ORIGINAL ARTICLE

Assessment of Knee Joint Proprioception in Weight Bearing and in Non-Weight Bearing Positions in Normal Subjects

Madhavi V Lokhande [1], Jaimala Shetye[2], Amita Mehta[2], Medha V Deo[1]*
[1]Terna Physiotherapy College, Nerul, Navi Mumbai - 400706 (Maharashtra), India
[2]Seth G. S. Medical College, Parel, Mumbai - 400012 (Maharashtra), India

Abstract:

Background: Assessment of proprioception is valuable for identifying proprioceptive deficits. There are several methods to assess the proprioception. Joint position sense can be assessed in weight bearing (WB) and non weight bearing (NWB) position of the limb whose joint is to be tested. *Aim and Objectives:* To find out the difference in joint position sense in NWB and in WB positions in normal subjects. *Material and Methods:* 40 normal healthy subjects between the age group of 20 to 25 years were selected. Subjects with recent lower limb trauma, pain and musculoskeletal deformity involving knee and ankle were excluded. Right knee joint proprioception at 30^0 knee flexion was measured using non weight bearing and weight bearing methods by active test with epsilateral active limb matching response. The knee joint position sense was measured by universal Goniometer. Average of 3 response angle was taken as the final reading. Two assessment procedures were compared with Mann-Whitney Test. Position sense accuracy was measured as a relative error. The relative error was calculated as an arithmetic difference between test and response positions. A measure of variability of individual observation was calculated by SD and coefficient of variation *Results:* Present study shows that there is a significant difference in two assessment procedures while testing joint proprioception (P <0.005). The mean of WB method [31.97^0] is relatively higher when compared with NWB procedure [30.42^0] but less inter-observation variability in terms of coefficient of variation is seen in WB position. In the present study relative error in WB position (-1.865^0) is more as compared to NWB position (-0.263^0), and the difference is statistically significant (p<0.005). *Conclusion:* There is statistically significant difference between the two assessment procedures. Average relative error of WB position is more as compared to NWB position. WB procedure produced more negative relative error i.e. Response was underestimated during WB testing of proprioception.

Key words: Knee Proprioception Assessment, WB (Weight Bearing), NWB (Non Weight Bearing) Testing of the Joint Position Sense.

Introduction:

Human being is aware of the position of the limbs under variety of conditions; both in moving [kinesthesia] and in stationary [static limb position sense.] In the normal healthy knee, both static and dynamic stabilizers provide support. Static stabilizers include ligament, meniscus, and the joint capsule. Although the primary role of these structures is mechanical, i.e. providing stabilization to the joint, the capsulo-ligamentous structures also plays an important sensory role by detecting joint position and motion. Sensory afferent feedback from the receptors in the capsuloligamentous structures projects directly to the reflex and cortical pathways, thereby mediating reactive muscle activity for dynamic restraint. Beard et al defined proprioception as 'the cumulative neural input to the central nervous system from mechanoreceptors in the joint capsule, ligaments, muscles, tendons and skin [1].

Proprioception can be described as **a)** Sense of position, which is awareness of position of one's own limbs and the orientation of their body parts with respect to one another, **b)** Sense of movement is the ability to perceive both direction and velocity of movement and **c)** Sense of force is the ability to estimate amount of muscular force that must be exerted in order to make movement or to maintain the position of the joint against a resistance [2].

Assessment of knee joint proprioception: Assessment of proprioception is valuable for identifying proprioceptive deficits. There are several methods to assess the proprioception. From an anatomic perspective, histologic studies can be conducted to identify mechanoreceptors within the specific joint structures. Neurophysiological testing can measure sensory threshold and nerve conduction velocities. Clinically, proprioception can be assessed by measuring the two components that make up the proprioceptive mechanism namely kinesthesia and joint position sense [3].

Kinesthesia: It is measured by either angle or time-threshold to detection of passive motion. In this with subject seated, the patient's limb is mechanically rotated at a slow constant angular velocity of 2 degrees per second. With passive motion, the capsulo-ligamentous structures come under tension and deform the mechanoreceptors located within. This information is then converted in to an electrical impulse which is then processed within the CNS. The patient is instructed to stop the lever arm movement as soon as person perceives motion. Depending on which measurement is used, either the time to detection or the degree of angular displacement is recorded.

