STUDY PROTOCOL

Effect of low-intensity plyometrics and eccentric training programs on pain, strength and function in patients with knee osteoarthritis: A randomized control trial protocol

[version 1; peer review: awaiting peer review]

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Abstract
Meniscus degeneration, synovial inflammation, subchondral bone changes, and cartilage loss serve as the best indicators of osteoarthritis (OA). The most prevalent type of joint conditions, OA, impairs mobility, lowers quality of life, and limits participation in social activities. Although pain is the primary concern for the majority of patients, clinical symptoms also include joint stiffness, discomfort, and dysfunction. There is enough data to draw the conclusion that physiotherapy treatments can reduce knee OA patients' pain and enhance their functional capabilities. Two treatment methods that are particularly effective and advantageous for people with knee OA are plyometrics and eccentric training programmes. Our study will compare the impact of eccentric training programmes and low-intensity plyometric training programmed on pain, strength, and function in patients with Grade 1 and Grade 2 knee OA. In this study, the following outcome measures will be utilised: the Visual Analogue Scale (VAS), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Two Minute Walk Test, as our final performance measures for pain and function, respectively. We will determine strength by using portable hand-held dynamometers. Through this study, we will be able to create a plyometric training regimen that can be given to individuals with knee osteoarthritis to improve their physical well-being and athletic performance. These training programmes would be highly effective in such patients, in addition to conventional treatment.

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Keywords
Knee Osteoarthritis, Physiotherapy, Plyometric Training Program, Eccentric Training Program, Pain, Muscle Strength, functional ability
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Introduction

Osteoarthritis (OA) of the knee is a condition that causes sub-chondral sclerosis of the bone, narrowing of the joint space, and osteophyte formation at the edges of the bone. The primary symptom of this condition is restricted range of motion and stiffness brought on by pain, joint effusion, and bony enlargements which impairs mobility, lowers quality of life, and prevents social engagement. Knee OA, which often affects all three segments of the knee joint, including the medial, lateral, and patellofemoral joint, typically develops gradually over a period of 10 to 15 years and limits daily activities. The two types of OA are primary (idiopathic or non-traumatic) and secondary (often brought on by trauma or mechanical misalignment), based on the cause of the condition. The 1957 introduction of the Kellgren-Lawrence (KL) method allows for the categorization of disease severity based on radiographic data.

The incidence of OA was 28.7% throughout the entire population of 4,680 people in few studies. Higher rates of OA prevalence were observed in those who used western toilets (42.1%), were sedentary (82.9%), were female, and were severely obese. According to the study’s findings, a sizable portion of the population falls below the cut off. For example, K-L grade 1, which is regarded as questionable or borderline in terms of OA diagnosis. Although pain is the primary concern for the majority of patients, clinical manifestations also include joint stiffness, discomfort, and malfunction. Risk factors include genetics, female sex, prior trauma, advancing age, and obesity. The increasing loss of articular cartilage, increased subchondral plate thickness, osteophyte growth at the joint borders, and the emergence of subchondral bone cysts are some of the distinctive structural changes in OA.

Physiotherapy, which uses a range of techniques, is a non-surgical treatment option for treating OA. Physiotherapy treatments may aid those with knee OA in experiencing less pain and having better function, according to enough evidence. Along with other exercises that can be used to enhance the knee muscles, plyometrics and eccentric training programmes can be used to reduce knee pain, increase functional capacity, and increase muscle strength. The stretch-shortening cycle, a frequently seen occurrence involving a fast lengthening of a muscle tendon unit, is one of the benefits of plyometric activities. When a load is applied during eccentric exercises, the musculotendinous unit lengthens. As a result, patients with knee osteoarthritis could benefit from either of these exercise programmes to lessen their pain and improve their lower limb functional ability and strength.

Several outcome indicators will be used in our study to assess the effectiveness of the training activities. The end measures we used in this trial for pain and function were the Visual Analogue Scale (VAS), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Two Minute Walk Test (2MWT). With the use of handheld dynamometers, we will measure strength.

Numerous studies have examined the effects of various physiotherapy techniques on patients with knee OA. Two treatments that are particularly effective and advantageous for people with knee OA are plyometrics and eccentric training programmes. Numerous studies have shown that eccentric training programmes combined with traditional physiotherapy are useful for treating knee OA in patients. The utilisation of a plyometric training programme in people with knee OA is not directly supported by any data, although there haven’t been many studies that used plyometric exercise as part of a therapeutic plan.

