International Journal of PharmTech Research
CODEN (USA): IJPRIF, ISSN: 0974-4304
Vol.9, No.4, pp 80-91, 2016

The Effect of Knee Osteoarthritis on Lumbar Proprioception

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Abstract: Background: Knee osteoarthritis (OA) is a common chronic disease affecting weight bearing joints. It alters kinetics and kinematics of all lower limb joints and lumbar spine.
Purpose: The purpose of this study was to study the effect of chronic knee osteoarthritis on lumbar proprioception.
Methods: Sixty subjects participated in the study. Their age were ranged between 40 and 60 years. The subjects were assigned into two equal groups; **Study group (A):** It was consisted of 30 chronic unilateral grade II knee osteoarthritic patients. **Control group (B):** It was consisted of 30 healthy subjects matched for age, sex, weight and height to the OA participants. Lumbar proprioception was measured by Biodex system III.
Results: There was a significant decrease in lumbar proprioception in the study group compared to control group where the level of significance was (P<0.001). he mean of the absolute angular error in the study group was 8.73± 5.31 while the mean of the absolute angular error in the study group was 1.33± 1.24.
Conclusion: There was a deficit of lumbar proprioception in chronic knee osteoarthritis.
Key words: lumbar proprioception, knee osteoarthritis, isokinetic.

1. Introduction

Osteoarthritis (OA) is the commonest joint disorder. It is strongly associated with ageing and is a major cause of pain and disability in the elderly population[1]. It was considered to be an exclusively chronic degenerative disorder that was a result of wear and tear in elderly joints**.** A formal definition of OA is that it is a painful degenerative process involving progressive deterioration of all joint structures and remodeling of subchondral bone and which is not primarily inflammatory[2]. The most common joint involved in this disease is knee joint[3,4].

Individuals with knee OA experience pain, stiffness and decreased range of motion of joints. These symptoms significantly limit an individual ability to rise from chair, stand comfortably, works or climb stairs[5]. Weight bearing tasks are among the most difficult for individuals affected by OA. Ultimately these limitations lead to a loss of functional independence[6]**.**

According to a reported prevalence of arthritis[7], by 2020, the estimated number affected by OA is projected to increase by 57%, with activity limitations estimated at 66%. It is becoming increasingly evident that we are entering an era where OA is being diagnosed in epidemic proportions[8]**.**

It is well accepted that knee OA not only changes the mechanics at the knee but also at the other lower limb joints during functional activities[3,9,10]**.** These primary and secondary changes may be related to both mechanical requirements and multi-joint coordination[11]**.**

Muscle activity adds stability, controls the stop-start of joint motion, and compensates for gravity. Joint proprioception or the perception of joint position provides input to the nervous system to guide particular muscle activity. Although these factors may be impaired in some individuals prior to disease development, they also may be made worse by OA[12]. Limb function depends more on proprioceptive information than on strength[13].

Impaired strength and mobility limitation in OA causes alteration in gait mechanics which in turn increase the mechanical energy expenditure or moments at the ankle and hip[14,15]**.** Impaired proprioception at the knee joint in OA affects the correct perception of the knee joint position and movement, which in turn affects the inter-joint coordination of the knee with other joints[16,17]**.** Bilateral knee osteoarthritis impaired the balance and increased the risk of fall, particularly in people with moderate knee osteoarthritis[18]**.**

Patients with medial compartment knee OA walk with a different gait pattern than normal subjects. All patients landed with the knee in a more extended position, experienced a more rapid increase in the ground reaction force, had greater knee and hip abduction moments, and had greater lateral ground reaction force, indicating a more rapid shift of the body's weight from the contralateral limb to the support limb and a lateral shift of the trunk. These compensations lead to increased axial loading rates at all joints of the lower extremity[3]**.**

The knee joint degeneration is compensated by pelvis and other joints in lower limb. Reduced motion of the knee joint leads to increased pelvic motion, which affect natural mobility of the lumbar spine and cause pain in lumbar region of the spin because of the existing kinematic interaction[20]**.**

Patients with knee osteoarthritis have asymmetrical pronation which causes lumbopelvic disorders as sacroiliac dysfunction and an increase in degree of anterior pelvic tilt with a subsequent increase in lumbar lordotic curve causing low back pain. Pronation of the foot acts to internally rotate the leg and causes internal rotation of the femur and hip joints that result in the lower pelvis and acetabulum being pushed posteriorly which in turn causes an anterior shift in weight bearing (anterior shift in a center of mass). This forces the pelvis to tilt forwards which in turn increase the lumbar lordotic angle. Pelvic inclination angle is higher in subjects with pronation of the foot than in normal subjects[21].

