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Joint Proprioception in Normal and Osteoarthritic Knees

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Abstract

Background: As aging occurs degenerative changes overcome the regeneration capacity of body and this becomes a cause of decreased motor control. Proprioception is a deep sensory faculty that helps in controlling activation of the dynamic restraints and motor control. Error in estimating Joint position sense (measured by angular repositioning at a predetermined angle) reflects the proprioceptive inaccuracy of the concerned joint. This can be such an error is present in all individuals but increases with threat to the joint integrity either due to trauma or aging. The purpose of the present study was to determine extent of proprioception deficits appreciable in degenerative joint disease of knees.

Method: Patients with knee OA previously diagnosed by the physician were included in study. Variables such as age, sex, height, body weight and Body mass index (BMI) were evaluated. Subjects were positioned in supine on a couch with knees in full extension and asked to move the test knee into a specific angle of flexion. The subject's perception of the angular position was recorded and compared with the actual angle of flexion.

Result: There was a significant difference between the joint position senses of persons with OA as compared to normal individuals. Those with osteoarthritic knees showed greater error in position estimation at all angles ($p < 0.05$).

Conclusion: It is proposed that reduced proprioception in elderly and osteoarthritic subjects may be responsible for initiation and/or perpetuation of degeneration of the knee.

Keywords: Osteoarthritis; Proprioception; Dynamic restraints; Motor control

Introduction

The worldwide increase in the elderly population is the most important change as per the public health statistics for 21st century [1]. It is being estimated that the number of people over the age of 65 will be doubled in the next 20 years [2]. Consequently, osteoarthritis (OA) and similar diseases that are more frequently encountered in advancing years become much more important from both medical and economic aspects [3]. A survey in India in 2007 revealed the OA prevalence rate of 32.6% in rural and 60.3% in urban population. OA was present in 50.2% population falling in age group 65-74 years whereas it was 97.7% in age group 84 years or older [4]. Socioeconomic impact of OA is greater than other diseases due to its higher prevalence [5].

Risk factors of OA [6] can be grouped as

a. Non-modifiable risk factors such as Age (The risk of developing most types of arthritis increases with age), Gender (Most types of arthritis are more common in women; 60% of all people with arthritis are women).

b. Modifiable risk factors such as Overweight and Obesity (Excess weight can contribute to both the onset and progression of knee OA), **Joint Injuries** (Damage to a joint can contribute to the development of OA in that joint), Infection (Many microbial agents can infect joints and potentially cause the development of various forms of arthritis), **Occupation** (Certain occupations involving repetitive knee bending and squatting are associated with knee OA).

c. Other possible risk factors such as Estrogen deficiency, Osteoporosis (inversely related to OA), Vitamins C, D and E deficiency – equivocal reports, Elevated levels of C-reactive protein (increased risk with higher levels).

Common signs and symptoms of knee OA include knee pain, tenderness, joint stiffness and decreased muscle strength. In addition, individual with knee OA often exhibit poor neuromuscular control, slower walking speed, decreased functional ability and increased susceptibility to fall [7-10].

Proprioception encompasses the senses of joint position and joint motion. These senses originate from the stimulation of specialized nerve-endings or mechanoreceptors in the joint capsule and ligaments. The receptors convert the mechanical energy of physical deformation into the electrical energy of a nerve action potential and this action potential propagates to the higher center for motor control [11].

Reflex contraction of muscles by stimulation of proprioceptors protects joints from mechanical insults. Conscious contractions are, in most cases too slow to prevent the injury, because their nerve paths are usually longer therefore slower. Proprioception involves different sensory systems of muscles, ligaments, tendons, joints, skin, and organs of vision and balance [9,12,13].

Most of the previous studies on proprioception have focused on young active athletes [14-16] or on recipients of total knee replacements [17-19]. Very few studies have focused on arthritic knees. The purpose of this study was to compare the proprioception deficits in age matched radiologically significant osteoarthritic and non osteoarthritic knee.

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There are many ways to measure the proprioception with joint position sense error [20]. We have attempted to measure joint position sense error by a wireless goniometer mediated solely by the patient without any external cue like visual, auditory etc. This is very simple method to measure the joint position error for interpreting the proprioception deficits.

Methodology

Subjects

Fifty six patients were approached with the proposal of the study. Out of which forty four were included. Eight did not fulfill the inclusion criteria and four refused to participate.

Inclusion and Exclusion criteria

Both male and female subjects with a pre diagnosed cases of knee OA of age group 40 to 65 years showing radiographic changes in one or both knee joints were included in the study. Any systemic infection, neurological or; vestibular disorder, deformity of back, hip, knee and ankle, history of either knee trauma during last 3 month or knee surgery, clinically significant Anteroposterior or Mediolateral instability of knee, taken steroid injection within 6 months in knee joint and uncooperative patient were excluded. Aim of the study and procedure were explained and a written informed consent was taken from subjects who agreed to participate.

Ethical approval and patients' informed consent

The ethical approval was taken from institutional ethical committee, NIOH Kolkata. Informed written consent was taken in the patient's language.