Our study compares the effects of eccentric training programmes and low intensity plyometrics on pain, strength, and function in patients with Grade 1 and Grade 2 knee OA. Through this study, we will create a plyometric exercise programme that can be provided to people with knee OA to help them feel better physically and perform better. These training programmes together with traditional exercise sessions will be quite helpful in such patients.

Aim and objectives of the study

1. To assess the impact of low-intensity plyometric exercise training program in Grade 1 and Grade 2 knee OA patients on pain (Visual Analogue Scale), strength (Hand Held Dynamometer), and function (WOMAC, Two Minute Walk Test).

2. To assess the impact of eccentric exercise training programmes in Grade 1 and Grade 2 knee OA patients on pain (Visual Analogue Scale), strength (Hand Held Dynamometer), and function (WOMAC, Two Minute Walk Test).

3. To compare the effects of Plyometric Training programs and Eccentric Training programs in Grade 1 and Grade 2 knee OA patients on pain (Visual Analogue Scale), strength (Hand Held Dynamometer), and function (WOMAC, Two Minute Walk Test).
**Trial design**
This study will be a single-centre, two arm parallel superiority randomized control trial.

**Protocol**
After obtaining approval from the institutional ethics committee of Datta Meghe Institute of Higher Education and Research, Deemed to be University, the participants will be gathered from the Physiotherapy OPD of Acharya Vinoba Bhave Rural Hospital Sawangi, Meghe, Wardha, Maharashtra. Before the study is started, participants will be informed of its goals and methods, and they will be required to sign written patient consent forms. Patients who match the inclusion and exclusion criteria and have Grade 1 or Grade 2 knee OA are going to be included in the analysis. Simple random selection will be used to divide them into Group A and Group B. A total of 40 participants will be in each group. Computer Generated Random Number system will be used for the randomisation process. Sequentially Numbered Opaque Sealed Envelope Method will be used for sample allocation. The study will be monitored by a departmental committee comprising PG Guide, Head of Department (HOD) Principal of Ravi Nair Physiotherapy College (RNPC) and member of Research Guidance Cell. We will ensure that the patients adhere well to the recommended treatment through regular treatment sessions. If needed, patients will be counselled or contacted telephonically for a reminder about the therapy sessions. The outcome measures will be evaluated before the analysis starts and after it is concluded. The Visual Analogue Scale (VAS), Hand Held Dynamometer, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the two-minute walk test (2MWT) are among of the tools used to measure pain, lower limb muscle strength and functional ability. Along with conventional treatment for pain, muscle strength, and functional ability, Group A will also undergo a plyometric exercise programme. Along with conventional treatments for pain, muscle strength, and functional ability, Group B will also receive an eccentric training programme. Figure 1 depicts the study’s design in visual form.

**Inclusion criteria**
1. Patients who are 40 to 50 years of age.
2. There should be both male and female patients.
3. People who have been diagnosed with OA of Grade 1 or Grade 2 according to the Kellgren and Lawrence classification method.
4. Patients who are interested to take part in the study.

**Exclusion criteria**
1. Patients with trauma-related knee injuries.
2. Patients suffering from different neurological diseases.
3. Patients with limb length differences.
4. Patients who have irreversible limb deformities.
5. Patients with pain referrals.
6. Patients who have had intraarticular injections.

**Interventions**
Groups A and B will receive the physiotherapy intervention for a total of six weeks. Three days a week will be dedicated to the intervention. Both Group A and Group B will undergo standard physiotherapy treatment. The exercise regimens will consist of two to four sets at 60 to 70 percent of 1 repetition maximum (RM) and eight to 12 repetitions each. Group A will also undergo traditional treatment and a programme of low-intensity plyometric training. Group B will additionally get the eccentric training programme in addition to the traditional treatment. Table 1 explains the conventional treatment that will be administered to the patients.
Recruitment of the Patients (n = 80)

Subjects will be screened by the inclusion and exclusion criteria. Informed consent and medical history will be obtained from the patients.

Perform Pre-Assessment (Baseline Assessment)

1. Visual Analogue Scale
2. WOMAC
3. Hand Held Dynamometer
4. Two Minute Walk Test

RANDOMISATION

Group A (40 participants) will receive
Plyometric Training Program along with Traditional Physiotherapy Treatment

Group B (40 participants) will receive
Eccentric Training Program along with Traditional Physiotherapy Treatment

6 weeks of Exercise Intervention will be given

Perform Post Training Assessment

1. Visual Analogue Scale
2. WOMAC
3. Hand Held Dynamometer
4. Two Minute Walk Test

STATISTICAL ANALYSIS

Figure 1. Flowchart of study design.
Experimental group

Plyometric training program:

Plyometric training comprises the stretch-shortening cycle (SSC), which uses a stretching action (eccentric) that is quickly accompanied by a shortening movement (concentric). The low-intensity plyometric training programme is depicted in Table 2.

