Original Article

Effect of lateral wedged foot insole on Knee Proprioception in Knee Osteoarthritis

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ABSTRACT

Background and Objective: Knee osteoarthritis (OA) is known as a degenerative joint disease, characterized by joint pain and stiffness. Proprioception declines with articular disease such as OA. Impaired proprioception at the knee joint may affect the correct perception of the knee joint position and movement, which in turn affects the inter-joint coordination of the knee with other joints. This study aimed to investigate the effect of lateral wedged foot insole on knee proprioception accuracy in medical knee osteoarthritis (MKOA). Subjects: Thirty patients from both sexes were assigned randomly into 2 equal groups participated in the study. Group A, fifteen patients with mean age 46.57±6.04 years, mean weight 83.92±5.07 kg, mean height 160.42±2.84 cm and mean body mass index (BMI) 31.28±2.84 kg/m2. Group B, fifteen patients with mean age 47.54±9.39 years, mean weight 82.9±10.27 Kg, mean height 165.36±7.01 cm and mean BMI 30±5.11 Kg/m2. Method: Measurements of proprioception accuracy of knee before and immediately after finishing three months of treatments were conducted for each participant. Group A received conventional treatment program for three months and group B received the same conventional treatment program combined with wearing 5° laterally wedged insoles. Results: There was significant improvement in knee proprioception accuracy in group B where P-value was 0.013 but there was no significant improvement in group A where P-value was 0.894.On the other hand there was significant difference in post treatment between groups where P-value was 0.002 and this significant reduction in favor to group B than group A. Conclusion: It was concluded that using the laterally wedged insole together with the conventional treatment program proves to be more beneficial than using the conventional treatment program only.

Keywords: Knee Osteoarthritis, Proprioception, laterally wedged insole.

Introduction

Osteoarthritis (OA) is known as a degenerative joint disease, associated with joint pain, stiffness and disability [1-3]. The International Association for the study of pain (IASP) defines pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage [37]. The knee is the most common weight-bearing joint of the lower limb site for OA. Nowadays, due to better health care system which leads to increase ageing society as well as the sedentary lifestyle that leads to increase obesity epidemic in our population, the prevalence of osteoarthritis is increasing [36]. Some factors also facilitate the creation of knee osteoarthritis, including obesity, strike, rupture of knee joint elements (such as meniscus, ligaments and joint capsule), diseases cause softening of the cartilage under the patella and its frequent dislocation and knee joint deformities [38]. The medial tibiofemoral compartment is the most commonly affected

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and the incidence of the disease is 5 to 10 times more than the lateral compartment [4-7].

This difference in the incidence between the medial and the lateral compartment due to the difference in biomechanical loading between both sides that, the medial tibiofemoral compartment exposed to 60% of loading during walking [7-9].

Women are more exposed to knee OA than men and degenerative process increases with age. Difficulties in maintaining an independent life and impairment in physical functions are the main disorders with degenerative knee OA [3, 10].

Proprioception deficits, decrease number of mechanoreceptors and weakness of quadriceps are present with knee OA patients when compared with healthy one and these indicated that degenerative OA affect not only intracapsular tissues but also periarticular tissues, such as ligaments, articular capsules, muscles, and tendons [3, 11-13].

Sensory proprioceptive input and motor response are considered as a major factor in joint protection. Proprioception has two aspects of position sense; static (ligament, capsule, articular surface geometry) and dynamic neuromuscular systems and so has a role to protect the joint during static and dynamic activities [14].

Degenerative knee OA may result from disorders of protective neuromuscular reflexes that may lead to change of load distribution across the articular surface. Also degenerative OA process may be due to disruption of static restraints as muscle, ligament, capsule and tendon mechanoreceptors [7, 15].

As a result, and combined with the fact that medial compartment knee OA is common [7, 9]. Research is now interested in interventions that reduce the symptoms and control degenerative process of medial knee OA [16].

Laterally wedged insoles (LWI) are orthotic devices placed within the shoes that have been recommended to manage medial knee OA (MKOA) [17].