Knee OA is a multifactoral disease process that involves many interrelated factors that interact to produce biomechanical changes throughout the disease process. The previous studies concentrated on kinetic and kinematic changes associated with OA and measure proprioception locally on the knee. There is gap in literature regarding influence of OA on proprioception of other joints as lumbar region. So this study was designed to measure lumbar proprioception in patients with knee osteoarthritis. We hypothesised that lumbar proprioception would be affected in knee OA.

Subjects, Materials and Methods

This study was conducted in isokinetic lab at the Faculty of Physical Therapy, Cairo University to measure lumbar proprioception in patients with chronic unilateral grade II knee osteoarthritis.

1) Design of the study:

One shot measurement session.

2) Selection of subjects:

Thirty knee OA patients and thirty healthy subjects (male and female) participated in the study. Their age were ranged between 40 and 60 years.

The subjects were assigned into two equal groups; study group (A) and control group (B)

Study group (A): It was consisted of 30 chronic unilateral knee osteoarthritic patients. They will have moderate OA (grade II according to the Kellgren/Lawrence (K/L) classification)[22]. They were referred by an orthopedist and a rheumatologist. They will be selected from the Outpatient Clinic of the Faculty of Physical Therapy, Cairo University and El-Kasr El-Eini Orthopedic Outpatient Clinic.

Knee OA was diagnosed according to the criteria of the American College of Rheumatology[23]**.** The criteria involved a radiographic evidence of medial femorotibial OA on plain weight-bearing standing X-rays, medial knee pain for most days in the past month, pain of at least 30 mm on a 0–100 mm Visual Analog Scale (VAS) following physical activities during the previous two days and at least one of the following items: age greater than 50 years, morning stiffness of less than 30 min duration or crepitus on active knee joint motion.

Control group (B): It was consisted of 30 healthy subjects matched with group (A) for age, sex, weight and height.

In both groups, lumbar proprioception (active reposition accuracy) was measured at the Isokinetic Lab. in the Faculty of Physical Therapy, Cairo University.

Exclusive criteria for both groups are history of lumbar pathologies as disc prolaps, spodylosis, spondylolithesis and previous surgeries, history of knee disorders as malalignment of the knee (varus / valgus), effusion, knee arthroplasty, meniscial and ligamentous problems, diseases contributed to sensory motor control as inner and middle ear infection, vestibular insufficiency or loss, ataxia, vertigo and Parkinsonism, metabolic or vascular disease with a neurological component such as diabetes, inability to comprehend and follow instructions as in dementia or language problems, systemic inflammatory arthritis as rheumatoid arthritis and morbid obesity (body mass index >45 kg/m2).

3) Instrumentation:

Biodex system 3 Pro Multijoint system isokinetic dynamometer (Biodex Medical Inc, Shirley, NY) was used to measure lumbar proprioceptive accuracy **(Fig. 1)**. It was found to be both a valid and an accurate research tool[24,25]**.**

4) Measurement procedures:

Instrumentation /Subject positioning:

All subjects agreed to participate in the study by completing an informed consent form. Personal data (age, address, telephone and dominant leg), anthropometric measures "weight and height" and BMI was measured before starting the evaluation procedures.

Instrumentation /Subject positioning:

In order to standardize the tests, they were administered to all subjects between 10 a.m. and 12 p.m. All measurements were carried out in one experimental session for each subject. Calibration of the dynamometer was performed according to the specifications outlined by the manufacturer's service manual[26]**.** The dynamometer and chair rotation were adjusted to zero degree (as dictated by the manufacturer). The dynamometer tilting was adjusted to zero degree. The dynamometer orientation was adjusted to 90 degrees. The limb support] was set in place and the lumbar attachment was fixed to the dynamometer so that the fulcrum of the dynamometer corresponded to the axis of subject's lumbar region. The standard toe straps were used over the back. The chair, dynamometer and the arm rest height were adjusted according to the height of each subject (as dictated by the manufacturer). Each subject was seated on the dynamometer chair**.** Two straps were wrapped around the extremity proximal to the patella and the pelvis to minimize movements of the trunk, hip and knee during testing. Uniform instructions were given to each subject about the isokinetic equipment and the study prior to testing. Participants were regularly instructed to keep their muscles relaxed during measurement.

