VALIDITY AND RELIABILITY OF REBEE WEARABLE SENSOR TO MEASURE KNEE JOINT RANGE OF MOTION

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LIST OF ABBREVIATIONS

APPS : Applications

AROM : Active Range of Motion

BMI : Body Mass Index

ROM : Range OF Motion

UG : Universal Goniometer

CHAPTER I
INTRODUCTION

Range of motion (ROM) of the joint is one of the factors that determine function of the musculoskeletal system. This parameter should be measured and recorded by a valid and reliable method **(Yaikwawongs et al., 2009).** It is considered to be an essential component of lower limb physical examination, which can be applied using various instruments such as goniometers and inclinometers **(Pourahmadi et al., 2017).**

Range of motion of the knee joint is one of the major factors determining the outcome after knee injuries. It is also an important measurement required by many knee scoring systems to determine the preoperative status and postoperative outcome **(Anouchi et al., 1996)**. Measurements are used by physical therapists to quantify limitations of motion, used to decide an appropriate therapeutic interventions, and document the effectiveness of these interventions. The ideal measuring device should give reproducible valid and reliable data **(Yaikwawongs et al., 2009).**

Two-arm digital goniometer is still widely used in measuring uniaxial ROM of joint of extremity, there is high validity, intra rater and interrater reliability of the digital goniometer. It is considered valid and reliable tool that simplify physical therapists' work (**Svensson et al., 2019).**

The measurement of joint ROM is required an essential skill in the musculoskeletal assessments commonly performed by physiotherapists. The digital goniometer is the most commonly utilized clinical tool for measuring joint range of motion, the evolution of sensors technology and applications are easy to use, relatively inexpensive, and highly accessible **(Keogh et al., 2019).**

Rebee is a wearable motion sensor package of sensor with its own mobile application, which measures range of joint movement in different planes easily which the patient able to wear the sensor and move easily to measure ROM and record the measurement at the application software, that is facilitate the tele-measurement which the patients are supposed to put on the sensors and perform the actions themselves, or with assistance from physical therapist.

So this study will be conducted to test the criterion related validity and intrarater reliability of the rebee wearable sensor in measuring active knee joint ROM compared with digital goniometer measurement.

Statement of the Problem

1- Is the rebee wearable sensor valid to measure active knee joint ROM compared with digital goniometer measurement?
2- Is the rebee wearable sensor reliable in measuring active knee joint ROM?

Purpose of the Study

Purpose of the study to test the criterion related validity and intrarater reliability of rebee wearable sensor in measuring active knee joint ROM compared with digital goniometer measurement.

Significance of the Study

Measurement the joint ROM with the digital goniometer is considered time consuming and difficult with respect to repeated measurements. (**Svensson et al., 2019).**

So there is a need to the sensors system which could be considered as a clinical measurement for ROM which will reflect in rehabilitation process through measuring the patient ROM easily **(Hamel et al., 2008).**

Some researchers would prefer taking the ROM of lower limb in a more functional way such as standing and walking given that the sensors were

developed, which the patients are supposed to put on the sensors where the sensor placed on prominent bony landmarks at the level of lateral malleolus. It will be stabilized on the testing limbs by elastic bands and perform the actions themselves, with or without the supervision from the physical therapist **(Vohralik et al., 2015).**

With the use of rebee wearable sensor, the ROM of knee joint flexion and extension can be monitored easily and recorded, that lead to facilitation of tele rehabilitation. Which the patients are supposed to put on the sensors and perform knee flexion and extension themselves, with or without the supervision from the clinicians.

Hypotheses

It is hypothesized that:

1. Rebee wearable sensor will not be valid to measure active knee joint flexion ROM compared with digital goniometer measurement.
2. Rebee wearable sensor will not be valid to measure active knee joint extension ROM compared with digital goniometer measurement.
3. Rebee wearable sensor is not reliable to measure active knee joint flexion ROM.
4. Rebee wearable sensor is not reliable to measure active knee joint extension ROM.

Basic Assumption

It is assumed that:

- The movement applied will be the same for all participants and will be the same for each participant repeatedly.
- All participants will comply with the instructions honestly.
- All participants will have the same psychophysiological condition during the treatment period.

