Effectiveness of Dynamic Proprioceptive Exercises and Plyometric Training on Joint Position Sense Using Wireless Motion Sensors in Unilateral Knee Osteoarthritis Subjects

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Abstract. Osteoarthritis (OA) is an all-encompassing, broadly prevalent illness that mostly affects the knee joint. It is a complex progressive disorder leading to loss of articular cartilage, joint space reduction, pain, function loss, and physical incapacity causing deterioration in quality of life. In today's era with technological advancements artificial intelligence powered devices can be helpful in evaluating symptoms and functional outcomes of osteoarthritis knee. Various physiotherapeutic interventions have showed significant improvement in symptom management but this study focuses on the proprioceptive Plyometric exercise to enhance osteoarthritis patients' awareness of joint position. The study had 40 participants with unilateral osteoarthritis in their knees, who were allocated into two groups: group A (n=20) received dynamic proprioceptive exercise, while group B (n=20) received plyometric training for four weeks.Both results for finding out joint position sense was carried out by Orthyo® system sensors and Both the groups showed improvement in intervention when compared to the baseline values. However, compared to dynamic proprioceptive activities, plyometric training demonstrated a greater enhancement in joint position sensing. Dynamic proprioceptive exercises were shown to be less effective than plyometric training. The use of wireless motion sensors proved to be helpful in evaluating and monitoring joint position sense among knee osteoarthritis subjects.

Keywords: Plyometric exercise, Knee osteoarthritis, Artificial intelligence.

1 Introduction

Osteoarthritis is a degenerative, irreversible disease that results in impairment in joint, proprioceptive abnormalities, joint stiffness, and persistent pain. Osteoarthritis being a progressive disorder particularly affecting weight bearing joints, makes the knee joint the most common to get affected. Knee osteoarthritis can be defined as degenerative joint disease resulting due to wear and tear and progressive loss of articular cartilage

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[1]. Dehydration and the deterioration of intra articular and per articular structures are pathophysiological alterations associated with osteoarthritis. This, in turn, induces mechanoreceptor distraction, which results in a reduction in both static and dynamic kinaesthetic sensibility.Pain, lower limb muscle weakness and functional decline may directly or indirectly be related to proprioceptive defect in knee [2]. The most popular test for knee joint proprioception is the joint position sense test, though there are other ways to assess proprioception as well. Goniometers are the typical instruments that are used generally but for greater accuracy, effectiveness and easy administration devices using inertial sensors can be used to evaluate joint position sense. With the help of artificial intelligence (AI) these devices through software's are directly connected to applications in the phone where then progress and reports can be monitored anywhere at any time [5].

Limitations of stability, postural control, and knee proprioception are important variables that can greatly contribute to impairment, disability, and falls in osteoarthritis, therefore physiotherapy interventions can play a major role in improving joint position sense. It may be necessary to use specific strategies, such as proprioceptive training, plyometrics, weight bearing exercises etc to tailor the therapeutic program for patients with osteoarthritis. Recent research indicates that proprioceptive training enhances muscle strength, balance, static and dynamic posture, and everyday function. Proprioceptive exercises focus on training the afferent pathways to increase the sense of movement to enhance proper performance of complicated movements without any difficulty [3].Plyometric exercises have been shown to benefit in neuromuscular characteristics, balance, and joint awareness. It helps to facilitate neural adaptations which would help enhance proprioception, kinaesthesia, and muscle performance [4]. One of the study focuses to find out the effectiveness of dynamic joint proprioception exercises and plyometrics on knee proprioception in subjects with osteoarthritis, using motion sensors that are coupled with mobile application to evaluate joint position sense of knee

2 Methods

This comparative study aimed to assess the efficacy of dynamic proprioceptive exercises against plyometrics in enhancing joint position sensing in individuals with unilateral osteoarthritis of the knee. 40 subjects were recruited at random from Saveetha Medical College and Hospital based on the inclusion and exclusion criteria.

2.1 Inclusion Criteria

Participants with unilateral arthritic knees aged 25 to 50 years, both male and female, were included.

2.2 Exclusion Criteria

Patients with one or more joint complaints, polyarthritis, rheumatoid arthritis, or other systemic inflammatory arthropathies, knee arthroplasty surgery, or an intraarticular corticosteroid injection given in either knee during the last three months were excluded.

