice that there are two ways degree, it is zero on the, on the upper side, it is zero till 180 and on the lower side, it is 180 till zero.

If you are measuring this way, or if you are measuring this way, the both way, we can basically measure the thing, this particular part, which is fixed, it is called the fixed arm. So, the fixed arm will be aligned with the fixed part of the body part. And this is a movable arm. So, the movable arm will be moving along with the body part. For example, if I am going for a flexion, so this will be along with the arm. And this is a fulcrum. So, the fulcrum will be aligned with the joint axis of rotation. So, that is at the elbow. And if my forearm is moving, I will be moving this movable arm along with the forearm like this. And whatever degree it reaches, I can basically measure that degree, and that is the range of motion for the particular movement.

Similarly, if I go to this one, it is also working the same way. So, this is a protractor. This is a fulcrum that we already talked about in the slides. And this is the fixed arm, and this is the movable arm. So, the fixed arm is aligned with the fixed part of the body.

And the fulcrum is aligned with the joint line, the joint axis of rotation, and the movable part will be moving along with the part that is moving to get the range of motion. So, we can basically measure from this end or from this end, whichever is suitable for the particular range of motion. Along with that, I have one more goniometer with me, and this is a small goniometer, similar to the universal one, but only the size is small. This goniometer is typically used for small joints like the fingers, like the wrist or the fingers.

I will be demonstrating this as well, just to demonstrate, I am checking the elbow range of motion for a particular person. So, this is the universal goniometer that I am using. First, make the person lie down in a proper position. So, this is a suitable position in order to get the proper range of motion.

You can do that in sitting and standing as well. So, I know the elbow joint line is basically this, where the axis is there. So, I can just align this axis with the fulcrum of the goniometer like this, and the fixed arm will be aligned with the arm because this will be the fixed part, and the forearm will be the moving one, I am just aligning it like this and aligning it with the forearm like this, it is always better to keep it at the desired degree. So, I am just setting it at zero now and fixing it up here like this.

We can do both things: we can go for the active range of motion as well as the passive range of motion. For the active range of motion, what I will do is basically fix it up here like this, and I will ask the person to do a flexion. [So, can you please flex your arm? Yeah, and I will align this along with this. So, if this is coming, I am just holding it here].

The degree which is coming for the elbow section is somewhere around 124 degrees. You can see here, right? And if I go for the passive range of motion, so it will be something like this. I am holding it here. Holding it here and I am just moving along with this and going till here. Just holding the things here like this and you can see that the range of motion increased up to 142 degrees here. So obviously, the passive range of motion is higher than the active range of motion. Similar way, if I want to go for the knee again, I will be following the same thing. I will just assess the knee joint line. I know where the knee joint line is. The axis of rotation, so align that with the fulcrum like this. And ask the person to flex the knee. So, can you please, flex your knee?

[Yeah. Yeah. Go. Go. And just check the range of motion].

You can see it is basically coming around 120 degrees. So, if you see, it is coming somewhere around 124 degrees again, right? Okay, straight. And if I am going for a passive range of motion, again, fixing the fulcrum at the joint line, I will do the passive flexion.

[Okay, flex].

I will do the flexion. I will do the flexion along with the goniometry. It is coming around 130 degrees now. You can see it is coming around; it is coming around 130 degrees now. This way you can use it for the various ones. This 360-degree protector. So, it is as simple as that. The fixed arm will be aligned with the thigh like this. The movable will be moving along with the leg. And it is coming something like this. And you will be ranging the range of motion in the 360-degree protector like this. Straight.

This is the small goniometer I showed you earlier. This is we usually use for the smaller joints like let us just have a demonstration on the wrist. So, you can so, wrist if I am checking the flexion and extension like this. Okay. So, I know the joint line is somewhere here, so I just align the fulcrum with the joint line like this, like this right and ask the person to flex the wrist.

[Go for the flexion and just align this with this, and I can record the reading here]. And for the joints like finger and all even I can use this here like this. The flexed arm will be coming along the the metacarpals and the fulcrum will be aligned with the knuckle, knuckle bone here. So, it will be something like this, just fix it and ask the person to go for the finger traction like this and the movable arm will be moving along with the, with the finger and you can see the reading is coming up, up here.