### Table 1. Conventional treatment regimen.

<table>
<thead>
<tr>
<th>Rationale</th>
<th>Regimen</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>To educate the patient</td>
<td>The patient will receive education on the</td>
<td>At the start of the treatment plan</td>
</tr>
<tr>
<td>symptoms of OA, how to manage them,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and how to protect their joints while</td>
<td></td>
<td></td>
</tr>
<tr>
<td>staying active.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To decrease pain</td>
<td>Interferential Therapy (IFT)</td>
<td>Parameters: Frequency = 4000 Hz,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>base = 90 Hz, sweep = 40 Hz, Beat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>frequency = 90-130 Hz, quadripolar,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>duration = 10-20 minutes, IFT output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>intensity was increased until the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;normal&quot; tingling was encountered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>by the patient.23</td>
</tr>
<tr>
<td>To enhance functional control</td>
<td>a) Exercises for Quadriceps: Quad sets</td>
<td>2 to 4 sets with 8 to 12 repetitions</td>
</tr>
<tr>
<td>and muscular performance</td>
<td>Multiple-Angle Isometric Short-Arc</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Terminal Extension</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Exercises for Hamstrings: Hamstring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sets Multiple-Angle Isometric Exercises</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for Hamstrings24</td>
<td></td>
</tr>
<tr>
<td>To promote range of motion and</td>
<td>Passive and Self Stretching techniques for</td>
<td>3 reps with 30 sec hold24</td>
</tr>
<tr>
<td>flexibility</td>
<td>Quadriceps and Hamstrings24</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. Low - intensity plyometric training program.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Exercise Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>FRONT CONE HOP TEST</td>
</tr>
<tr>
<td></td>
<td>A row of six to ten cones or tiny barriers that are</td>
</tr>
<tr>
<td></td>
<td>eight to twelve inches (20 to 30 cm) tall, positioned</td>
</tr>
<tr>
<td></td>
<td>three to six feet (91 to 183 cm) apart, and that are</td>
</tr>
<tr>
<td></td>
<td>six to ten in number. Take a standing stance with your</td>
</tr>
<tr>
<td></td>
<td>feet shoulder-width apart at the end of the barrier row,</td>
</tr>
<tr>
<td></td>
<td>with the length of the barrier extended in front of you.</td>
</tr>
<tr>
<td></td>
<td>Maintaining a shoulder-width distance between your feet,</td>
</tr>
<tr>
<td></td>
<td>jump over each obstruction, landing on both feet</td>
</tr>
<tr>
<td></td>
<td>simultaneously. Use a double-arm swing to shorten the</td>
</tr>
<tr>
<td></td>
<td>distance between each obstacle.12</td>
</tr>
<tr>
<td>2.</td>
<td>DROP AND FREEZE</td>
</tr>
<tr>
<td></td>
<td>A 18 to 24 inch high landing box or platform is used.</td>
</tr>
<tr>
<td></td>
<td>You stand there with both feet on the front edge of the</td>
</tr>
<tr>
<td></td>
<td>box. One foot is raised and one toe is extended over the</td>
</tr>
<tr>
<td></td>
<td>border of the box. Drop lock the ankle. Just enough</td>
</tr>
<tr>
<td></td>
<td>movement of the other knee will allow you to use it to</td>
</tr>
<tr>
<td></td>
<td>freeze and push your feet out. Attempt to descend to the</td>
</tr>
<tr>
<td></td>
<td>exact height you are above the surface of the ground.</td>
</tr>
<tr>
<td></td>
<td>Knees bent, stopped on both feet, halting any further</td>
</tr>
<tr>
<td></td>
<td>descent at this moment. The development of landing</td>
</tr>
<tr>
<td></td>
<td>control for all plyometric activities and eccentric</td>
</tr>
<tr>
<td></td>
<td>strength will be helped by this frozen motion.12</td>
</tr>
<tr>
<td>3.</td>
<td>30 SECOND BOX DRILL</td>
</tr>
<tr>
<td></td>
<td>A 30 inches by 20 inches by 12 inches is the size of the</td>
</tr>
<tr>
<td></td>
<td>box. Stance at the side of the box with your feet</td>
</tr>
<tr>
<td></td>
<td>shoulder-width apart. Jump on the box, touch down on</td>
</tr>
<tr>
<td></td>
<td>the other side of the floor, and then leap back up.</td>
</tr>
<tr>
<td></td>
<td>Continue to jump across the top of the box for the</td>
</tr>
<tr>
<td></td>
<td>allotted number of touches; each touch counts as one.</td>
</tr>
<tr>
<td></td>
<td>Utilise the following advice: 30 touches in 30 seconds</td>
</tr>
<tr>
<td></td>
<td>Training at a low intensity starts.12</td>
</tr>
<tr>
<td>4.</td>
<td>LATERAL STEP UP JUMP</td>
</tr>
<tr>
<td></td>
<td>Put your left foot in the centre as you position on one</td>
</tr>
<tr>
<td></td>
<td>side of the box. Leap to the other side of the box with</td>
</tr>
<tr>
<td></td>
<td>a double arm swing, landing with the right foot on the</td>
</tr>
<tr>
<td></td>
<td>roof and the left foot on the ground. To complete this</td>
</tr>
<tr>
<td></td>
<td>exercise, continuously rock back and forth over the top</td>
</tr>
<tr>
<td></td>
<td>of the box.26</td>
</tr>
<tr>
<td>5.</td>
<td>FORWARD STEP UP AND JUMP</td>
</tr>
<tr>
<td></td>
<td>A position at top of the box. Keeping your right foot</td>
</tr>
<tr>
<td></td>
<td>in place, take a step down onto the ground with your</td>
</tr>
<tr>
<td></td>
<td>left foot. Place your right foot first, then your left</td>
</tr>
<tr>
<td></td>
<td>foot back on the box. Ascend the box now. As you go</td>
</tr>
<tr>
<td></td>
<td>through these motions, switch legs.26</td>
</tr>
</tbody>
</table>
Control Group