Lumbar active repositioning accuracy measurement:

A joint repositioning test:

One commonly used method for testing joint repositioning is the assigned joint position test[27]. During this test, the joint is actively moved to a target position that is memorized by the subject. It is then returned to the initial position. Thereafter, the joint is moved actively back to the target position. The subject will be blindfolded to eliminate visual input[28,29]**.** Prior to testing, each subject will be given two test runs to familiarize himself with the procedures. Three trials will be recorded, each beginning from the starting position /angle. There is a period of rest equal to 30 seconds between each trial and the other. The subject was seated on the chair of the Biodex system, knee block positions will be individually adjusted by two curved anterior leg pads, the feet will hold in a position with no contact with the floor, both thighs will stabilize by two straps, the pelvic brace will be then applied and positioned as far down as possible to press firmly but comfortably against the superior aspect of the proximal thighs. In addition, lumbar pad will be located against the lower lumbar spine.

The seat was adjusted so that the axis of the actuator arm was aligned with L5/S1 disc space. This will clinically identify by palpation of the posterior superior iliac spine (PSIS), which is at the level of S2, and then moving one inch superiorly. The upper part of the trunk will be strapped to the back attachment with a belt. With the subject sitting erect, the force application straps was adjusted vertically with the second intercostal cartilage on the anterior chest wall. The head was stabilized neutrally on adjustable head rest. Each subject was positioned into an upright neutral starting position. This position is such that the anterior superior iliac spine and the posterior superior iliac spine were aligned in the horizontal plane[22]**.** The predetermined spinal range of motion, which was chosen to be the "target position" for the subjects during the testing protocol, was from neutral spinal posture to 30° lumbar flexion[30] **(Fig.1).** This position was adopted because it is of a magnitude that could be attained by all subjects. Each subject was asked to move into flexion as much as he can to determine the maximum available lumbar ROM to determine if he was able to perform the experimental task. The dynamometer was locked in the 0º position to ensure the same starting position in the three testing trials for each subject. This was followed by a practice trial in which each participant was allowed to perform 3 repetitions of the test. Once each subject was completed the practice trial, the standard test session starting which consists of the following: each subject was positioned in 30° of lumbar flexion for 10 seconds and he will be instructed to remembered the position because he was asked to reproduce this position. Then the participant was returned to the neutral position and then was be given the verbal instruction of reproducing the target position as accurately as he can.

The subjects were reported to the tester when he fell he reached the target position. The subject was required to hold the final position for 3 seconds and then a hold button will be pressed so that the reproduced position was recorded. The test was repeated three times with a pre-adjusted rest period of 10 seconds in-between each trial. No verbal or visual feedback on accuracy was provided to the subjects[22,31,32].

The absolute error (AE) values about the 30° target position was recorded for the three trials done by each subject and then the mean deviation for each subject will be calculated[33]**.**

• **Absolute angular error**

will be recorded as the participant perceived the reference angle. The mean angular differences of the three trials, between the target angle position and the participant's perceived end range position will be recorded (in degrees) as the deficit in repositioning accuracy and will be used in statistical analysis[34]**.**

Fig. 1: Measurement at target angle (30^0)

Statistical Analysis

Numerical data were explored for normality by checking the distribution of data, calculating the mean, median and mode values, drawing histogram and box plot as well as using the tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Data -in addition to histogram and box plot drawing. Lumbar proprioception showed non-parametric distribution.

For parametric data (demographic data of the participants); independent t test was used. For non parametric data; MannWhitney test was used to compare between lumbar proprioception of the OA patient and normal subject. To test the association between lumbar proprioception and knee OA Spearman correlation was used. Numerical data presented as mean and standard deviation. Qualitative data were presented as frequencies (n) and percentages (%). Chi-square test was used for comparisons between males and females

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20.

The purpose of this study was to study the effect of chronic knee osteoarthritis on lumbar proprioception.

General Characteristics of the Subjects:

In this study, sixty subjects participated in the study. They were assigned into two groups (A and B).

