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Use of smart phone for measuring shoulder rotational range of motion in patients with frozen shoulder: A comparative study

Kartik Shah[1,*], Mangala Deshpande[2], Priyesha Ramteke[3], Jyoti Singh[4], Anjali Sondawle[5]

[1]Assistant Professor, Dept. of Musculoskeletal Physiotherapy, [2]Formar Director, [3,4,5]Internee Student, VSPM's College of Physiotherapy, Nagpur, Maharashtra, India

***Corresponding Author:**
Email: kdshah23@gmail.com

Abstract
Assessment of shoulder range of motion in patients with frozen shoulder is important aspect for physiotherapist for documentation and to check progression in disease. From long time, goniometer is used as gold standard measurement tool for measuring range of motion. Due to some practical difficulties like finding out precise bony landmark for fulcrum, aligning two arms as per long axis of bones and subjective errors among less experienced physiotherapist and students, goniometer may be less appropriate for using. There are many smart phone applications including Clinometer are available to measure joint range of motion and is easy to use in some aspect compared to goniometer. Our aim was to compare the result of smart phone clinometer with gold standard goniometer for measuring shoulder rotational ranges in patients with frozen shoulder. The mean and standard deviation of the range of internal rotation measured by goniometer and clinometer was 42.4°±10.90° and 42.36°±11.38°, respectively. The mean and standard deviation for external rotation measured by the goniometer was 33.6°±15.75° and by clinometer was 34.2°±16.61°. This comparative study shows that there is no difference between measurement of clinometer and goniometer. This can be concluded that smart phone clinometer can be used clinically to measure shoulder rotational range of motion in frozen shoulder.

Keywords: Frozen shoulder, Goniometer, Rotational range of motion, Smartphone Clinometer application.

Introduction
Frozen shoulder also called adhesive capsulitis is one of the common conditions affecting the age group between 40-60 years.(1) Diagnosis of frozen shoulder is very much important for proper physiotherapy treatment and to prevent long term disability. Diagnosis is based on capsular pattern and limitation of both, active and passive range of motion of the shoulder joint. Capsular pattern for shoulder joint is greatest limitation of external rotation; less limitation of abduction and least limitation of internal rotation.(2) Assessment of shoulder range of motion is important aspect for physiotherapists during their routine evaluation and even important to observe recovery after giving treatment. For measuring range of motion, goniometer is used worldwide from long time due to easy accessibility, good reliability with validity and relatively inexpensive. There are many methods available to measure range of motion apart from goniometer like digital goniometer, digital inclinometer, visual estimation, bubble goniometer, motion analyser, etc. There are also some difficulties for using double armed goniometer along with advantages. To measure range of motion with goniometer, there is requirement for precise location of bony landmark on which fulcrum of goniometer is placed. Along with that movable arm and stationary arm should be placed in line with axis of long bones. Sometimes it is difficult to find precise bony land mark if patient is obese. There is also difference between physiotherapists to accurately mark and locate bony landmark because of their subjective errors. There may be difficult for less experienced physiotherapist to use goniometer because of difficulty to place accurately on body parts. In this current age of technology, most of the people use smart phones to make life easier. With advancement of technology, there is availability of smart phones applications that can be used in the field of physiotherapy. There are many recent studies suggest the use of different smart phone applications like, Physio2Go, GetMyROM, Dr Goniometer and Clinometer for measuring joint range of motion.(3-8) Clinometer is one of the applications available on android phones as well as on iPhones. Clinometer is easy to use and it relays on gravity to determine angles and so that it reduces subjective errors. Furthermore, there is no need to find out perfect bony landmark and bone alignment as like goniometer. It is also time-saving as compared to goniometer. There are various studies to support the use of smart phone Clinometer application in measuring shoulder joint range of motions and these studies have focused on athletes, patients with shoulder pain and post-operative patients of total shoulder replacement.(6-8) For our knowledge, no one has studied about the use of clinometer in patients with frozen shoulder to measure joint range of motions. Our aim was to compare the use of goniometer and clinometer to measure shoulder rotational ranges in patients with frozen shoulder. Examination of passive range of motion is important to indentify end-feel and capsular pattern in frozen shoulder. Study also proved that passive range of motion is reliable outcome measure in patients with frozen shoulder.(9) So, we

examined passive range of internal and external rotation in this study.