This way you can use it for the fingers, you can use it for the toes, and even the bigger goniometer I have shown you, you can use it for your cervical traction and extension itself and the cervical rotation as well. For example, so, if I am having this, so I will be aligning with, so I need to assume the range of motion here. So, I know, I just ask the person to do a range of motion of a survival rotation. Do the rotation.

[Yeah, like this].

The range of motion is somewhere here, so I am just aligning this straight. I am just aligning with the axis of rotation. So, the flexed arm will be the lower one, and the movable arm will be the upper one. And I will ask the person to do the rotation. And after this, I just move my moving arm in the particular direction that aligns with the nose, and I can measure the range of motion of the rotation as well. So, this way, we can use the goniometer for all the different joints, and it is always advisable to use the smaller goniometer for the smaller joints.

[So, friends, the thing which I am holding in my hand is basically called a digital goniometer].

You can see the parts of the goniometer; this is a sensor or part of the fulcrum as well. And these are the arms. So, one of the arms could be the fixed arm, and one of the arms could be the removable arm. And this is a data acquisition system or the reader.

Both the things are there in this particular device. If you can see, this is the main sensor, and it has a button here for the on and enter functions. And so, this is the fixing, and this arm we can basically move like this. We can fix one part of our arm with this. And the other with the movable arm like this. Now, this becomes a complete goniometer. You can see this is a fixed arm which is not moving, and this one is the one that is basically moving. So again, this sensor will be along with the joint line. The fixed arm will be along the body part which is fixed, and the movable arm will be along with the body part which is moving. And so, as this is the data acquisition and the reader, we just need to start it like this. So, it has three things here: test, review, and setting. So, before that, we need to first make it, you know, they need to be connected first or they need to be calibrated.

We need to go to setting, so there are options like how many tests I want, the system, instruments, and the exit. So, if I go to system, I need to register it first. When I press register, it is scanning the system.

To make sure the system is on, I just need to press this button, so that you can see the light is blinking here. Scanning for the system for instruments. The system is already registered. Now, I am just going to exit and go to the test. So, it is asking me to press enter to set zero. So, to set zero, the common procedure is to fit on a table top like this. Make sure that it is of 180 degrees. So, this is roughly, you can basically adjust this according to your own joint that which you are testing. So, then if I press the 0 here, so you can see that it is set as 0. So, I have purposefully set it at 180 degree.

It is now coming at it as in 0 degree. If I want to set it to the other degree, it will come showing as in other degree only. If I move now, you can see that the degrees are changing here. You can see the reading there on the display unit.

You can see, this way it works. So, this will go along with the joint line along with the flexed part and this will move along with the body part. If I move in any direction, it will basically changing the values on the display unit like this. We are testing the same thing again the elbow flexion and i am setting it at it as zero. You can see that in the the display unit so i am aligning the flexed arm along with the arm and aligning the sensor with the

joint axis of rotation here like this okay and then okay i will ask the person to go for an elbow flexion can you please press your elbow yeah

Then I will align this with the body line, with the body segment, and you can see the range of motion here. In a similar way, if I go for some passive movement, you can see some more range of motion. So, I can move along with the body part as well. This part.

If I want to go for the knee extension, let me come a little bit to this side. So, again, I will be just assessing the knee joint line here first. Aligning the sensor with this, the flexed arm will be along with the thigh, and ask the person to go for the flexion.

For the knee joint range of motion, if you see one of the arms, you can basically move only this much. So, it is always better to turn it around like this, and set it at zero, fix this thing, and ask the person to go for the knee flexion. Flex your knee and then move it something like this, and you can see the range of motion is coming straight away here. So, this way you can basically go for the various tests, and if you want to. If you want to use it for a smaller joint, just simply remove this. Simply remove this, and you can use it as a little bit itself. So, remember, I have shown you the small goniometer for the finger and arm.

You can use the same thing with this kind of thing. You can see this is a fixed arm here, and this is a movable arm here.

[Thank you, and see you in the next video].