Instrumentation to measure proprioception

The ability to replicate target knee-joint angles was assessed using an electronic goniometer (Tracker Freedom Wireless Goniometer). The test subjects were positioned in supine lying and made to wear headphones and dark glasses to eliminate auditory and visual cues from the testing apparatus. They wore shorts to negate any extraneous skin sensation from clothing touching the knee area. An Electrogoniometric scale was fastened to the lateral side of the knee with fixed arm pointing towards greater trochanter of femur, movable arm pointing to lateral malleolus and fulcrum at the joint line (Figure 1). Skin stretch was checked while fastening the arms with adhesive tape. A trial was allowed at each angle before testing. The knee was positioned in full extension. The subject was then asked to flex the knee joint to a pre-determined target angle of 30°, 45° and 60° (Figure 2). Auditory feedback was constantly provided by the therapist during trial. Hold time was 5 seconds at each targeted angle. After returning to the starting position and having remained there for 10 seconds, the subject was asked to flex the knee again to reach the target angle. At every angle (30°, 45°and 60°) three readings were taken, mean was calculated and recorded as the patient's joint position sense. Although the validity and reliability of position matching tests have rarely been evaluated, it is well accepted that the magnitude of accuracy can be a useful indicator of proprioceptive acuity. Precisely those individuals who are prone to making large position matching errors are thought to be, at least in some way, proprioceptive deficient. This is supported by Torres et al. [21] who stated that the testing protocols for proprioception measurement usually comprise defined target position that is identified and appreciated by the subjects, which are blindfolded. Then, the target position is reproduced passive or actively to the best of subject's ability.

Figure 1: Initial position of JPS measurement.

Figure 2: Reading position of JPS measurement.

Results

Demographic data

Forty four patients (19 male and 25 female) were evaluated for the study. Their age (in year), weight (in kilogram), height (in centimeter), and BMI (Kg/m^2) was recorded. Table 1 represents the details of the mean and standard deviation of these scores.

Joint Position Sense (JPS) Error

Data for the JPS error was measured at the day before taking any intervention. For both groups data were taken at three predetermined angle at 30°, 45°and 60° respectively. Between group comparison of JPS error is represented in Table 2. In non arthritic subjects the difference measured between the real and the perceived angles of flexion varied from 0.79 to 7.39 whereas in osteoarthritic knees it varied from 6.63 to 12.55. The JPS error was found to be significantly different between two groups at all the preset angles ($p < 0.05$).

Discussion

Our study has shown that with aging there is some proprioceptive error without any clinical feature as in group B. It is also supported by Stauffer et al. [22] who suggested that proprioceptive diminution with age and might be the major factor for age related gait pattern. This is also in line with the findings of Saxton et al. [23] who stated that elderly subjects tended to overshoot the criterion angle more often than subjects from the young and middle-aged groups. In osteoarthritic knee (group A) this error was more in comparison to non osteoarthritic knee. This error of proprioception might be expected as a result of various mechanisms. Barrett et al. [10] stated that laxity of the capsule and ligaments caused by loss of cartilage and bone height, lytic enzymes released around the joint may damage the receptors end organ within the capsule decreasing proprioception perception. This is also supported by Hurley and Scott DL [24] who reported that in patients with knee OA, articular damage may reduce quadriceps motoneurone excitability, which decreases voluntary quadriceps activation thus contributing to quadriceps weakness and diminishing of proprioceptive acuity. This is corroborated with Diracoglu et al. [8]

Variables	Group A Mean(SD) N=22	Group B Mean(SD) N=22	T-TEST	
			t	P
AGE	53.18(6.88)	53.32(5.36)	-0.07	0.94
WEIGHT	62.04(5.97)	61.95(8.06)	0.04	0.97
HEIGHT	155.54(3.07)	156.86(3.98)	-1.23	0.22
BMI	25.69(2.68)	25.17(3.12)	0.59	0.56

Table 1

Angle (in degree)	Group A JPS Error (in degree) Mean(SD) (in degree)	Group B JPS Error (in degree) Mean(SD) (in degree)	T-TEST	
			t	P
30	10.61(1.94)	4.49(2.90)	-1.16	0.23
45	9.92(2.92)	3.07(2.28)	-0.17	0.84
60	9.31(2.68)	4.21(2.77)	0.13	0.80

Table 2

who reported that balance and strength training brought significant improvement in proprioception reflecting weakness as a factor of diminution of proprioception. But this finding is contradicted by Koralewicz et al. [25] who reported that loss of proprioception might occur prior to the development of the structural changes of arthritis.

From this study it is not possible to conclude whether loss of joint position sense causes osteoarthritis or is a consequence of it. Allum et al. [26,27] reported role of proprioceptive input and emphasized proprioception as an essential component for initiating and modulating postural adjustments. Hence correction of proprioceptive error should be planned as a major deficit and should be included in threatened lower limb.

Conclusion

Our method of measuring proprioception is easily reproducible. Proprioception deteriorates with aging and more deterioration with degenerative disease in elder.

Limitation

Proprioception deficits with grade of knee OA were not studied. Population without radiological changes but with clinical symptoms not studied.

Recommendation for further study

Proprioceptive correction should be thought in elder patients especially with degenerative changes to lower extremity.

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