Delimitations

The principles respected in selecting the cases and data recording are:

1- 40 normal participant will be assigned to group, this number detected by G*power 3.1 software (Universities, Dusseldorf, Germany) was used for calculation.

2- The participant's age ranged from 35 to 45 **(Miranda et al., 2002).**

3- The participant from both sex **(Correll et al., 2018).**

4- Participant Body mass index (BMI) from (19 to 25) normal weight **(Weisell et al., 2002).**

5- Knee flexion and extension ROM will be measured with the digital goniometer.

6- Knee flexion and extension ROM will be measured with the rebee wearable sensor.

7- The procedures will repeated two times with one week interval between measurements.

CHAPTER II
LITERATURE REVIEW

Range of Motion

Range of motion of the joint is the arc of motion that occurs at a joint, it is one of the factors that determine function of the musculoskeletal system. This parameter should be measured and recorded by a reproducible only method **(Yaikwawongs et al., 2009)**

The assessment of joint range of motion (ROM) is an important component of a physical therapy examination. These measurements are critical for providing baseline data, determining functional limitations, and monitoring changes in joint mobility in response to treatment. Measurement of ROM may also be used to detect asymmetry and movement restrictions that may increase risk of injury **(Clarkson et al., 2005).**

Range of motion of the knee joint is one of the major factors determining the outcome after knee injuries. It is also an important measurement required by many knee scoring systems to determine the preoperative status and postoperative outcome **(Anouchi et al., 1996)**.

Causes of ROM Limitation

Reduced range of movement is where there is a limitation of movement at a joint. Types of reduced range of movements are:

- Muscle Injury
- Ligament injury
- Pain
- Swelling
- Arthritis

(Konor et al., 2012)

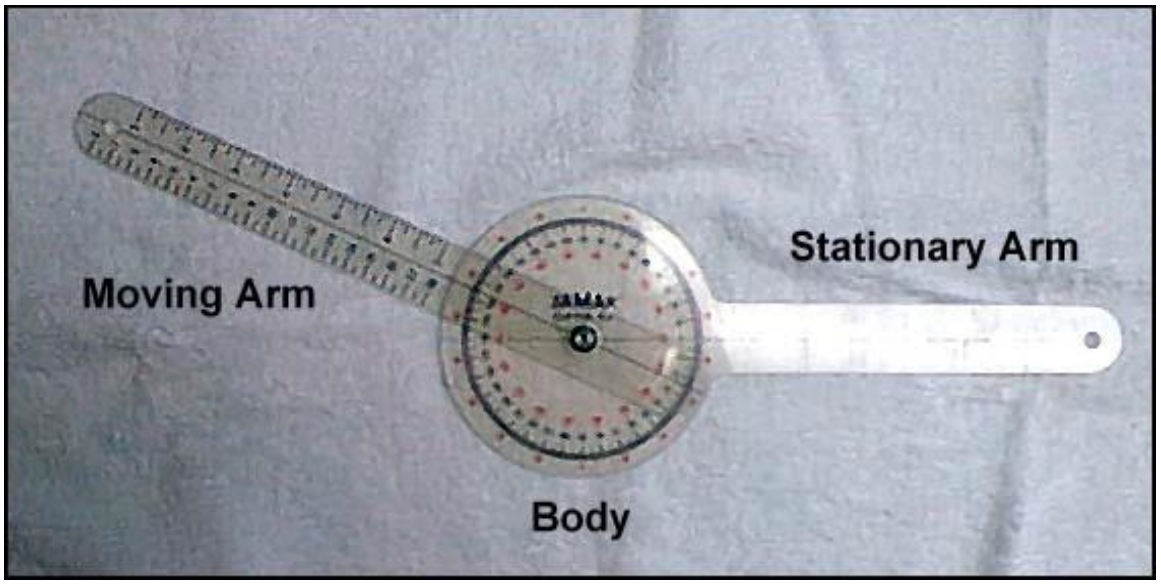
Physical Examination of ROM

Each specific joint has a normal range of motion that is expressed in degrees. The reference values for the normal ROM in individuals differ slightly depending on age and gender. For example, as an individual ages, they typically lose a small amount of ROM **(Yaikwawongs et al., 2009).**