Laterally wedged insoles are hypothesized to reduce the moment arm of the ground reaction force (GRF) vector relative to the knee joint centre during walking [18], and most biomechanical analyses investigated that lateral wedges can improve poor load distribution and misalignment in MKOA by shifting the load away from the medial component of the knee and reducing the peak adduction moment in patients with MKOA by approximately 5-10% [18-21].

Degenerative knee OA patients show degradation and declines of proprioception [3]. Laterally wedged insoles are orthotic devices placed within the shoes that have been recommended to manage MKOA but not determined if lateral wedged insole has an effect on Proprioception accuracy or not. So this study aimed to investigate the effect of lateral wedged foot insole on knee proprioception accuracy in MKOA.

Materials and Methods

Design of the Study

This study was conducted in the Faculty of Physical Therapy, Cairo University during March 2016 through march 2018. Assessment procedures were conducted in the isokinetic analysis laboratory and the treatment procedures were conducted in the outpatient clinic of the Faculty of Physical Therapy, Cairo University, Egypt. The Purpose of this Study was to investigate the effect of the lateral wedged insole on knee proprioception accuracy in patients with MKOA.

Subjects

Thirty subjects were randomly assigned in two groups. The study design was a randomized controlled trial, two groups pre-post test design**.** Each patient was assessed pre and post 3 months for measurement of proprioception accuracy. Measurements of proprioception accuracy were in the form of active reproduction of active positioning test (Absolute error) by using Biodex System 3 Pro Isokinetic Dynamometer (Biodex Medical Inc., Shirley, New York, USA).

The participants number were determined by power analysis. Sixty-five community volunteers were recruited into the study from orthopedic clinics, physiotherapy clinics, and advertisements. Diagnosis was based on clinical and radiographic criteria and radiographs were read by an experienced academically based musculoskeletal radiologist. After assessment there were forty-five participants had MKOA and indicated for the study but only thirty patients (four males and twenty-six females) completed the study and tests due to limitations during the study as following: 1- Biodex System 3 Pro Isokinetic Dynamometer was disabled for more than 6 months and needs maintenance so all protocols have been discontinued until maintenance. 2- After the maintenance there were many protocols late and it was necessary to wait for the role of our protocol with the existence of one responsible or supervisor for the follow-up of all protocols. Continuing of the study was difficult and very slow. 3- The proprioception accuracy measurements of the knee were supposed to be measured three times (pretreatment, immediately after one month of the treatment and immediately post three months of the treatment) but according to problems and delays in the Isokinetic lab, they were measured pretreatment and immediately post three months of the treatment only. 4- Also, the number of patients has decreased due to the irregularity of time in measurements with different social conditions of participants and nearly twelve patients have finished the therapeutic program of treatment without measurements during the maintenance and the rest apologized for continuing due to their social conditions.

All participants signed informed consent and were randomly assigned into two groups. Group A: Fifteen patients, received conventional treatment program three times per week for three months. Group B: Fifteen patients, received conventional treatment with worn 5° lateral wedged foot insole three times per week for three months.

Participants in this study, were selected according to the following criteria: Age ranged from 40 to 60 years old, subjects having MKOA diagnosed by orthopedists and radiologists, duration of illness more than three months, grade 2-3 OA according to Kellgren and Lawrence scores [22] and body mass index ≤ 35. Also, they were excluded according to the following criteria: Use of a gait aid, lateral tibiofemoral compartment joint space narrowing greater than medial, body mass index ≥ 36 kg/m^{2}., hip or knee replacement; knee surgery or injection (past 6 months), use of insoles or foot orthotics (past 6 months) and foot or ankle problem precluding use of insoles and footwear incompatible with insoles [7, 16].

Instrumentations & Tools

Instrumentations used for assessment

1. Weight and height scale

   Calibrated floor scale ZT-120 model, Health scale was used to determine the weight of each subject in kilograms and height in centimeters to determine body mass index for each subject. Before each measurement, a known weight was applied to the scale for its calibration procedure.
2. Biodex System 3 Pro Isokinetic Dynamometer (Biodex Medical Inc., Shirley, New York, USA).

