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Reliability and validity of shadow goniometer for measuring range of motion in knee joint

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Abstract
Background & Objective: The high cost and the seldom availability of Isokinetic moving devices and Electro goniometer devices in Indian market gives less opportunity to do research as well as accurately measure the proprioception of joints. Hence Shadow goniometer was developed and designed. However the reliability and validity of it need to be investigated in measuring range of motion. So that this tool can be used to measure the joint position sense.
Materials & Methods: Ten healthy subjects were selected with an age group of 20 to 25. The standard goniometer was used to measure knee flexion followed by Shadow goniometric measurement of knee flexion. The measurements were repeated with shadow goniometer on the second day.
Results: The shadow goniometer was found to be a good reliable with Intraclass correlation of 0.993(p value < 0.0001) and valid tool with correlation coefficient 0.996(p value < 0.0001) in measuring knee flexion range of motion.
Conclusion: The shadow goniometer found to be a reliable and valid tool for measuring knee flexion range of motion. This instrument can be alternative to electro-goniometer for measuring joint position sense.

Keywords: Joint position sense, Proprioception, Goniometer

1. Introduction
Proprioceptive acuity is defined as an individual's ability to sense joint position, movement, and force to discriminate movements of the limbs [1]. Impaired proprioception is cited as a major factor predisposing to degenerative joint disease and ongoing instability in the ACL deficient knee [2]. Consequently, Proprioceptive acuity is an essential component of injury prevention and rehabilitation, but it is often ignored with devastating consequences, because Proprioceptive deficits may be responsible for many acute ankle and knee injuries [1].
Stretching is commonly used as a technique for injury prevention in the clinical setting [3]. It has been reported that the accuracy of Joint position sense will improve as the muscle stretched and that this increase in accuracy might be responsible for the increase in motor capabilities after stretching. Such an increase may be due to a better proprioceptive feedback, but may also act indirectly by leading to a better sensory imaginary [4].
Various methods have been used in order to measure the conscious sub modalities of Proprioception *i.e.* JPS, kinaesthesia and tension sense [5, 6]. Joint position sense is generally defined as the ability to assess the limb position without the assistance of vision [4]. A reliable method for the estimation of JPS is the measurement of the reproduction of a specific target position, the difference between target position and the estimate position being used [7]. A number of techniques for clinically examining proprioceptive acuity are described in the literature, including threshold detection of passive movement, the absolute method and joint position sense (JPS). An individual's JPS primarily determines his or her ability to perceive a target joint angle or limb position and then, after the limb has been returned to its starting position, to reproduce the predetermined angle. The JPS tests are routinely administered by clinicians to assess any proprioceptive deficits in the knee joint after anterior cruciate ligament injury, stretching, fatigue, pain, patellar taping, and cooling. The primary reason JPS is assessed by clinicians is to identify any reduction that may predispose an individual to proprioception-related injury [1]. There are various techniques used in the literature such as electro goniometry, Isokinetic dynamometer, automatic two dimensional computer analysis from the video images, kinematic analysis system, visual estimation for remodeling the angles

tested (for example in a goniometer, joint model or computer monitor), the combination of videography and goniometry, and combined photography and goniometry [8].

Electrogoniometer measurements may be affected by abnormal sensory feedbacks while the axis of goniometer and the joint center of rotation are not coincided [9]. 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 [10]. 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 [11, 12, 13]. Computer analysis methods for joint position sense are expensive, time consuming and complicated [8]

The high cost and the seldom availability of such devices in Indian market gives less opportunity to do research as well as accurately measure the proprioception of joints. Hence Shadow goniometer was developed and designed to analyze proprioception for a research study where the joint position sense (proprioception) of knee joint need to be measured pre and post intervention. However the reliability and validity of this new method need to be found so that this tool can be used to measure the joint position sense. The objective of the study was used to find out reliability valuation of shadow goniometer and its concurrent validity with that of standard goniometer in measuring knee range of motion. If it is reliable, Shadow goniometer can be used for the measurement of knee joint position sense

2. Materials & methods

Approval for this research study was granted by the institutional ethical committee of Padmashree institute of physiotherapy. Prior to participation in this study, all subjects completed an informed consent form. A Correlative study was employed for assessing the intrarater reliability and concurrent validity of shadow goniometer with standard goniometer. Ten healthy male subjects were selected with an age group of 20 to 25. Subjects were randomly taken from students of Padmashree institute of Physiotherapy. The only criterion was to make sure that the subject had a complete knee range of motion. Right knees of the participants were tested. Subjects with recent knee injuries, knee pathologies and who were unwilling to participate were excluded from the study. Materials required were overhead projector, protractor, set square, wide screen/wall, long table and a standard goniometer.