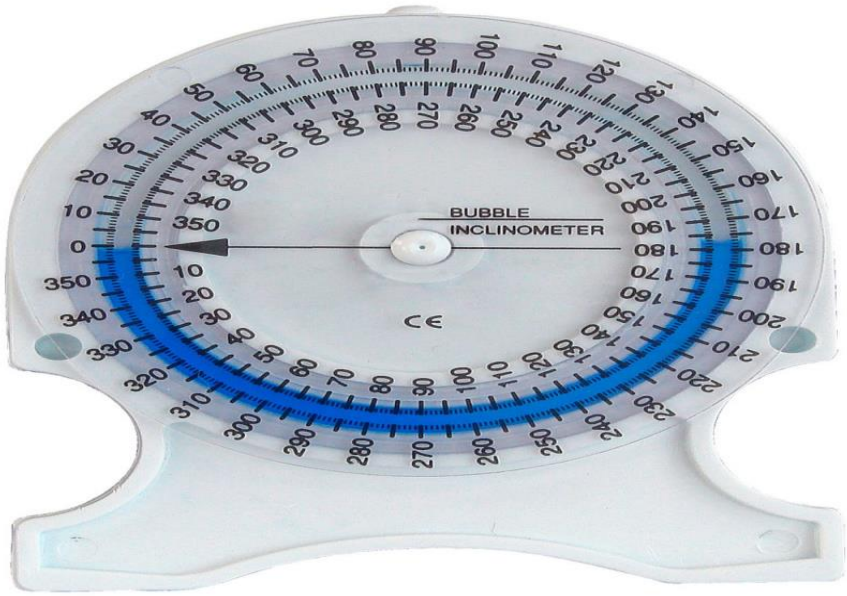
Analog and traditional devices to measure range of motion in the joints of the body include the goniometer and inclinometer which use a stationary arm, protractor, fulcrum, and movement arm to measure angle from axis of the joint.

Over the years, the most common instrument used for joint measurement in physio-therapy has been the universal goniometer (UG) **(Norkin et al., 1995).** Important psychometric characteristics of this instrument, such as intratester and intertester reliability, have been examined in many research studies. In the clinical setting, these characteristics are important because patients are often treated and reassessed, either by the same or by different physical therapists **(Gogia et al., 1987).**

Many research studies have found the UG to have overall good intratester and intertester reliability. However, the majority of these studies have found intratester reliability to be greater than intertester reliability **(Roach et al., 1991)**



In addition to the goniometer, another device being used by some clinicians to measure range of motion is the digital inclinometer. The inclinometer is similar to the goniometer in that both are lightweight and portable. However, the inclinometer has significantly more associated cost. The inclinometer has been demonstrated to possess good to excellent reliability and concurrent validity with the universal goniometer **(Clarkson et al., 2005)**



The digital goniometer is the most commonly utilized clinical tool for measuring joint range of motion, it gives the physiotherapist a useful method to diagnose musculoskeletal function in terms of ROM, monitor the progress of an intervention **(Yaikwawongs et al., 2009).**

There is high validity, intra rater and interrater reliability of the digital goniometer **(Svensson et al., 2019).**

To measure joints with the digital goniometer is considered time consuming and difficult with respect to repeated measurements. (**Svensson et al., 2019),** so there is a need to a new device that sensors system could be considered as a clinical measurement for ROM which will reflect in rehabilitation process **(Hamel et al., 2008).**

New evolution for measuring ROM called rebee wearable sensor. With the use of rebee wearable sensor, the ROM of knee joint flexion and extension can be monitored easily, that lead to facilitation of tele rehabilitation. Which the patients are supposed to put on the sensors and perform knee flexion and extension themselves, with or without the supervision from the clinicians.

The patients are supposed to put on the sensors and perform the actions themselves, with or without the supervision from the clinicians/ research. The evolution of sensors technology and applications are easy to use, relatively inexpensive, and highly accessible **(Keogh et al., 2019)**

CHAPTER III
SUBJECTS, MATERIALS AND METHODS

This study will be conducted at the Outpatient Clinic of Faculty of Physical Therapy, Pharos University, Alexandria, Egypt. to test the criterion related validity and reliability of rebee wearable sensor in measuring Active Knee Joint ROM compared with digital goniometer measurement.