2.3. Outcomes measures

Primary outcome: wireless motion sensors

3 Procedure

The subjects were divided into two groups and the detailed procedure for performing the test was explained to the subjects Group A received dynamic proprioceptive exercises while group B were given plyometrics for 4 weeks respectively. Informed consent from the subjects were taken before commencement of interventions. The pre and post test for evaluating joint proprioception was executed by the Orthyo® system sensors [6] to evaluate proprioception of knee joint at the start and end of 4 weeks. Before the test was administered, the subjects were enrolled in the web panel. Four sensors were implanted on the lower limb, with one mounted to the lateral side of the thigh, and another on the greater trochanter which is placed 15 cm distally.[6]. The sensors were linked to the mobile software installed on a mobile device equipped with the Android 5.0 Lollipop operating system. The smartphone was paired to the sensors using Bluetooth via the above mentioned application. The knee proprioception was tested based on the subject's potential to recreate a target knee joint position without visual modality. Testing position of the subject was prone lying, and the testing knee was flexed passively to 60°. The individual was instructed to keep this position for five seconds before extending the knee. The individual repeated the process, consciously recreating the target joint position and holding it for two seconds. The terminal angle was recorded by the application. A group A received dynamic proprioceptive exercise in which this group contained one leg balance, blind advanced one leg balance, cross body leg swing, and toe walking [11]. Exercises were given for 30 minutes a day for 5 days a week for 4 weeks. The subject is asked to stand straight and bend one leg at the knee to lift the foot behind. Balance needs to be maintained on the foot placed on the ground for 1 minute. After 20 to 30 seconds of relaxation, the same needs to be repeated with the other leg. 3 sets need to be performed. The exercise which is called blind advanced one leg balance is like a balance training in doing standing straight and bend one leg at the knee to lift the foot behind with the eyes closed. Balance needs to be maintained on the foot placed on the ground for 1 minute. After 20 to 30 seconds of relaxation, the same needs to be repeated with the other leg. 3 sets need to be performed. The cross body leg swing exercises in which the subject is asked to stand with support for help while the weight bearing is on the affected leg, and is asked to swing the other leg for several times. The same is said to be performed with the weight bearing over the unaffected leg. 15 repetitions and 3 sets need to be performed with each leg respectively. Toe walking is also given for 20 m for 30 minutes.

The group B received plyometric exercise which includes drop and freeze, 30 second box drill, lateral step-up jump, forward step up and jump [13]. Exercises were given for 30 minutes a day for 5 days a week for 4 weeks. Each exercise were given for 3 sets and 10 reps. the drop and freeze was done by instructing the participant to place both feet on the box's edge while standing on a platform or box. The toe was stretched over the box's edge and one foot was lifted. The participant was instructed to jump or drop with the other leg, landing on both feet and stopping further descent. The 30-second box drill performed by The person was told to stand at the side of the box, feet shoulder-width apart, leap on it, and land on the other side of the floor. This was requested to continue for the stated amount of touches, with each touch counting as one.30 touches have to be accomplished in 30 seconds. The lateral step-up jump was made to position

the left foot in the centre of the boxand leap over to the opposite side, landing with the right foot on the roof and the left foot on the ground.

4 Results and statistical analysis

Based on the statistical data collected both the interventional groups show statistical significance, but the group that underwent plyometrics showed greater significance statistically as well as in improving joint position sense compared to dynamic proprioceptive exercises. Table 1 shows Comparison of joint position sense between experimental group in pre and post test and Table 2. Comparison of joint position sense between control group in pre and post test. When comparing the both groups, the p value (0.0310) obtained from the unpaired t test revealed statistical significance ($p < 0.05$). The outcome measures were assessed and presented as means. To analyze statistical differences, both groups used the paired t test .The significance level is set to 5%, with a p-value less than 0.05 and a 95% confidence interval. Statistical significance among both the groups post-test was carried out by unpaired t test. The confidence interval was set as 95% and p value less than 0.05 was considered as significant. The p value obtained was 0.0310 and this difference is considered statistically significant. Fig.1 shows Post values between groups.

Table 1. Comparison of joint position sense between experimental group in pre and post test.

DYNAMIC PROPRIOCEPTIVE EXERCISE (GROUP A)					
Sr. No	Outcome	Pre test (Mean in degrees)	Post test (Mean in degrees)	t value	Level of Significance
1.	Joint Position Sense of Knee	65.125	63.770	2.4255	P value = 0.0254

Table 2. Comparison of joint position sense between control group in pre and post test.