Group (A) (Osteoarthritis group):

Thirty patients were included in this group. The data in **(Table 1)** represented their mean age (49.7±6.5) years, mean weight (88.9±13.86) kilograms (Kg), mean height (164.95±12.32) centimeters (cm), body mass index(BMI) 33.22±5.98(Kg/m^2) and duration of OA onset (20.33±12.3) (month).

Group (B) (Control group):

Thirty patients were included in this group. The data in **(Table 1)** represented their mean age (52.43± 4.7) years, mean weight (87.56±15.8) (Kg), mean height (160.69±7.07) (cm) and body mass index (34.60± 6.40) (Kg/m^2).

There was no significant difference between both groups concerning age, weight, height, BMI and sex as p values were (>0.05) as shown in table (1).

Table (1): Physical characteristics of patients in both groups (A and B).

Variables	Group (A)		Group (B)		Comparison		S
	Mean	± SD	Mean	± SD	t-value	P value	
Age (years)	49.7	**±6.5**	52.43	± 4.7	1.651	0.106	NS
Sex **Male (No/%)** **Female (No/%)**	(12/40%) (18/60%)		(10/33.3%) (20/66.7%)		0.287	0. 592	NS
Weight (Kg)	88.9	13.86	87.56	15.8	0.303	0.763	NS
Height (cm)	164.95	12.32	160.69	7.07		0.152	NS
BMI (Kg/m^2)	33.22	5.98	34.60	6.40	0.766	0.448	NS
Duration of OA. onset (month)	20.33	±12.3					

***SD: standard deviation, P: probability, S: significance, NS: non-significant.**

Lumbar repositioning accuracy (Absolute error):

(Table 2) and (Fig.2) demonstrated the lumbar repositioning accuracy (Absolute error) of groups (A and B). There was a significant difference between group (A) and (B) lumbar repositioning accuracy (Absolute error) as the mean value of group (A) was (8.73± 5.31) degree and for group (B) was (1.33±1.24) where the t-value was (5.795) and P-value was (<0.001).

Table (2): Mean and ±SD, Z and P values of lumbar repositioning accuracy (Absolute error) of both groups.

Lumbar repositioning accuracy (Absolute error)	Group (A)	Group (B)
Mean	8.73	1.33
SD	5.31	1.24
Mean Difference	7.4	
Z-value	5.795	
P-value	<0.001	
S	significant	

SD: standard deviation, P: probability, S: significance, S: significant, DF: degree of freedom

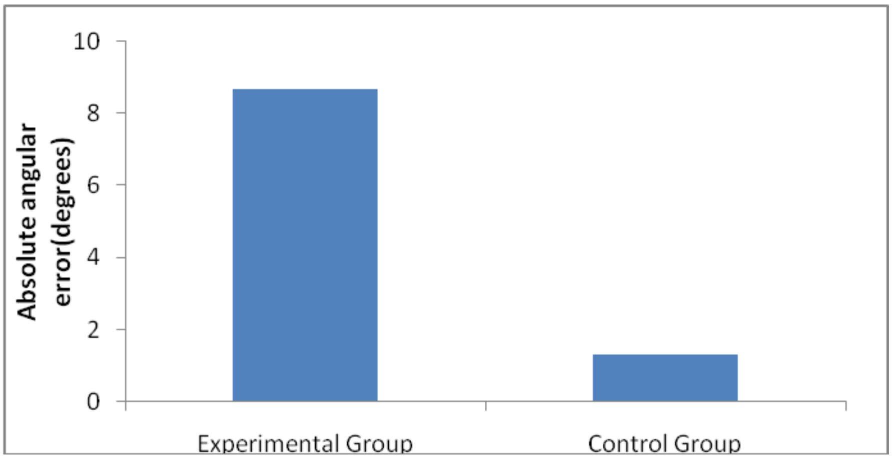

Fig. (1) Correlation between lumbar proprioception and knee OA

Discussion

Knowing that the human body is a multi-segmental series where all the segments act together in closed kinematic chain activities and any change in the alignment of one segment is associated with compensatory changes in the alignment of nearby segments and joints. So, this study was to examine the effect of knee osteoarthritis on lumbar proprioception in knee OA.