Shadow goniometer produced the shadow of leg (moving arm) and thigh (stationary arm) over a visible 180˚ protractor which was projected on a screen or wall. The couch was arranged so close to the wall. Patients were positioned prone lying on the couch. Foot of the subjects was placed outside the couch. A small steel pointer was place along with long axis of leg with help of straps. This will act as moving arm. Eyes of the subjects were blind folded. The protractor and setsquare were placed above over head projector (fig: 1). The height of the projector was arranged so that the horizontal line in protractor (stationary) arm is in line with long axis of thigh. So the centre of the projected protractor was aligned with the knee joint axis. A small towel was kept under the thigh of test leg for the free movement of patella during knee flexion.

The knee flexion was measured according to the guidelines given by Cynthia C. Norkin [14]. The subjects were instructed to bend from testing the right knee from extension to available flexion. Measurement of flexion can finally be obtained from the wall, as the leg shadow will be visible on the displayed protractor (Fig: 2). Thus the range of motion can easily be obtained. For the reliability the knee range of motion were measured by shadow goniometer on two consecutive days and for validity, shadow goniometer measurements were compared with standard goniometer on same day.

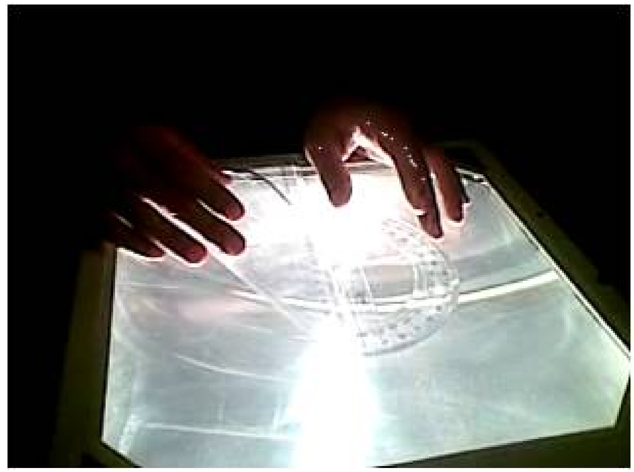


Fig 1: Alignment of Protractor and setsquare above overhead projector

Fig 2: Shadow of leg is created on the wall.

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 intra-class correlation coefficient. Karl Pearson test was used to analyze concurrent validity.

3. Results & Discussion

3.1 Results

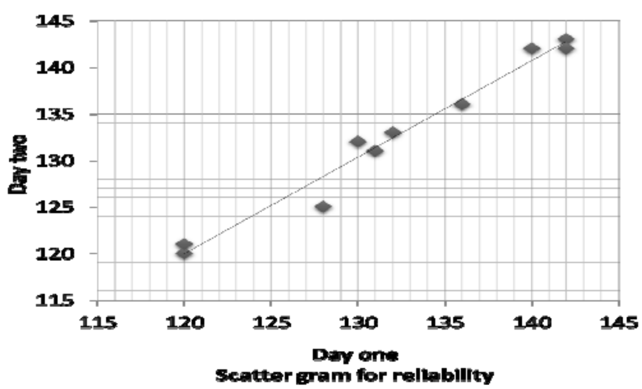
Table I show Descriptive statistics for standard goniometer and shadow goniometer- day one & day two measurements. Table II shows the reliability of single measures, the ICC coefficient was 0.985 with a upper confidence interval of 0.996 and lower confidence interval of 0.942, which was statistically significant ($p<0.0001$)(Graph I). For the average measures, the ICC coefficient was 0.993 with a upper confidence interval of 0.998 and lower confidence interval of 0.97, which was statistically significant ($p<0.0001$).The shadow goniometer is a valid tool with correlation coefficient of 0.996 which was statistically significant (Graph II).

Table I: Descriptive statistics for outcome variables.