Joint position sense: It is assessed through the reproduction of active and passive joint positioning. The examiner places a limb at a preset target angle and holds it there for a minimum of 10 seconds to allow the person to mentally process the target angle. Following this, the limb is returned to the starting position. The person is asked to either actively reproduce or stop the device when the passive repositioning of the angle has been achieved. The examiner measures the ability of the person to accurately reproduce the preset target angle position. The angular displacement is recorded as the error in degrees from the preset angle. Active angle reproduction measures the ability of both the muscle and the capsular receptors, whereas passive repositioning primarily measures the capsular receptors. Both tests are done with eyes closed, to eliminate visual cues.

Traditionally, this joint position sense is assessed in non weight bearing position [NWB]. In recent years, increasing numbers of authors have recommended weight bearing [WB] test of joint position sense, as weight bearing tests are more functional and involve all of the cutaneous, articular and muscular proprioceptors that act in concert during normal everyday activities [4]. Also as per the findings of Marks, Gilsing and Patrella in seperate studies, standing weight bearing assessment have more clinical relevance when evaluating proprioception in relation to falls in elderly and other weight bearing specific pathologies. Since gait cycle includes both WB stance phase and NWB swing phase, there is justification for both NWB and WB proprioception assessment. The results of many published studies comparing WB and NWB assessment have been inconclusive. The present study was undertaken to assess knee joint proprioception in NWB and WB position in normal subjects and to study the difference between the two methods.

Material and Methods:

Study design was an observational study. Seth G.S Medical college ethics committee approval was obtained before the commencement of the

Fig. 1- NWB testing

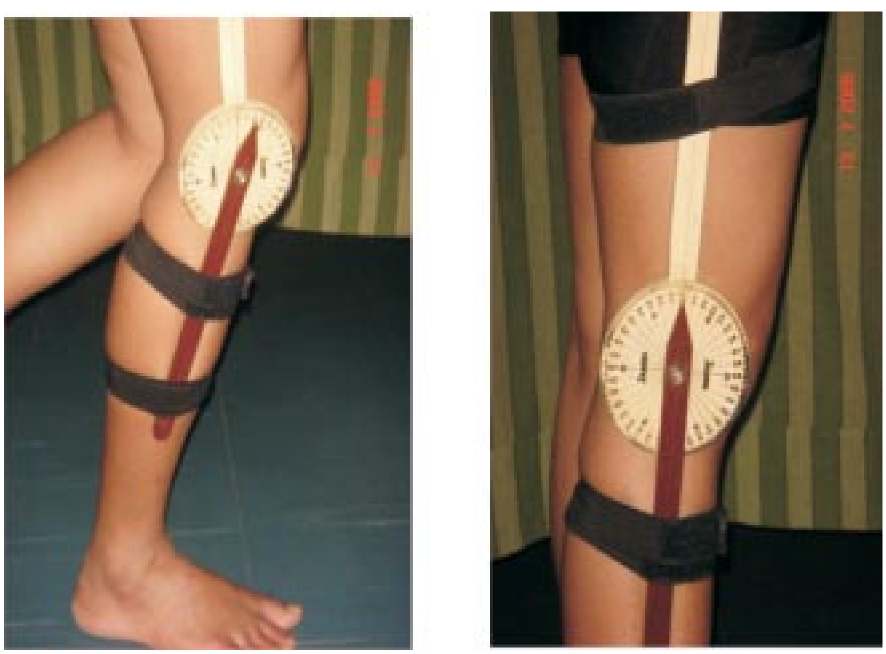


Fig. 2- WB testing

study. Forty normal healthy subjects in the age group between 18 to 25 years were included in this study. The subjects with recent trauma or surgery of the knee, pain or musculoskeletal deformity involving the knee were excluded from the study. Material: Materials used were plinth and Velcro straps. Joint range was measured with a universal Goniometer.