Patients with OA habitually walk more slowly, have shorter stride length[35,36,37], increased toe-out angle, have reduced knee range of motion[38], have increased knee extension angle at weight acceptance, greater knee and hip adduction moments, and increased axial loading in all lower extremity joints[3].

OA patients have biomechanical changes include increased mid-stance knee adduction moments, decreased peak knee flexion moments, decreased peak hip adduction moments, and decreased peak hip extension moments[39]. In addition, patients with knee OA demonstrated a significantly reduction of walking speed, shorter stride length, more prolonged stance phase of the gait, and slower stair walking time cycle. Analysis of the kinematic data of these patients showed that patients had a reduced range of motion at the hip, knee and ankle joints[40].

In symptomatic knee OA, there is quadriceps weakness, reduced knee proprioception, and increased postural sway. Pain and muscle strength may particularly influence postural sway[41].

Patients with knee osteoarthritis demonstrate an increase in knee range of motion at initial contact during level walking and stair descent, causes shifting the body line of gravity pass posterior to knee joint, this might cause anterior pelvic tilting which in turn increase the lumbar lordotic angle[42].

Understanding the relationship between a balanced pedal foundation and total postural health improves the effectiveness of individual case management. Forces of gravity work through the interrelated linkages of the feet, knees, and legs into the spine and pelvis. These forces also influence the patient's ability to respond to and maintain adjustments. The body functions as a closed kinetic chain, where movement at one joint influences movement at other joints. Knee osteoarthritis occurs in an estimated 44-70% of people over the age of 55 while in the over 75 age group. Many pelvic and spinal distortions can be traced to altered knee biomechanics[43].

Also, the results of the present work was consistent with [44] who stated that foot pronation can be used as an example to illustrate how alterations in its function can be followed by a series of biomechanical changes that produce a wide variety of signs and symptoms through the 69 interrelated structures and systems of the body. As the pronated foot presents with multiple site fixations that could include the posterior subtalar joint, the calcaneotalonavicular complex, the cuboid, ankle joint and the first ray. Weight will be borne on the medial structures and there will be an internal rotation of the entire lower extremity accompanied by an increase of the normal anterior pelvic inclination.

The second explanation might be related to quadriceps weakness and arthrogenous muscle inhibition which were reported in the patients with OA of the knee[45].

Patients with knee O.A demonstrate an increase in knee ROM at initial contact during both level walking and stair descent, the increased knee flexion at initial contact as observed generally in knee O.A patients when compared with the healthy elderly. So increase knee flexion cause shifting the bodyline of gravity pass posterior to the knee joint, this might cause anterior pelvic tilting which in turn increase the lumbar lordotic angle[42].

Furthermore, OA patients seem to adapt a gait pattern in an attempt to unload the affected structures during walking possible by changing moment at the adjacent ankle and / or hip, it is likely that the increase loading rate at the foot is transferred to some extent, to the joints proximal to the foot ground interface, if this is the case, then patients with knee OA may experience not only greater relative loads on the medial comportment of the knee, but also a more rapid increase in axial force at the ankle, knee and hip. A higher 70 loading rate at the tissue level may lead to the initiation or propagation of structure fissures in cartilage similar to that seen in OA cartilage, which may ultimately lead to a faster rate of progression of OA, thus secondary gait changes in patients with medial compartment knee OA may be associated with increased load not only on knee cartilage, but also on cartilage at the ankle and hip[3].

Moreover, the result of current study was supported by another study which reported that knee joint degeneration was compensated for in part by the pelvis and other joints in the lower limb. Reduced motion of the knee joint leads to increased pelvic motion, which should affect the natural mobility of the lumbar spine and cause pain in the lumbar region of the spine because of the existing kinematic interaction[20].

There are several explanations for exploring of the relationship between concurrent LBP or disorders and knee pain. There is closed kinetic relationship between the human knee and low back spine so that any dysfunction of this may result in trick motion and compensation, joint dysfunction and eventually pain in one or both countries. Thus, LBP could cause increased knee pain due to biomechanical interrelationship of knee joints and low back spine joints in the kinetic chain[46].