Materials and Methods

The approval was obtained from the Institutional Ethics Committee to carry out the project work. Purposive sampling was used to collect sample population for this comparative study. Diagnosed cases of frozen shoulder with both genders coming to OPD of V.S.P.M's College of Physiotherapy, Nagpur, India were selected for the study. Patients having restricted shoulder mobility associated with neurological disorder were excluded. The importance of the measurement of range of motion was well explained to the patients. The procedure that was to be carried was explained thoroughly to the patient and consent was obtained. We have used free version of Clinometer application (Plaincode, Stephanskirchen, Germany) downloaded from Google play store in Micromax A63 smart phone (Fig. 1) and half circle goniometer (Fig. 2) to measure range of motion. Activity band (Fig. 3) was used to place smart phone on patient's body part.

Fig. 1: Clinometer application on smart phone

Fig. 2: Half-circle goniometer

Fig. 3: Activity band to place smart phone on patient's body part

The patient was asked to lie down on the plinth in supine-lying. The arm of the patient was abducted to 45° and elbow was flexed to 90°. The olecranon process and the ulnar styloid process of the arm were marked as reference points for measurement of range by the goniometer. The fulcrum of the goniometer was placed on olecranon process and the movable arm was aligned with the ulnar styloid process. The movable arm was tied to the patient's forearm with the help of a strap to eliminate any manual errors. During testing, therapist holds a stable arm and move the shoulder joint passively in the ranges where he finds end-feel or at the limit of pain. The scapula of the patient was stabilised by the therapist to avoid trick movement thus eliminating the chances of false range. This stabilisation was carried out for both the instruments. The range of internal rotation and external rotation of the shoulder was measured in the same order for all the patients (Fig. 4 and Fig. 5). The ranges were noted. The goniometer was then removed. The smart-phone was put on the silent mode and then inserted in the activity band. Then activity band along with smart phone was placed onto the ulnar aspect of distal forearm. The passive movement of internal and external rotation was performed by therapist and at the end of the movement measurement was noted. (Fig. 6 and Fig. 7)

Fig. 4: Measurement of internal rotation with goniometer

Fig. 5: Measurement of external rotation with goniometer

Fig. 6: Measurement of internal rotation with clinometers

Fig. 7: Measurement of external rotation with clinometer

Results

The data was collected and the master chart was prepared. The internal and external rotation ranges were presented as Mean and Standard deviation. The internal and external rotation ranges were compared between goniometer and clinometer by performing independent t-test. The level of significance was $p<0.05$. Statistical software STATA version 14.0 was used for data analysis. The study was conducted on thirty patients of adhesive capsulitis aged between 40-74 years with mean age was 52.6. Out of the thirty populations, fourteen were males and sixteen were females. (Fig. 8)

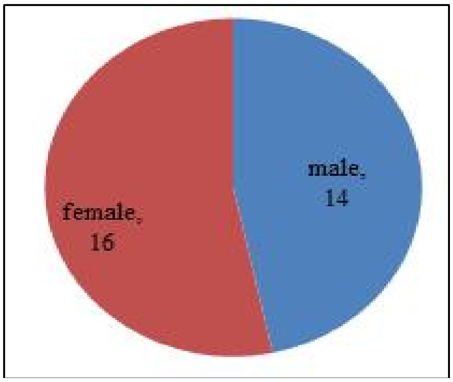

Fig. 8: Distribution of male and female

The mean and standard deviation of the range of internal rotation measured by goniometer was 42.4°±10.90°. While the mean and standard deviation measured by the clinometer was 42.36°±11.38° (Table 1 and Fig. 9). Calculated p value was 0.96, which proves that there is no statistically significant difference between the ranges measured by the both the instruments. The mean and standard deviation for external rotation measured by the goniometer was 33.6°±15.75° and by clinometer was 34.2°±16.61° (Table 2 and Fig. 9). Calculated p-value was 0.35, which proves that there is no statistically significant difference between the ranges measured by the both the instruments.