All the subjects were informed about the procedure & a written consent was taken. The right knee position sense was measured using WB and NWB methods as explained below. Right knee joint position sense was assessed by active test with epsilateral active limb matching responses, i.e. with the subject's eyes closed the examiner passively moved the limb to reach the knee joint to 30 degree which was the 'Test Angle'. To gain accuracy in measuring the angle, the Goniometer was tied to the lower limb in such a manner that the fulcrum was coinciding with the lateral knee joint line, while one arm of the Goniometer was aligned parallel to the line joining greater trochanter and fulcrum with the other arm to the leg i.e. along the line joining fulcrum and lateral malleolus.

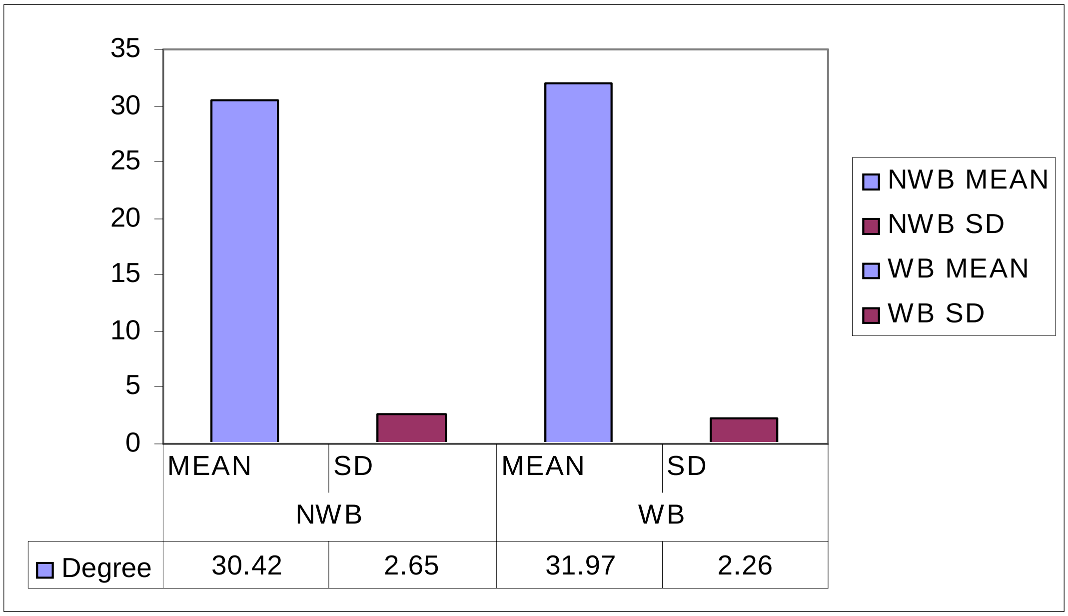
NWB assessment was done in bed side sitting position with legs out of the plinth and thigh fully supported. Subject was blind folded to avoid any visual cues. Examiner passively flexed knee joint from extended position to the target angle of 30 degree at very slow speed (about10 degree/second). Subject attempted to identify test position whilst holding it actively for 4 seconds and then passively returned to the starting position. Five practice repetitions were given and then asked to reproduce target position actively using the same limb (Fig. -1). Weight bearing assessment was done in unilateral standing (on right leg) with minimal finger touch support for balance. This was done by keeping left foot off the ground and slowly flexing the right lower extremity which is the weight bearing limb until told to stop on reaching the target angle of 30 degrees. The subject was then asked to hold this position for 4 seconds and sense the knee joint position. Then subject was asked to return to bilateral WB stance. Five such practice repetitions were given (Fig. 2). The assessment order was systematically rotated throughout examination so as to balance out possible interactive effects between adjacent procedure and effect of learning. All subjects were given initial explanation and practice before formal examination. Response position was measured as the angle at which subject stopped. Three consecutive response angles were noted.

Statistical Analysis:

Position sense accuracy was measured as a relative error. Relative error is the arithmetic difference between test and response angle. A negative sign was assigned if the response position underestimated (i.e. was more flexed than) the test position and a positive sign if the response position overestimated (i.e. was more extended than) the test position. The mean of each set of 3 relative errors was then calculated. After application of test for normative data, it was found that the data is not normally distributed. Hence non-parametric test was used to compare two assessments. Mann-Whitney Test was used to compare response angle and relative error in NWB & WB assessment. Measures of variability of individual observation were calculated as standard deviation (S.D.) & coefficient of variation (C.V.).