Design of the Study

The study is Cross Section Study (Observational study).

Participants

40 normal participant will be assigned to one group, this number detected by G*power 3.1 software (Universities, Dusseldorf, Germany) was used for calculation.

Selection of Subjects

The participant will be recruited from faculty, staff, and students of Pharos University, Egypt. Graduate Program in Physical Therapy after achieving the inclusion and exclusion criteria. Each participant will sign an informed consent before beginning of the study to insure complete satisfaction (Appendix 1)

Inclusion Criteria

1. 40 normal participant's age ranged from 35 to 45. **(Miranda et al., 2002)**
2. The participant from both sex. **(Correll et al., 2018)**
3. Participant Body mass index (BMI) from (19 to 25) normal weight (BMI= weight (kg) / [height (m)] ^{2}) **(Weisell et al., 2002).**

Instrumentations

1. Digital goniometer.

   The digital goniometer will be used as a valid and reliable ROM measurement tool, the type of digital goniometer will be used in the study called digital absolute axis goniometer with accuracy about 0.99**(Correll et al., 2018)**

2. Rebee wearable sensor and application by XCLR8 Technologies.

   The package of sensor and application will be used for measure, interpret and store participant measurement for test the criterion related validity and intrarater reliability of rebee wearable sensor in measuring active knee joint ROM

3. Health weight scale for weight and height measurement to calculate BMI. (BMI= weight (kg) / [height (m)] ^{2}) **(Weisell et al., 2002).**

Procedure for testing Validity

The digital goniometer will be used as a valid and reliable ROM measurement tool to be compared with rebee wearable sensor in measuring active knee joint ROM.

Measure AROM of Knee Flexion with Digital Goniometer

The participant will be at supine position with the testing knee extended, which allows assessment of the joint ROM without interference from tightness in the rectus femoris muscle, axis location at lateral epicondyle of the femur, stationary arm will be along the femur to the greater trochanter, The movement arm will be along the fibula to lateral malleolus.

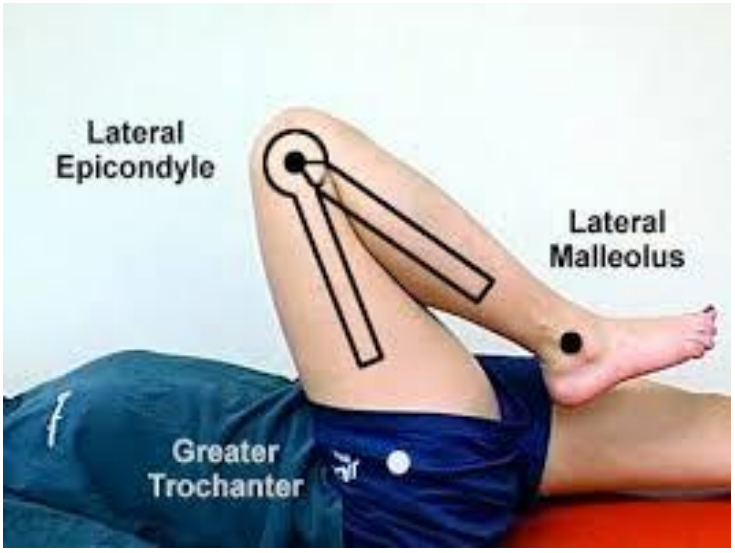
The participant will asked to flex the testing knee fully through available ROM and the therapist will record the measurement to compare with rebee wearable sensor measurement.

Measure AROM of Knee Extension with Digital Goniometer

The participant will be at supine position with the testing knee flexed, which allows assessment of the joint ROM without interference from tightness in the rectus femoris muscle, axis location at lateral epicondyle of the femur, stationary arm will be along the femur to the greater trochanter, The movement arm will be along the fibula to lateral malleolus.

The participant will asked to extent the testing knee fully through available ROM and the therapist will record the measurement to compare with rebee wearable sensor measurement.

The following picture illustrate that measurement with the digital goniometer will be from the similar supine position of measurement with the conventional goniomtere



Procedure for testing Reliability

Designed according to Guidelines for reporting Reliability and Studies, investigating the intrarater reliability of a rebee wearable sensor will be conducted. The study will be designed in accordance with the ethical guidelines from the Helsinki declaration of ethical principles (World Medical Association **(Kottner et al., 2011)**).