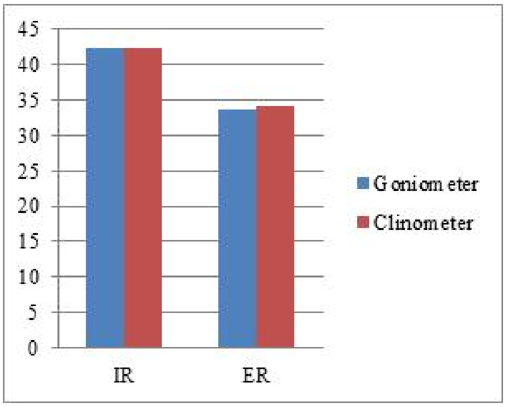

Fig. 9: Mean range of internal and external rotation measured by goniometer and clinometer

Table 1: Mean and Standard deviation of internal rotation by goniometer and clinometer

Internal rotation	Goniometer range	Clinometer range
Mean	42.4°	42.36°
SD	10.90°	11.38°
p value	0.9631	

Table 2: Mean and standard of deviation of external rotation by goniometer and clinometer

External rotation	Goniometer range	Clinometer range
Mean	33.6°	34.2°
SD	15.75°	16.61°
p value	0.3581	

Discussion

In this comparative study, we found that there is no statistically significance difference between the passive ranges of internal and external rotation measured by goniometer and clinometer. Result of this study shows that, clinometer is as useful as goniometer to measure passive internal and external rotational ranges in patients with frozen shoulder. Similar to our study, Smith Allison B also found that there was no difference between measurement of goniometer and clinometer for measuring shoulder internal and external rotation range in athletes.(6) Werner et al(8) also used clinometer application to measure shoulder range of motion but they measured range of motion by examiner continuously holding a smart phone on patient's forearm but in this study, activity band was used for attachment of smart phone onto the patient's distal forearm as described by Smith Allison. When comparing this study to the study of Smith Allison,(6) difference lies in the position of shoulder joint for measurement of rotational ranges. Current study used 45° of shoulder abducted position and previous study used 90° of shoulder abducted position to measure rotational ranges. So, the result of our study indicates that smart phone clinometer can be used effectively to measure rotational ranges in the patients with shoulder stiffness that cannot achieve 90° of shoulder abduction. Results of present study conclude that smart phone clinometer can be used to measure shoulder rotational ranges in patients with frozen shoulder. This study suggests the use of clinometer, but some practical suggestions must be remember while using Smartphone clinometer. First, activity band is required to attach Smartphone on patient's body part. Second, clinometer uses gravity to measure angle. Therefore, patient must assume particular position in such a way that clinometer measures desirable range of motion. It is not always possible practically for patient to assume desired position. To keep in mind these suggestions, physiotherapists can use clinometer application in their routine evaluation. Limitation of this study is, only passive internal and external rotation ranges were measured but other shoulder ranges were not measured. Further study is required to measure shoulder ranges other than rotation in patients with frozen shoulder. Future study is also required to measure joint range of motion for other joints with the use of clinometer application for better conclusion.

We have taken reference of Werner et al(8) for calculating sample size with SD of 10.8, by using the formula as below:

$$n = \frac{4 \times (SD)^2}{(L)^2}$$

n = 4 × (10.8 × 10.8) / 4 × 4
n = 29.16 = 30

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