Patients with knee pain were 12 times more likely to have multiple joint problems. According to this study, conducted on 16222 individuals, isolated knee pathology accounted for only 1 in 11 patients with knee pain. Knee pain and LBP were second common joint combinations. In addition, individuals with knee pain were 3 times and individuals with knee and low back pain were 10 times more likely to have difficulty in standing and walking than those without knee disorders[47]**.**

Another study done by[48], 54.6% patients with knee pain reported LBP. Thus, LBP was prevalent among OA patients and was associated with clinically significant increase in pain[48]**.**

An association of anterior knee pain syndrome and sacroiliac joint dysfunction was studied in several fields. In a randomized, controlled, double-blind study, the effects of conservative lower back treatment in knee-extensor strength and muscle inhibition were measured in patients with anterior knee pain. In this study, 28 patients with anterior knee pain were randomly assigned into intervention and control groups. Intervention group which was treated conservatively with sacroiliac joint manipulation had significant improvement in knee a muscle activity[49]. It concluded that sacroiliac joint manipulation may be effective in improving knee pain by reducing hip joint impairments. However, we evaluated ROM of hips in the cases and the controls which have significant differences in most respects. A survey in 2003 showed that there was a relationship between lumbar lordosis and limited knee extension. In this study, 366 patients with LBP or knee pain were studied. Finally, it was concluded that the knee could lead to symptomatic lumbar degenerative changes (knee-spine syndrome)[50]**.** In our study, 33.3% cases and 25% controls had lumbar hyperlordosis. Nevertheless, the difference between these two groups was not significant statistically. Due to relatively high mean age (47 years), perhaps hyperlordosis was lost in some patients with aging[51]**.**

Low back disorders may be responsible in the development and/or progression of knee pain. Conversely, chronic and debilitating LBP can be due to the effects of knee pain and lower extremity impairments. The relationship between lumbar and knee pain disorders should be considered in the assessment and management of patients with knee pain[52]**.**

It is theorized that loss of joint sensation (proprioception) may cause small gait alterations, repetitive microtrauma and ultimately excessive joint loading[53]**.** Proprioceptive deficits at the ankle joint are predictors of ankle injury[54]**.** Impaired proprioceptive sense had effects on functional parameters such as impairment in walking rhythm, shortened distance of step, and decrease speed of walking[55]**.** So it is suggested that improvement of proprioception sense will improve the overall functional performance[56]. Diminished proprioception and evertor muscle weakness are possible causes of recurrent sprains of ankle[57,58]**.**

Quadriceps strength and proprioception are clearly important for balance control. They were compromised in subjects with knee OA. Increased postural sway in these subjects may be due to impairment in both or one of this parameter. The reason for this may be that proprioceptive input from ankle mechanoreceptors, muscle spindles, and the cutaneous receptors of the sole make an important contribution to the maintenance of static postural control[59], thus compensating for reduced knee proprioception during this assessment[60,61,62,63]**.**

The integrity of our sensorimotor systems is essential to affect a smooth, stable gait[64 ,65]**.** Proprioceptive acuity ensures accurate timing and placement of the lower limb at heel strike[66,67,68]**.**

Mechanoreceptors embedded within ankle ligaments believed to be responsible for providing a proprioceptive role in maintaining ankle joint stability. Proprioception which results from the afferent neural input originating from mechanoreceptors about the joint contributes to dynamic joint stability mechanisms and coordinated motor patterns[69].

Proprioceptive training is important in any comprehensive rehabilitation program. As proprioceptive deficits may predispose the subject to reinjure through, decrements in the inhibition of complete rehabilitation. As with respect to lower extremity, mechanoreceptor located within the joints are most functionally stimulated when the extremity is positioned in a closed kinetic chain orientation and perpendicular axial loading of the joint is permitted, these exercises should be performed at various positions throughout the full range of motion because of the difference in the afferent response, that has been observed at different joint positions[70]**.**

Training to enhance proprioception or muscle strength is effective in promoting joint stability and maintaining balance[71,72,73,74,75]**.**

The results of the current study provide scientific evidence of the effects of knee osteoarthritis on lumbar proprioception and they direct the attention of the physical therapists to evaluate the whole posture of the patient and don't focus their attention on the symptomatic area as postural knee alterations can produce and maintain far-reaching effects both in spinal and pelvic distortions and when these changes are overlooked, symptoms referred to other parts of the body continue because their cause, being in the knee, has failed to be properly diagnosed and removed. Lumbar proprioception training should be added to the rehabilitation program of knee osteoarthritis.

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