Written consent will be retrieved from all subjects before participating in the study, the procedures will repeated two times with one week interval between measurements. Researcher will records all the measurement.

Knee Active ROM Measurement with Rebee Wearable Sensor

This process postulated by Kimberlin, 2008

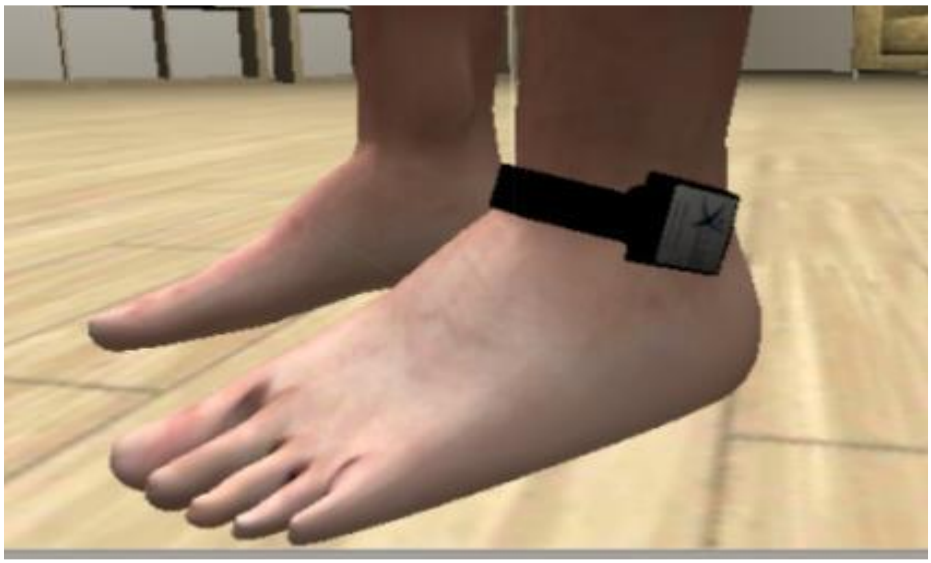
To detect the joints ROM, the sensors were placed in the most distal part of the limbs with prominent bony landmarks at the level of lateral malleolus. It will be stabilized on the testing limbs by elastic bands. With the sensor light facing Lateral malleolus

Measure AROM of Knee Flexion with Rebee Wearable Sensor

The participant will be standing in upright position, the sensor position at the level of the Lateral malleolus, participant will be asked to flex the testing knee fully while standing supported in one leg.

Measure AROM of Knee Extension with Rebee Wearable Sensor

The participant will sitting at the edge of plinth with knee flexed, the sensor position at the level of the Lateral malleolus, participant will be asked to extent the testing knee through the full ROM.

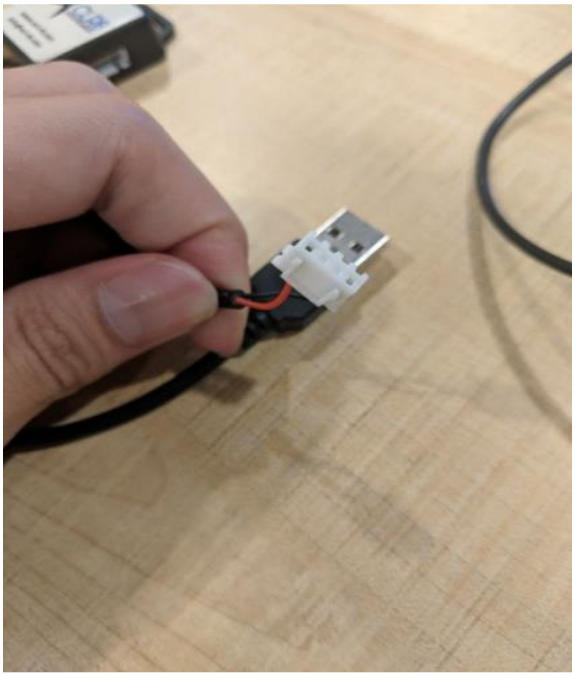


The Digital goniometer and rebee wearable sensor will be used for comparison of their validity for measuring knee joint flexion and extension ROM.