Results:

Graph 1 - Comparison of NWB and WB Joint position sense for target position at 30^0



Data average = Mean (SD)
Target position = 30^0

Variable	NWB	WB
Response angle (degrees)	30.42(2.65)	31.97(2.26)
Median	30.000	31.330
W, p value	**W = 1332, 0.0057**	

H0: Response angle of NWB = WB
H1: Response angle NWB not= WB

Variable	NWB	WB
Response errors (degrees) Relative error	-0.263	-1.865
Median	0.000	1.330
W, p value	**W = 1896.5, 0.0079**	

Coefficient of variation	NWB	WB
	8.73%	7.09%

Since the p-value is less than the chosen a level of 0.05, we conclude that there is sufficient evidence to reject H0. Therefore, the data does support the hypothesis that there is a difference between the population medians.

Discussion:

Present study shows that there is a significant difference in two assessment procedures while testing joint proprioception, which is supported by P value of 0.0057. The mean of WB method is relatively higher when compared with NWB procedure.

However, as will be elaborated below, this does not necessarily mean that weight bearing position sense is better during the weight bearing position assessment.

The WB assessment in the present study has shown more deviation from target position but less inter-observation variability in terms of coefficient of variation when compared with

NWB assessment, In the present study relative error in WB position (-1.865) is more as compared to NWB position (-0.263), and the difference is statistically significant (p=0.0079). This finding of the apparent smaller relative error during NWB as compared to WB procedure suggests better accuracy in NWB test position. Possible explanations for the differences include the balance requirement in WB position, where individual has to pay attention to the required test angle as well as have to maintain the balance too, which may compromise on accuracy of the response angle. The weight bearing procedure is associated with greater (body weight) resistance of muscles throughout the lower limb than the (limb weight) resistance in NWB knee repositioning procedure. Whether the magnitude and distribution of muscle contraction augments or interferes with proprioceptive acuity is unclear. During WB assessment of proprioception the response angle could be underestimated. Maximum number of subjects have shown overshooting which is seen with relative error of -1.865. Study done by Stillman and McMeeken have shown a smaller absolute and relative error during the WB as compared with the NWB limb repositioning procedure. Weight bearing may augment the afferent discharge from compressed mechanoreceptors in connective tissue structures distributed throughout the weight bearing joints [5].

In a specific study of WB vs NWB procedures, Refshauge and Fitzpatrick (1995) have examined the threshold for detection of low velocity passive ankle movements. With the knee straight and the feet dorsiflexed in WB standing compared with the same joint positioning in NWB sitting, no significant difference could be found between the two sets of results. However when the knee is flexed in NWB sitting position, the perception threshold increases approximately two folds. The authors have concluded that the foot and the knee postures, including calf stretch, are the major determinants of the WB (and NWB) test results, and not WB as such because of the greater dorsiflexion, the weight bearing procedure of the present study would also have involved greater calf stretch than the NWB limb repositioning procedure [6].

Even the slightest resistance substantially increases the afferent output from muscle spindles (Wilson et al 1997) [7], which supports the generally accepted view that active joint position sense tests produce better results than passive tests (Crake and Crawshaw1975, Velay et al 1989).

On the other hand, no change in elbow position sense is demonstrated when Darling and Hondzinski (1999) loaded the forearm during their joint position sense assessments [8]. Also threshold detection of elbow movement is seen diminished when Wise et al (1998-1999) invoked co-contraction of surrounding muscles. Thus at present it can only be hypothesized that differences in the magnitude and distribution of resisted muscle contractions might affect WB versus NWB results.

All subjects in the present study have required at least minimal finger touch support in order to maintain stable test position in unilateral WB stance. Study done by Clapp and Wing (1999) and Rabin (1999) has shown that even fingertip contact insufficient to constitute physical support significantly diminishes sway in unilateral and bilateral stance with eyes closed [9]. They propose that proprioceptive feedback from the skin of the supporting fingertips, and the joints within the supporting limbs may play a role..

Lackner et al (2000) have found that light fingertip contact can completely compensate for disturbed propriocepiton at the ankle produced by vibrating the surrounding muscles. This raises the question of whether fingertip or contra lateral foot contact might invalidate all examinations for pathologically disturbed knee or ankle proprioception in predominantly unilateral WB stance [10].