PLYOMETRICS (GROUP B)					
Sr. No	Outcome	Pre test (Mean)	Post test (Mean)	t value	Level of Significance
1.	Joint Position Sense of Knee	63.305	60.105	5.0234	P value = < 0.0001

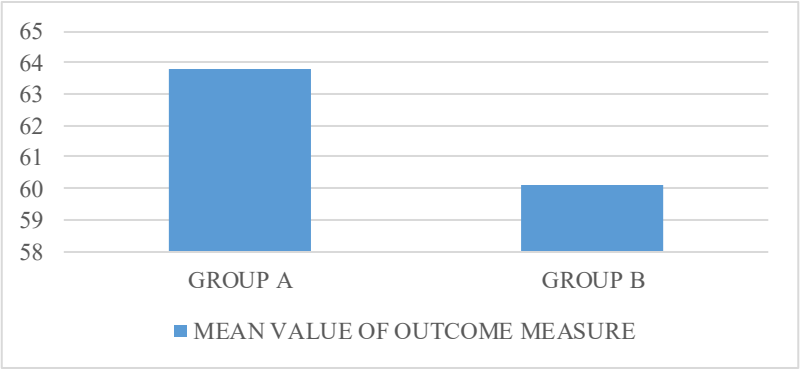

Fig.1. Post values between groups.

5 Discussion

The purpose is to determine the effectiveness among dynamic proprioceptive exercises and plyometrics on improving joint position sense in unilateral osteoarthritis knee patients. Based on physiotherapy therapies, the study by Jagoda et al. (2020) found that Orthyo® wireless motion sensors were beneficial for patients with osteoarthritis in their knees. The sensors were utilized to analyze joint position sense through a proprioceptive test, and the results obtained were accurate and dependable, making it a verification tool. In the present study these motion sensors were used to evaluate joint position sense among unilateral osteoarthritis knee patients.

Toby et al, 2012 conducted a meta-analysis which showed that when compared to general strengthening exercises and non-proprioceptive exercises, proprioceptive exercises showed greater results in improving joint position sense and functional outcome in osteoarthritis knee patients [7]. According to a study done by Raana et al, 2019 it was concluded that plyometric training was effective in female badminton players. In the current study both dynamic proprioceptive exercises and plyometrics showed improvement in knee joint position sense but plyometrics showed greater effectiveness compared to proprioceptive exercises.S

Tomas Vetrovsky et al,2018 concluded that plyometric exercise might be seen as a practical and secure substitute for conventional strength training, particularly when the goal of supervised training is to improve a person's dynamic neuromuscular performance [8].

Sana Naq et al, 2021 concluded that both proprioceptive and isometric workouts significantly improvement in the knee osteoarthritis. No severity rating was applied to the participants. The only metrics used to compare the efficacy of the exercises were knee range of motion and visual analog scale [9]. Kamya Somaiya et al 2023 concluded that the impacts of low-intensity plyometric exercises and eccentric training regimens on function, strength, and discomfort in individuals with are first two graded OA patients. In order to help persons with knee OA feel better physically and function better, we will develop a plyometric exercise regimen through this study. For these patients, these training programs in addition to conventional exercise sessions will be quite beneficial [10].Numerous studies have examined low-intensity plyometric training in a range of populations, such as those with anterior cruciate ligament injuries,

but not in knee OA. According to our findings, combination of eccentric and plyometric training was the most successful protocol to promote favourable changes even though all training techniques produced improvement to varied degrees. Accordingly, the combined protocol is the most effective training regimen since it improves both functional performance and stability in elite female athletes recovering from ACL surgery [11].

6 Conclusion

Although there are various physiotherapeutic interventions for osteoarthritis knee, from this study its concluded that dynamic proprioceptive exercises and plyometrics also contribute to symptom improvement in osteoarthritis knee. Though both the interventions showed results in improving joint position sense, plyometrics proved to be more effective. Joint position sense, being a significant component towards maintaining balance needs to be addressed in osteoarthritis patients. These interventions combined with other conservative management can also be helpful in managing and treating symptoms of knee osteoarthritis. The uses of wireless motion sensors proved to be beneficial in accurately assessing the difference in joint position sense recreated by then subjects. This shows that use of artificial intelligence powered devices can be helpful for physiotherapeutic evaluations. As the current study and most other recent studies centered on the short-term effect of proprioceptive exercises and plyometric, further studies can be carried out with a larger population to study the long-term effects of these exercises not only on joint position sense but also on other functional outcomes of knee osteoarthritis.

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