Rebee wearable sensor will be used as mentioned above and this procedures will repeated two times with one week interval between measurements to test its reliability. Researcher will records all the measurement.

Steps for Using Rebee Sensor Package

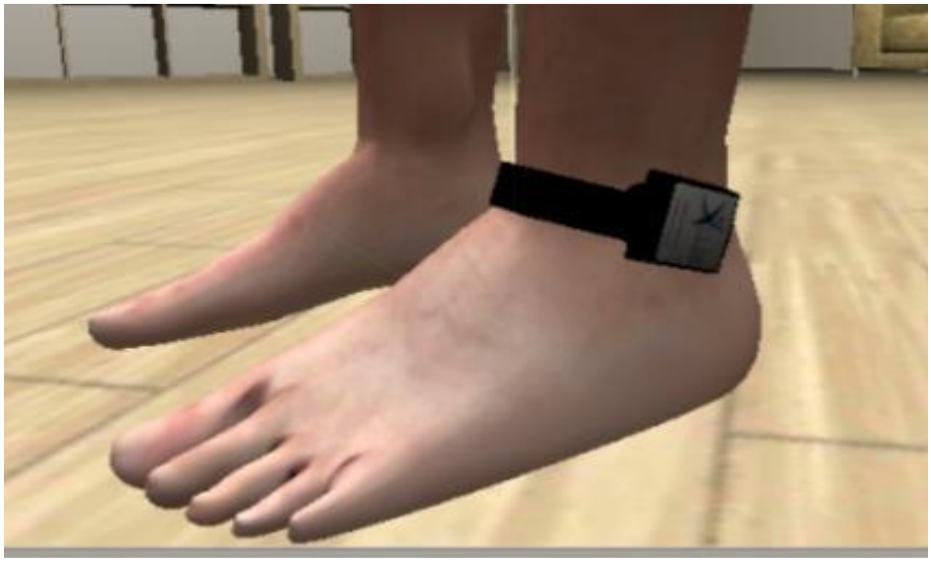
1- Take the charging end of the charging cable and look for the charging port on the sensor.



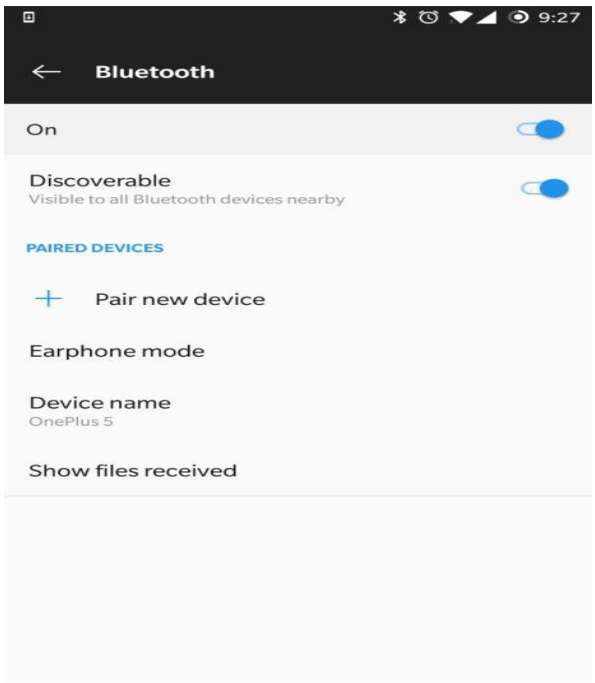
2- Making sure the cable aligns with the port then connect the charger.

3- The USB end of the charging cable must be connected to a USB port / USB charger.
4- Check the sensor for a red LED light to know that it is successfully charging. The red LED will turn off once the device is fully charged.

5- Wearing the devise at the level of the Lateral malleolus with the sensor light facing Lateral malleolus.