According to research done by Lonn et al (2000), the NWB knee repositioning procedure has the greatest potential for revealing the proprioceptive status of only the knee joint because it does not involve any movement, resistance or weight bearing of its own or through adjacent joints. Because the examiners slowly and passively move the knee to and from the target position, there is also less likelihood that the subjects derive cues from these movements to assist in locating the test positions. For example, it is possible for subjects to sense the amplitude of movement of the knee to the test position, especially if it is produced actively and/or rapidly, then reproduce amplitude, and hence the final (test) position, during the response (Lonn et al 2000) [11]. Active limb movement is unavoidable in the WB procedure, hence there was a greater potential for the standing subjects to use movement cues. On the one hand a simple active movement to a test position is arguably more functional because it corresponds to the usual circumstances of everyday proprioceptive function. Conversely, allowing patient's ready access to movement cues may allow them to mask deficient position sense at the examined joint; thereby misleading the examiner.

The whole discussion about two assessment methods has shown that there are different reasons which can influence the test result, such as movement cues, increased muscle contraction during weight bearing, calf stretch during ankle dorsiflexion, finger touch support during unilateral weight bearing. All these factors need to be considered while reporting impairment in knee proprioception.

Conclusion:

The above study shows that there is a statistically significant difference between the two assessment procedures (W B and NWB) while measuring joint proprioception. However as there is need to check proprioception in both the ways for reasons mentioned before, it is essential for the examiner to keep in mind the factors affecting in the two procedures and then conclude about the impairment.

Clinical Application:

At present, it seems that WB assessment of proprioception might have greatest relevance in the area of sports medicine where relatively healthy subjects are more likely to be able to meet the weight bearing assessment requirements, and where clinicians should be particularly interested in their subjects' proprioceptive and balance capacities under WB functional conditions. However such assessment should not be used as a substitute for NWB single joint positioning assessments which are likely to be more specific for the examined joint.

References:

1. Barr ML and Kiernan JA. The Human Nervous System, An Anatomical Viewpoint. 4th edition. Philadelphia: Harper and Row. 1983
2. Schmidt RF, Altner H. Fundamentals of sensory physiology, Robert 3rd edition, Springer-Verlag, 1986: 47.
3. Ellenbecker TS. Knee ligament rehabilitation. Philadelphia, PA: Churchill Livingstone, 2000: 362-363.
4. Horch KW, Ciark FJ, Burges PR. Awareness of knee joint angle under static conditions. *J Neurophysiol* 1975; 38: 1436-1447.
5. Stillman BC, McMeeken JM. The role of weightbearing in clinical assessment of knee joint position sense. *Aust J Physiother* 2001; 47 (4): 247-253.
6. Refshauge KM, Fitzpatrick RC. Perception of movement at the human ankle: effects of leg position. *J Physiol* 1995; 488 (Pt 1): 243-248.
7. Wilson LR, Gandevia SC, Burke D. Discharge of human muscle spindle afferents innervating ankle dorsiflexors during target isometric contractions. *J Physiol* 1997; 504(Pt 1): 221-232.
8. Darling WG and Hondzinski JM. Kinesthetic perceptions of earth- and body-fixed axes. *Exp Brain Res*1999; 126 (3): 417-430.
9. Rabin E, Bortolami SB, DiZio P and Lackner JR. Stabilization of posture: Changes in arm proprioception and cutaneous feedback for different arm orientations. *J Neurophysiol* 1999; 82(6): 3541-3549
10. Lackner JR, Rabin E and DiZio P. Fingertip contact suppresses the destabilizing influence of leg muscle vibration. *J Neurophysiol* 2000; 84 (5): 2217-2224.
11. Lönn J, Crenshaw AG, Djupsjöbacka M, Pedersen J and Johansson H. Position sense testing: Influence of starting position and type of displacement. *Arch Phys Med Rehabil* 2000; 81 (5): 592-597.

***Author for Correspondence**: Dr. Madhavi V Lokhande, Assistant Professor, Terna Physiotherapy College, Nerul, Navi Mumbai- 400706 (Maharashtra), India
Email: madhavilokhande@gmail.comCell9869657483*