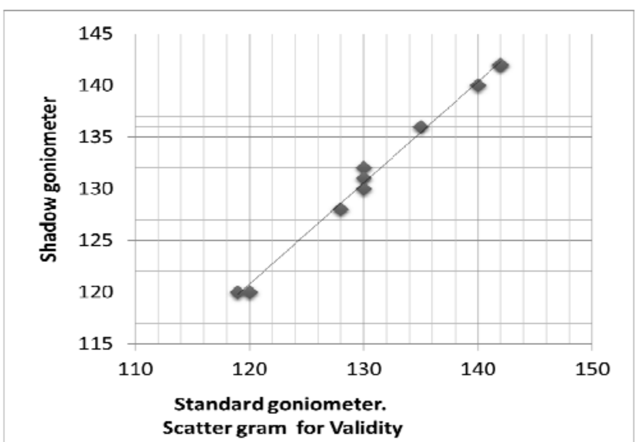
Instrument	Range	Min	Max	Mean	SD
Standard Goniometer	23.00	119.00	142.00	131.60	8.25
Shadow goniometer:day1	22.00	120.00	142.00	132.10	8.09
Shadow goniometer: day 2	23.00	120.00	143.00	132.50	8.50

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

Variable	Intraclass Correlation	95% Confidence Interval		p Value
		Lower Bound	Upper Bound	
Single Measures	0.985	0.942	0.996	< 0.0001
Average Measures	0.993	0.97	0.998	< 0.0001



Graph I: Scattergram for reliability



Graph II: Scattergram for validity

3.2 Discussion

The objective of the study was to find the reliability and validity of shadow goniometer, 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 shadow goniometer is a valid tool with correlation coefficient of 0.996 which was statistically significant. This could be due to both standard and shadow goniometer use standard protractor divisions (in degrees) in measuring ROM and in this study the measurements were taken using the guidelines of Cynthia C. Norkin [14]. in measurements using standard goniometer and shadow goniometer.

The repeated measurements on the same subjects on 1st and 2nd day with shadow goniometer found same result (day one - 132.10 and day two -132.50). This finding could be due to less error from the measurement as once the axis is being fixed, neither the subject nor the shadow goniometer moves. More over the size and contours of the body parts are not affecting the measurements [2]. Thus repeated measurements thus do not change the results obtained.

Kiran D *et al.* investigated correlation during concurrent measurement among three Isokinetic dynamometer, electrogoniometer, and two dimensional (2D) video analyses in sitting position and between two measures in standing position. The author concluded that either 2D video or an electrogoniometer may be used to measure JPS in standing position; however, in sitting position 2D video should not be used if the camera is required to be placed at 10 degrees from the plane of motion [15]. Some of the confounding variables in measuring JPS include visual, auditory, and tactile cues from the environment. An inclinometer can provide an affordable and accurate measure of JPS. The small, lightweight inclinometer generates no sound while operating and may provide less tactile feedback than other devices, so it may prove effective in measuring JPS. Geoffrey Dover *et al.* concluded that inclinometer was a reliable instrument and can provide an affordable and accurate measure of range of motion and JPS. Both JPS and FR were also reliable measures of proprioception in the shoulder [16]. The shadow goniometer does not give visual, auditory and tactile cue when compare to other instruments.

N. Nasseri *et al.* introduced a objective method of measurement for JPS. The author found the accuracy and reliability of a system, consist of digital photography, non reflective markers and manual analysis were evaluated. The angles were measured by using transparent sheets and goniometers as manual method. AutoCAD software was used to evaluate the accuracy of the manual results. The author concluded that the AutoCAD measurement, as a new system, was reliable and precise enough so it could be utilised for evaluating the JPS [8]. Compared to the above study shadow goniometer measurements were fast and inexpensive.

The advantages of shadow goniometer 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 shadow goniometer can be superior to conventional goniometer in measuring joint position sense because neither stationary arm nor moving arm of shadow goniometer touches the limb. If it would have been touched the skin it can increase the joint position sense.

Limitations of the study was sample size was small. The study was done in younger age group.

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 shadow goniometer is a reliable and valid tool in measuring knee flexion range of motion. Thus the shadow goniometer can be used to measure joint position sense compared to other methods as these measurements are fast, inexpensive and reliable. So shadow goniometer can be used for research purpose for measuring joint position sense.

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