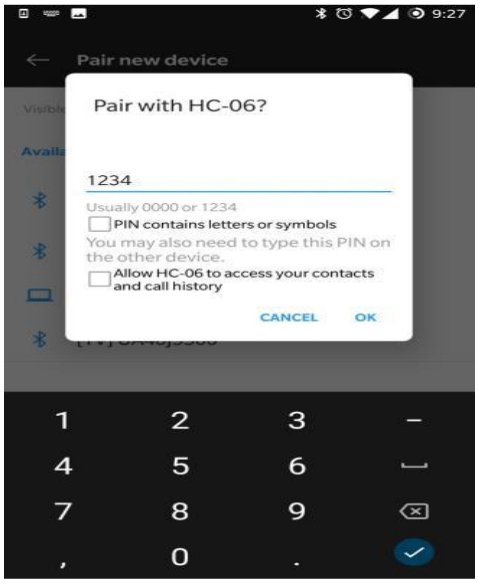


6- Connecting the sensor to the device

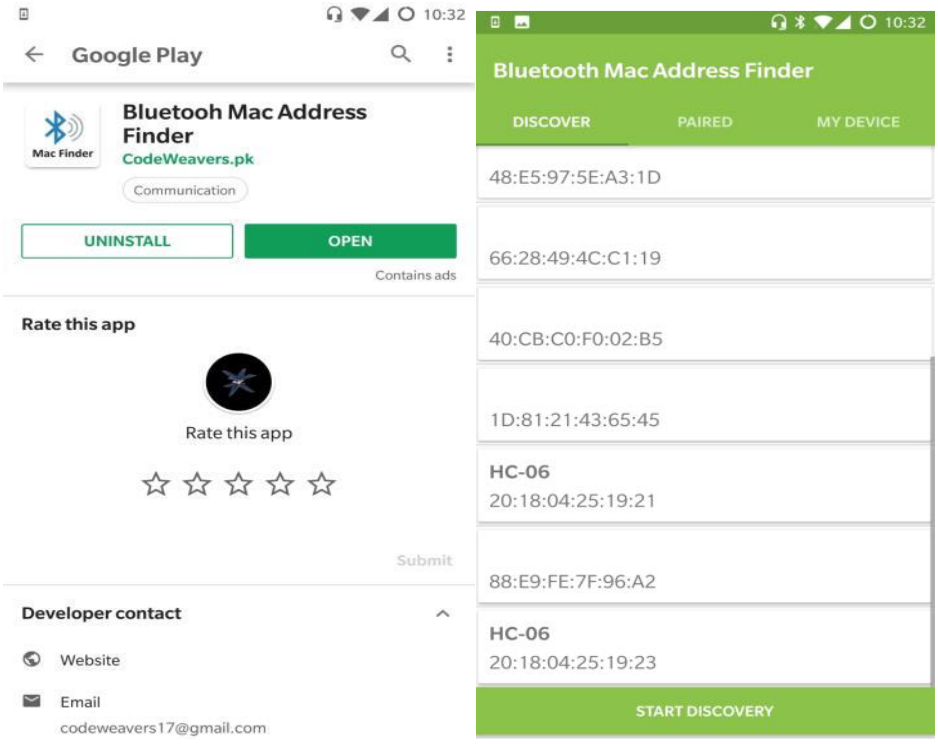


Step a: Switch on the sensor device.
Step b: Go to phone's settings and turn on device's Bluetooth.

7- Look for “HC-06” (Default sensor name) under “Available devices” and tap on it.



8- Identifying the Sensors to Software



Step a: Connect the sensor you are trying to identify
Step b: Look for the sensor in the list with the name “HC-06”

Statistical Analysis

Statistical methods will be used to calculate the reliability and validity of our measurements will be descriptive statistics for mean and standard deviation, also the Pearson product-moment correlation coefficient (r), an assessment of covariance.

Ethical Considerations

1. All participant will sign a consent form to declare that they are not forced to participate in this study. (Appendix I)
2. The study will be conducted after approval of ethical committee of the Faculty of physical therapy, Cairo University, Egypt.

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Appendix I
Patient Consent Form

I am freely and voluntarily consent in this research study under the direction of the researcher /Ahmed Mohamed Ahmed Saleh. A thorough description of the procedure has been explained to me and I understand that I can withdraw my consent and discontinue participation in this research at any time without prejudice to me.

Participant: Signature:

Researcher: Signature:

Date: