Reliability and validity of android application for measuring proprioception of the knee joint

[1]Muhammed Nabeel K, [2]Subin Solomen, [3]Chacko P George
[1]Physiotherapist, [2]Scientific Assistant (Physiotherapy), [3]Assistant Professor
[1]Department of Physiotherapy,
[1]Pain & Palliative centre, Mankada, India

Abstract: Various methods that measures proprioception may induce abnormal sensory feedback which may result in inaccurate judgment of proprioception. Newer methods such as shadow goniometer, even though it is not inducing sensory feedback, still requires as a projector, current, protractor, darken room, and wide space. Smartphone applications are widely available, allowing Smartphone to be used as a protractor application for measuring ROM and Proprioception. However psychometric properties this app was not checked previously and it is not known that whether mobile app can be substitute for measuring proprioception. So there exists a need to find and reliability and validity of mobile application. If it is found reliable it can be used as tool for measuring proprioception. So, this mobile app it can be used for measuring joint ROM and proprioception of the joint. Ten healthy subjects were selected with an age group of 20-25. The standard goniometer was used to measure knee flexion followed by Mobile Application measurement of knee flexion. The measurements were repeated with Mobile Application on the second day. The mobile application was found to be a good reliable with interclass correlation of 0.897(p value <.001) and valid tool with correlation coefficient 0.950(p value <.003) in measuring knee flexion range of motion. The study concludes that the mobile application found to be a reliable and valid tool for measuring knee flexion range of motion and can be used to measure proprioception.

Key words: Range of motion, Mobile application, Joint position sense, Proprioception, android application, smart phone application

1. Introduction

Millions of people throughout the world perform physical exercise and play sports. The regular physical activity is probably the most important overall determinant of a population's health. Unfortunately, physical activity may extract a cost in the form of an activity – related injury. The sports injury result from acute trauma or repetitive stress associated with athletic activities. Sports injury can affect bone or soft injury (ligament, muscle, and tendon). The sprain is common type of sports injury mainly affected on knee and ankle joint. This type of injury is mainly due to proprioceptive deficit. So that the proprioceptive acuity is play important role in injury prevention and rehabilitation. The main aim of rehabilitation program is to regain pre-injury level in all aspect of the physical agent. It ensures full recovery and in order to prevent re-injury.

The proprioception means that the ability to sense stimuli within the body regarding position, motion, and equilibrium [(1)]. It consists of three components that are joint position sense (JPS), kinesthetic sense, and tension sense [(2, 3)]. Impaired proprioception is cited as a major factor predisposing to degenerative joint disease ongoing instability in ACL deficit knee [(4)]. Many acute knee and ankle injury is due to lack of proprioception [(1)]. So that, the proprioceptive acuity play important role in injury prevention and rehabilitation.

Angular measurements have been used by researcher to assess one of the sub modality of proprioception, the joint position sense [(5-11)]. The joint position sense tests are routinely administered by clinician to assess any proprioceptive deficit in the knee joint after ACL injury. Stretching, fatigue, pain, patellar taping and cooling alters the joint position sense. Clinicians identify any reduction in JPS that predisposes an individual to proprioception related injury [(1)]. Various methods have been used in order to measure the conscious sub modalities of proprioception i.e. JPS, kinesthesia, and tension sense [(12-13)]. The variety of the technique have been used; such as electro-goniometry[(10-21)], isokinetic dynamometer[(22-23)], automatic two-dimensional computer analysis from video image[(24-25)], kinematic analysis system[(26)], visual estimation for remodeling the angle tested[(27)], combination of video grapy and goniometry [(28)], combined photography and goniometry , Digital photography ,Non reflective marker and 'AUTO CAD '[(29)] , and shadow goniometer [(30)]

Some of the listed techniques having direct contact with the body that will induce abnormal sensory feedback lead to error in the result [(29)]. The abnormal sensory feedback means; during measuring proprioception if there is having directly contact with the body that will induce extra articular stimulation. This extra articular stimulation interferes with intra articular stimulation lead to more feedback which results in accuracy of the evaluation of the proprioceptive system. Because of that, the results become inaccurate.

Electrogoniometer, which is a electrical devices used for measuring the joint range of motion and joint angle. These devices give more accurate value of joint ROM. But this device is costly and less available in Indian market. The electrogoniometer has

difficulty to measure the proprioception of the joint. The result may be affected by abnormal sensory feedback. Also in case where the abnormal activity of proprioceptor due to the imposed pressure holding from the holding strap and fixator, is present. The other limiting factor is the lack of inter-rater reliability and the fact that angular changes of less than 10^0 may provide invalid result. [32]

Isokinetic dynamometer consist of a positioning chair attached to adjustable strength and computer control unit, it is mainly used for assessing the performance of different muscle group. The main problems with isokinetic dynamometer are the abnormal sensory feedback due to limb fixator and inability of the evaluation of the JPS in functional or weight bearing position [33, 34, 35].

Kinematic research is deals with study of motion variable, ignoring, the causing source, or in other words. It is the study of linear or angular displacement, velocity, and acceleration. It consists of high speed cameras, electromagnetic tracking system, electrogoniometer and accelerometer. However, high speed cameras and spherical reflective marker, which are placed on the limb, are used more than other tools. One of the main difficulty is the high speed camera require so much time to analyze the video image [26]. Computer analysis of video image, the replicated angle are measured with aid of a video camera and a two dimensional automatic digitizing system. For ease of visualizing, some markers are attached to the limb to reflect the ordinary or infrared light. But this method is costly, time consuming, and sophisticated are the disadvantage [24-25]. The angle measurements are taken by a system of digital photography, non reflective markers and Auto CAD analysis in laboratory setup. This method is more accessible because of more reliability and accurate value. But high cost, need of the camera and Auto CAD software are the disadvantages [29].

Later the shadow goniometer was developed in 2014 [30] for measuring joint ROM as well as proprioception of the knee joint. Various tools are utilized in this method, such as overhead projector, protractor, set square, wide screen wall, long table and standard goniometer. Shadow goniometer produce the shadow of leg (moving arm) and thigh (stationary arm) over visible 180^0 protractor which was projected on the screen or wall. The measurement of flexion can finally be obtained from the wall, as the leg shadow will be visible on the displayed protractor. Thus the range of motion can easily be obtained. This method is more reliable and validate for measuring proprioception of the joint. But need of the projector, darkened room, widen space are the disadvantage [30]. The smart phone applications are now widely available, allowing smart phone to be used as a protractor application. Hence this smart phone application can be used to assess the joint ROM. (Reliability valuation of this application and its concurrent validity with that of standard goniometer in measuring knee ROM. If it is reliable tool then this application tool can be also used for assessing the proprioception of the knee joint).

2. Materials & Methods

This study was conducted at the EMS Co-operative Hospital and research center at the physiotherapy department. Prior to participation in this study, all subjects completed an informed consent form. A correlative study design was employed for assessing the intra rater reliability and concurrent validity of the android application with the standard goniometer. 10 healthy subjects were selected with an age group of 20 – 25 .The subject were randomly taken from students of EMS Co-operative Hospital and research centre at the physiotherapy department. The application has 180^O protractor, (Figure 1&2) which is seen on the screen of mobile. These having two arms (both are movable). During measuring one arm kept as fixed arm and other arm kept as fixed arm. Patients were positioned prone lying on the couch. Foot of the subject was placed outside the couch. Eye of the subject were blind folded. Adjust the distance of mobile. The fixed arm is placed on parallel to the long axis of femur and the movable arm is placed on parallel to the long axis of the tibia. Axis is pointed on the knee joint.

The knee flexion was measured according to the guideline given by Cynthia C Norkin. [31]The subjects were instructed to bend from the testing knee from extension to available flexion. Measurement of flexion can finally be obtained at screen of the mobile. Thus the ROM can easily be obtained. For reliability the knee range of motion were measured by this application on two consecutive days and for validity, this application measurement were compared with standard goniometer on same day.

Data analysis: Statistical analysis was performed by using SPSS software (version 17) compatible with Windows. Alpha value was set at 0.05. Descriptive statistics was used to assess outcome variables. The intra-rater reliability was assessed using the coefficient. Karl Pearson test was used to analyze concurrent validity. Microsoft Excel was used to generate graph.

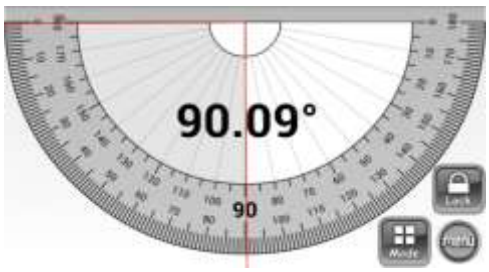


Fig 1: screen of mobile application

Fig 2: Mobile application measurement

3. Results & Discussion

3.1 Results

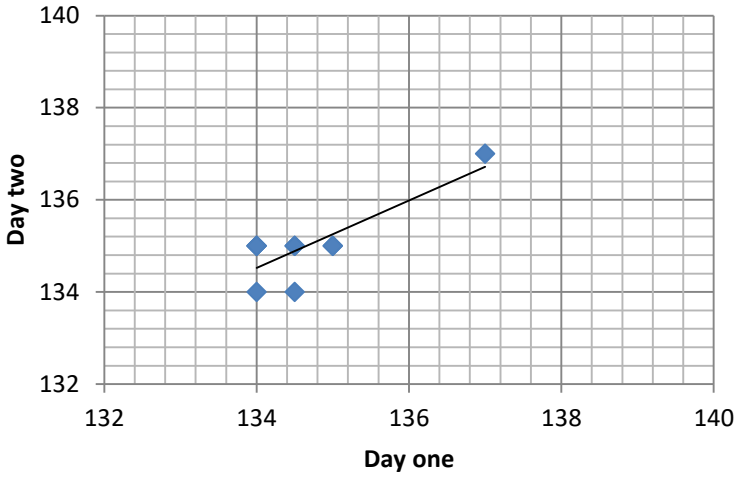
Table I show Descriptive statistics for standard goniometer and mobile application- day one and day two measurement. Table II shows the reliability of single measures, the ICC coefficient was 0.813 with upper confidence interval of 0.950 and lower confidence interval of 0.419, which was statistically significant ($p<0.001$)(Graph I). For the average measures, the ICC coefficient was 0.897 with a upper confidence interval of 0.974 and lower confidence interval of 0.585 which was statistically significant ($p<0.001$). The mobile application is a valid tool with correlation coefficient of 0.826 which was statistically significant ($p<.003$) (Graph II).

Table I: Descriptive statistics for outcome variables.

Instrument	Mean	Standard deviation	Min	Max	Range
Standard Goniometer	134.7	.948	134	137	3
Mobile App:day1	134.65	.914	134	137	3
Mobile App: day 2	135	.816	134	137	3

Table II: Intra-rater reliability, ICC (single& average), 95% CI & results

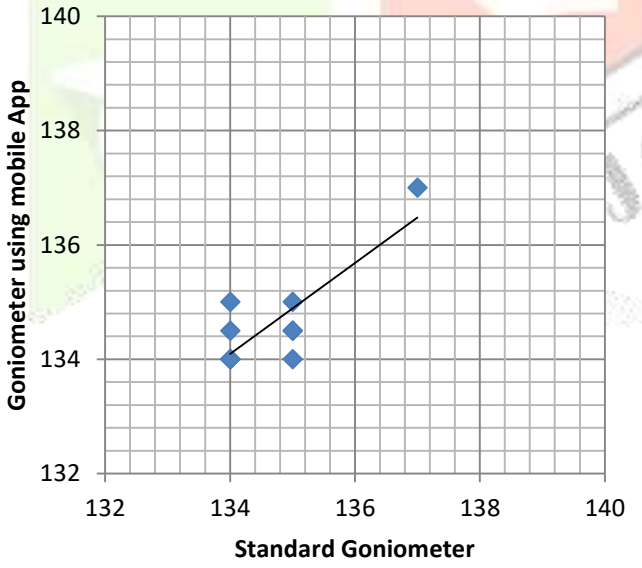
Variable	Intraclass Correlation Coefficient	95% Confidence Interval		p-Value
		Lower Bound	Upper Bound	
Single Measures	**.813**	**.419**	**.950**	**<.001**
Average Measures	**.897**	**.585**	**.974**	**<.001**



Graph I: Scatter gram for reliability

Table III: Concurrent validity between mobile application and standard goniometer

Correlation	Coefficient/ p value	Std. Goniometer
Mobile Application	Coefficient	.826
	P value	<.003



Graph II: Scatter gram for validity

3.2 Discussion

The objective of the study was to find the reliability and validity of mobile application, comparing with standard goniometer in measuring knee flexion range of motion. The study was done on ten subjects with uniform demographic variables with age group between 20 to 25 years. For the concurrent validity Karl Pearson correlation test was performed. The result showed that the mobile application is a valid tool with correlation coefficient of 0.826 which was statistically significant. This could be due to both

standard and mobile application use standard protractor divisions (in degrees) in measuring ROM and in this study the measurements were taken using the guidelines of Cynthia C. Norkin in measurements using standard goniometer and mobile application.

The repeated measurements on the same subjects on 1st and 2nd day with Mobile application found same result (day one – 134.65 and day two -135). This finding could be due to less error from the measurement as once the axis is being fixed, neither the subject nor the mobile application moves. Moreover, the size and contours of the body parts are not affecting the measurements. Thus repeated measurements did not deviate much from the first day measurements.

The smart phone application in joint measurement is an emerging field in assessment according to the systematic review conducted in 2014. In their study author has reviewed articles from 2011 onwards [32]. These types of applications use either inbuilt accelerometers, inclinometers, magnetometers and photographic systems. As compared to other clinical methods of assessment they are cheapness and easily available and in comparison with goniometry, they are easy to use and their relative speed of use. [33]

Electrogoniometer measurements are commonly affected by abnormal sensory feedbacks and their axis of goniometer and the joint center of rotation are not coincided. It will be also affected in cases where the abnormal activity of proprioceptors due to imposed pressure from the holding straps and fixators, is present. The other limiting factor is the lack of inter-rater reliability and the fact that angular changes of less than 10º may provide invalid results [34]. The main problems with Isokinetic dynamometer are the abnormal sensory feedbacks due to limb fixators and the inability of the evaluation of the JPS in functional or weight bearing position [35, 36, 37]. Computer analysis methods for joint position sense are expensive, time consuming and complicated [29]. However the shadow goniometer was developed for measuring the proprioception of the joint. It has more accurate value because of no abnormal sensory feedback. Pradeep et al [38] used the shadow goniometer to evaluate the knee joint position sense after quadriceps and hamstring stretch. It was very effective in determining Joint position sense. The absolute angular error was measured at 70 degree. The author concluded that concluded that dynamic stretching of hamstrings or combined stretch (quadriceps and hamstring) has significant effect on improving knee JPS compared to quadriceps alone in healthy adults when measurements were taken in knee flexion movement. But the need of protractors, projector, widened space and darkened room are the disadvantages. Hence the mobile application may be better for measuring the proprioception of the joint.

The advantages of mobile application could be that ROM is not limited by movement of subject or the goniometer, not affected by size and counters of the body parts. It will never produce abnormal sensory feedback. Hence the mobile application can be superior to conventional goniometer in measuring joint position sense because neither stationary arm nor moving arm of mobile application touches the limb. If it would have been touched the skin it can increase the joint position sense. The limitation of this study includes a less sample of convenience for reliability testing. The participants were belonging to young and healthy age group. However it is not known that, the placement of arms of mobile application in other populations may be different in case of obesity or limb deformations. So the study cannot be generalised. Further studies can be done measurements of ROM in other joints, measurements of joint position sense in lying, sitting and weight bearing positions such as standing,

4) Conclusion

The study concludes that the mobile application is a reliable and valid tool in measuring knee flexion range of motion. Thus the mobile application can be used as an alternative to measure joint position sense compared to other methods as these measurements are fast, inexpensive and reliable. So these mobile applications can be used for research purpose for measuring joint position sense.

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