   Isokinetic Dynamometer was exposed to many studies to investigate its validity and reliability, the results of these studies showed that Biodex System 3 Pro Isokinetic is valid and reliable measure that used to obtain different variables as torque, peak moment, angle of peak torque, ROM, and angular position which was used for measurement of proprioception accuracy in the form of active or passive positioning test (angular error) [23-25]. Isokinetic dynamometry is a method of quantitative myometry that uses hydraulic or electro-magnetic instrument to impose constant velocity movement at preset angular velocities. The basic parts of the isokinetic dynamometer are: Force acceptance unit: Interface between the subject and the system, Lever arm: converts the force signal into an electrical signal, Load cell: provides the base for the force acceptance unit and about a fixed axis, Hand assembly: houses the motor responsible for the motion of the lever arm, Seat or plinth: positions the subject with independent vertical and horizontal alignment options, Control unit: consists of personal computer and its associated peripheral equipment, Specific attachments: for various applications of the anatomical joints [26].

Tools used for treatment

1. Laterally wedged insoles

   Based on Kerrigan et al and Bennell et al [16, 19] whom determined the criteria for the insoles to be: Insoles were wedged 5° (as more than 5° not comfortable for foot), were worn inside the participant's own shoes, were wedged along the lateral edge of the entire length of the foot, were thinner at the instep and thicker at the outer edge of the foot. Insoles were used in this study were made of high density polyform material with its basic components of Pedilin material. Insoles were covered with leather sheets on both sides to be easier and comfortable during motion Figure (1) [27]. They were manufactured by a certified prothetist-orthotist specialist.

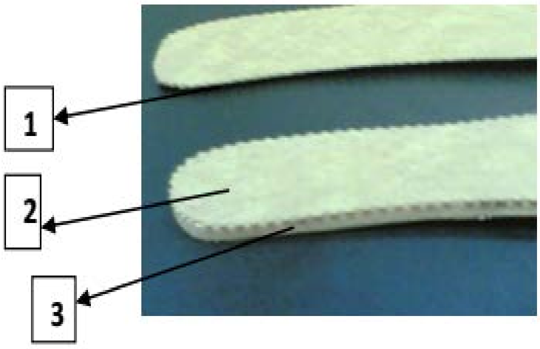

Figure 1: Lateral view of lateral wedged of foot insole. 1- Inner and thinner side of the insole. 2- layer of leather. 3- Outer and thicker side was made of polyform material (6 mm wedged sheets of pedilin)

2. Ultrasonic apparatus: (Digisonic, Chung Woo Medical (CWM) 302 made in Korea).

Interventions which delivered mechanical vibration using an ultrasound device at frequencies between 1.0–3.0 MHz. Criteria for optimal dose: intensity 0.1–3 W/cm2, continuous or pulsed output, treatment time 5 minutes [28].

Procedure

Assessment procedures

Each subject was informed about the procedures, the purpose of the study, demonstration on equipments and any question was answered. Personal data (name, age, address, telephone number) were recorded. Weight and height were measured using the health scale. Subjects in both groups were asked about; Duration of arthritic process, history of pain and any disorders of associated area. The knee joint was examined 1stly and refered from orthopedist or radiologist, radiographs were done from weight bearing position (standing position) and were read by an experienced academically based musculoskeletal radiologist then measurement of proprioception accuracy by using isokinetic dynamometer.

Measurement Procedures

Measurements of proprioception accuracy were recorded twice (Pretest measurement and Posttest measurement) by using Biodex System 3 Pro Isokinetic Dynamometer.

Pretest measurement:

Proprioception accuracy was measured in both groups by using the active reproduction of active positioning test (ARAP). Caliberation of dynamometer was performed according to the specifications outlined by the manufacturer service manual. Instructions were given to each subject about isokinetic equipment and the study prior to test.

Preparation of testing procedure:

According to the manufacturer of the device: The dynamometer and chair rotation were adjusted to zero degree, the dynamometer tilting was adjusted to zero degree, the chair dynamometer and the arm rest height were adjusted according to the height of each subject.

Starting position:

From sitting position, the subject was blind folded and the legs allowed to hang free of the end of the couch. Thus the tested knee was in a starting angle of 90 degrees' flexion without any effort by the subject. Target angle was set at 30 degree of knee flexion. Two straps were wrapped around the extremity proximal to the patella and the pelvis to minimize movement of the trunk and hip during testing which could interfere with knee measurements.

The testing procedure:

The subject was instructed to slowly straighten their knees and was told to stop at 30 degrees of knee flexion. Was asked to maintain and mentally visualize the position of their knee for 5 seconds, and then they were told to relax allowing their leg to hang freely. After 3 seconds, patient was asked to reproduce the test angle actively while his eye was closed. The reproduced angle was recorded. The difference between the test angle and the reproduced angle was recorded (absolute angular error). The procedure was repeated for 3 trials and recorded. The mean of angular error was calculated [29].

Posttest measurement:

- Also the previous pretest measurement procedure was repeated immediately post three months of the treatment and the results between pre, and post three months were statistically compared.

Treatment Procedures

Thirty patients with MKOA were randomly assigned into two groups with 15 patients in each group. Group A received 36 sessions of conventional physical therapy program (3 sessions per week for 3 months) [29]. Group B received the same conventional physical therapy program (3 sessions per week for 3 months) combined with the insertion of 5° inclination laterally wedged insole in the footwear of the affected leg). Conventional program of treatment in the form of: I-Pulsed ultrasonic therapy, 1 MHz frequency and 1.5 watt/cm2 power for 5 minutes to the medial side of the knee. Acoustic gel will be used as an active medium [29]. II- Therapeutic exercise program in the form of: Stretching exercise of the hamstring muscles from supine lying position for 3 times, 30 seconds each**.** Stretching exercise of the calf muscles from supine lying position for 3 times, 30 seconds each. Flexion straight leg raise (SLR) exercise in which patients were positioned in the half crook lying positions with the unexercised limb was the flexed one then the patients were asked to contract the quadriceps muscle and elevate the limb to 45° and hold for 6 seconds, slowly lower the limb and then relax for 6 seconds, 3 sets of 5 repetitions were done. Abduction SLR exercise from sidlying position with the sound limb was the lower one. The sound leg was flexed 45 degrees in hip joint and 90 degrees in the knee. The affected limb was extended and body weight was shifted forward. The subject was instructed to lift the affected limb upward, hold for 6 seconds, slowly lower it, and then relax 6 seconds. Three sets of 5 repetitions were done. Extension SLR exercise from prone lying position, the subject was instructed to keep his affected knee in extension and extend the hip as much as possible, hold for 6 seconds, slowly lower it then relax for 6 seconds. Three sets of 5 repetitions were done. The program of treatment was repeated 3 times/week for a period of 3 months and patients were instructed to follow up therapeutic exercises program at home [28, 30]. III- Lateral wedged foot insole**:** All patients in the group (B) were received the previous program of the treatment in addition to wear 5° lateral wedged foot insole in the tested leg. They were given insoles after the pretest measurement and instructed to wear them every day as much as they could. They were allowed to move insoles between the shoes to make sure that they were worn as long as possible [30]. Insoles were worn from 6-8 hours per day through 3 months of the treatment [31, 32].

Data collection

The data was collected from: Personal data sheet that included patients' age (years), weights (kg), height (cm), sex (male or female) and BMI (kg/m^2). Measurements of Knee repositioning accuracy (Absolute error) by Biodex System 3 Pro Isokinetic Dynamometer and data was collected before and immediately post three months of the treatment.

Statistical analysis

Statistical analysis was conducted using SPSS for windows, version 22 (SPSS, Inc., Chicago, IL).

Descriptive statistics (Parametric analysis) Was used to calculate the mean and standard deviation for the age in years, weight in kg, height in cm, BMI and proprioception accuracy in degree for each group.

Inferential statistics (Parametric analysis) in the form of:

Paired t-test

-Was used to study statistical significance difference measurements within group.

Unpaired t- test

-Was used to study statistical significance difference measurements between groups.

Level of significance

All statistically significant was set at p≤ 0.05 with a confidence interval of 95%.

Results

The purpose of this study was to investigate the effect of the lateral wedged insole on knee proprioception accuracy in patients with MKOA. The current test involved two independent variables. The first one was the (tested group); between subject's factor which had two levels (group A received conventional treatment program and group B received conventional treatment with worn lateral wedged foot insole). The second one was the (measuring periods); within subject factor which had two levels (pretreatment, post three months of treatment). In addition, this test involved one tested dependent variables (knee repositioning accuracy (Absolute error)). Accordingly, "paired t- test" was used to compare between pre and post tests for each dependent variables for each group. "Unpaired t- test" was conducted to compare dependent variables between both groups with the alpha level 0.05. There were no outliers in the data, as assessed by inspection of a boxplot. knee repositioning accuracy for each level of group were normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.05$), and there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.05$).

General Characteristics

The current study was conducted on thirty participants (twenty-six females and four males). They were randomly assigned into two equal groups. Group A consisted of fifteen female participants with mean age, body weight, height and BMI values of 46.57±6.04 years, 83.92±5.07 kg, 160.42±2.84 cm and 31.28±2.84 kg/m^2 respectively. Group B consisted of fifteen participants (eleven females and four males) with mean age, body weight, height and BMI values of 47.54±9.39 years, 82.9±10.27 kg, 165.36±7.01 cm and 30±5.11 Kg/m^2 respectively. As indicated by the independent t- test, there were no significant differences ($p>0.05$) in the mean values of age, body weight, height and BMI between tested groups (Table 1).

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

Items	Group A	Group B	Comparison		S
	Mean ± SD	Mean ± SD	t-value	P-value	
Age (years)	46.57±6.04	47.54±9.39	-0.315	0.756	NS
Body weight (Kg)	83.92±5.07	82.9±10.27	0.326	0.748	NS
Height (cm)	160.42±2.84	165.36±7.01	-2.402	0.50	NS
BMI (kg/m^2)	31.28±2.84	30±5.11	-0.117	0.432	NS

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

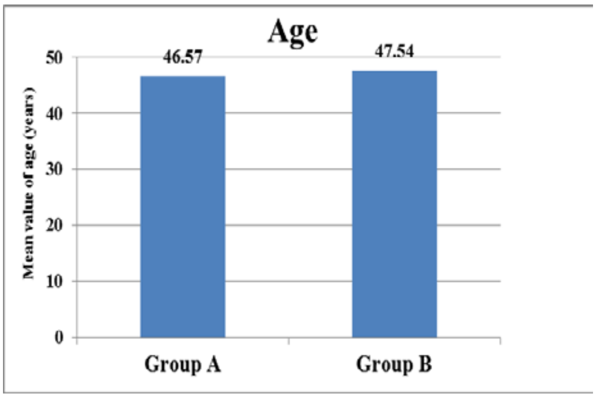

Figure 2: Mean values of age between groups

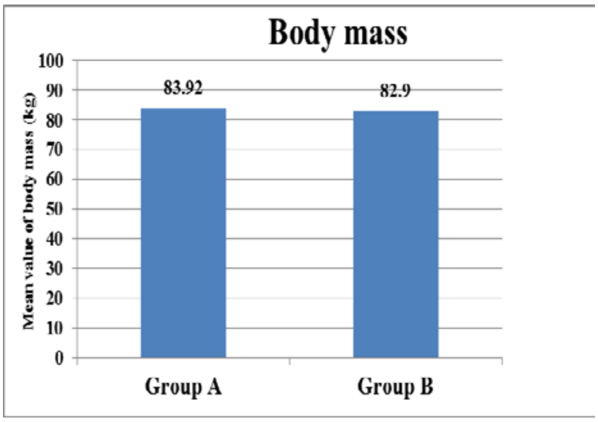

Figure 3: Mean values of body weight between groups

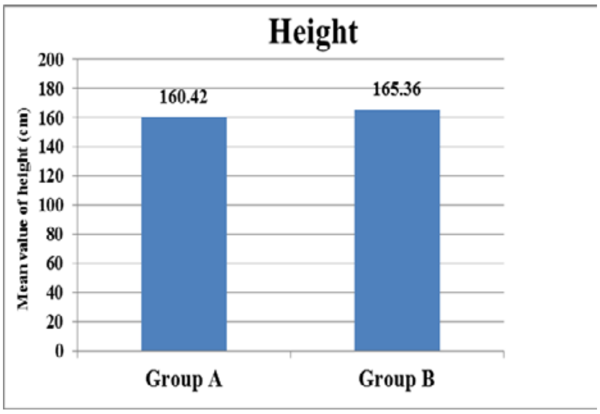

Figure 4: Mean values of height between groups.

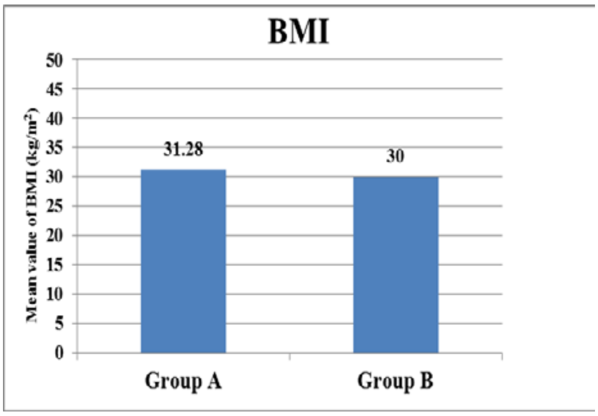

Figure 5: Mean values of BMI between groups.

Paired and unpaired t- test

Knee repositioning accuracy (Absolute error)

1. Within groups

As presented in table (2) and illustrated in figure (6), within group's comparison the mean ± SD values of Knee repositioning accuracy (Absolute error) in the pre and post tests were 5.53±2.8 and 5.15 ±2.4 respectively in the group A. Paired t-test revealed that there was no significant difference of Knee repositioning accuracy (Absolute error) at post treatment in compared with pretreatment where their t-value was -0.137 and P-values was 0.894. While, the mean ± SD values of Knee repositioning accuracy (Absolute error) in the pre and post tests were 5.09 ±3 and 1.83±.44 respectively in the group B. Paired t- test revealed that there was significant reduction of Knee repositioning accuracy (Absolute error) at post treatment in compared with pretreatment where their t and P-values were 3.283 and 0.013 respectively.

2. Between groups

Considering the effect of the tested group (first independent variable) on Knee repositioning accuracy (Absolute error), unpaired t- test revealed that the mean values of the pretest between both groups showed no significant differences with their t and P-values were 0.376 and 0.71respectively. AS well as, unpaired t- test revealed that there was significant difference of the mean values of the posttest between both groups with their t and P-values were 3.72 and 0.002 respectively and this significant reduction in favor to group B than group A.

Table 2: Mean ±SD and p values of Knee repositioning accuracy (Absolute error) pre and post test at both groups.

Knee repositioning accuracy (Absolute error)	Pre test	Post test	MD	% of change	t-value	p- value
	Mean± SD	Mean± SD				
Group A	5.53±2.8	5.15 ±2.42	0.38	6.87	-0.137	0.894
Group B	5.09 ±3	1.83±.44	3.26	64.04	3.283	0.013*
MD	0.44	3.31				
t-value	0.376	3.72				
p- value	0.71	0.002*				

Significant level is set at alpha level <0.05 SD: standard deviation MD: Mean difference p-value: probability value

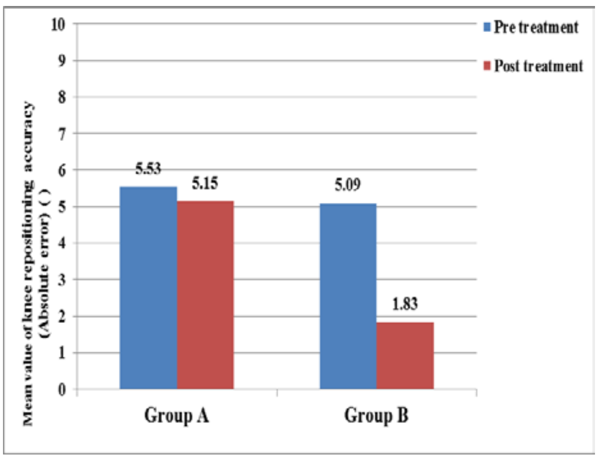

Figure 6: Mean values of Knee repositioning accuracy (Absolute error) pre and post tests in each group.

Discussion

The purpose of this study was to investigate the effect of the lateral wedged insole on knee proprioception accuracy in patients with MKOA. The study was conducted on 30 patients referred from an orthopedic surgeon with diagnosis of medial compartment knee OA. Their age ranged from 40-65 years and they were randomly assigned into two groups; group A which was consisted of 15 patients who received conventional treatment program only and group B which was consisted of 15 patients who received conventional treatment program combined with laterally wedged insoles which were placed in their footwear for 3 months.

All previous studies on LWI in knee OA discussed effects of LWI on symptoms and disease progression in MKOA as pain, physical function, adduction moment and health-related quality-of-life but according to the available research, this study was the first to investigate an effect of LWI on proprioception accuracy in MKOA. So, it was compared between results of previous studies on symptoms and disease progression that were considered as reasons of proprioception impairment with proprioception accuracy in this study. This study designed to answer the following questions:

Is LWI has an effect on knee proprioception accuracy in patients with MKOA?

Which method is more effective on knee proprioception accuracy, conventional treatment or the conventional treatment combined with LWI?

Knee repositioning accuracy (Absolute error) was measured and statistically analyzed in an effort to answer the previous questions. Initially there was no significante difference between groups by using unpaired t test that P-value was 0.71 ($p>0.05$). Paired t- test revealed that there was no significant difference of Knee repositioning accuracy (Absolute error) at post treatment compared with pretreatment in group A Where P-value was 0.894 ($p>0.05$). While, it revealed that there was significant reduction of Knee repositioning accuracy (Absolute error) at post treatment in compare to pretreatment in group B where P-value was 0.013 ($p<0.05$). Also, unpaired t test revealed that there was significant difference of the mean values of the posttest between both groups with P-value was 0.002 ($p< 0.05$) and this significant reduction in favor to group B than group A.

According to Taesung et al. [3] and Aigner et al. [33] that degenerative knee OA associated with pain, weakening of the quadrecipes, decrease in joint position sense, degradation of functional performance and a as a result degradation of proprioception. So, when pain level and physical functions significantly improved proprioception impairement should be improved as a result of improvement of pain and physical functons and vice versa.

Therefore, the current study confirms this expectation of improved proprioception accuracy due to improved pain and physical function and were in agreement with the result of Fang et al. [34] that found significant improvements in all three WOMAC subscales (pain, stiffness and physical function) and pain scores were significantly reduced especially for the most challenging activity (going up or down stairs) in OA patients were treated with lateral wedged foot insole. And also in agreement with Hinman et al. [21] whom demonstrated that laterally wedged insoles resulted in an immediate reduction in walking pain and knee adduction moment. As a result, and combined with the effect of lateral wedged foot insole on reduction in pain level and improvement in physical functions might be a reason for a significant improvements in propriocepion accuracy.

Furthermore, findings of the current study were in agreement with most biomechanical analyses which demonstrate that lateral wedges can reduce the peak adduction moment in patients with knee OA by approximately 5-10% and helps by correcting the malalignment and shifting the load away from the medial component of the knee [18-21]. So, when the adduction moment decreased and the malalignement corrected the perception of the knee joint position and movement might be improved, which in turn improves the impaired knee proprioception [35].

Conclusion

Based on the findings of the current study, it was concluded that using the laterally wedged insole together with the conventional treatment program was considered to be more beneficial and better than using the conventional treatment program alone in treatment of MKOA owing to the significant improvement in measurements of proprioception accuracy.

Recommendations

It is recommended to:

1- Replicate this study using the same treatment program for a longer period of time and a larger sample.
2- Investigate the effects of lateral wedged foot insole on plantar pressure distribution.
3- Investigate the effects of medially wedged insole in treatment of lateral compartment OA knee.

Investigate the effects of lateral wedged foot insole on degenerative process of MKOA.

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