Eccentric training program:

Strength Training can reduce knee pain intensity and leg strength in participants with symptomatic knee OA. When compared to the muscle’s capacity, the eccentric phase is frequently underloaded. The musculotendinous unit is lengthened during eccentric exercises when a load is applied to it (30). The eccentric training programme is depicted in Table 3.

Safety outcomes
Adverse events will be reported at each clinic visit.

Outcome measures
Primary outcome measures

1. Reduction in Visual Analogue Scale

A common, reliable, accurate, and responsive method to determine how much pain someone is feeling is the VAS scale. The tool is made up of horizontal lines that are 10 cm long and has anchor points of 0 (no pain) and 10 (severe pain). The intensity of knee pain is going to be evaluated using a VAS.13
2. Change in Hand-held dynamometer parameters

Hand-held dynamometers have been mentioned as alternatives. The manual muscle test, which has been used in clinical practice for years, is comparable to these instruments in that it can be done virtually anywhere and is portable, affordable, and helpful almost in any clinical setting. Using this apparatus, the muscle strength of the lower limbs may be effectively assessed.14

3. Change in WOMAC (The Western Ontario and McMaster Universities Osteoarthritis Index) Score:

Since its publication in 1988, the WOMAC Questionnaire has been used to evaluate the health of individuals with osteoarthritis. Including clinical symptoms (five questions), the degree of joint stiffness (two questions), pain intensity (nine questions), and daily activities (17 questions), it consists of 33 items that assess the patient’s health and function from several perspectives.13 Each question has five subscales, with the ideal situation receiving a score of never or none and the worst condition receiving a score of extreme or frequently. Higher scores here suggest a better state and less suffering.15

Secondary outcome measures

1. Change in Two Minute Walk Test Distance (2MWT):

The 2MWT is a test of functional capacity and self-paced walking ability that is especially useful for people who are unable to complete the longer Six Minute Walk Test (6MWT) or 12 Minute Walk Test. The individual is advised to move as quickly as they can for two minutes without help, and the distance covered is measured.16

Sample size calculation

We estimated the sample size using a power analysis with 80% power and 5% Type I error for the main variable, the WOMAC score, in comparison to the difference in mean score pre- and post-treatment for the eccentric training group from baseline to end visits. For the study, we used the previously determined effect size difference in percentage from the RCT.17 We anticipated a 20% margin improvement over the control group, which was significant for a clinically relevant margin of superiority at 20% based on expert opinion.

Formula using mean difference

\[ n_1 = n_2 = 2 \left( \frac{Z_{\alpha} + Z_{\beta}}{\delta} \right)^2 \sigma^2 \]

Primary variable (WOMAC)

Mean ± SD (pre) result on WOMAC for eccentric training group (pre) = 49.7 ± 17 as per reference article17

Expected clinically relevant superiority 20% result on WOMAC for low intensity plyometric training group (post) = (49.7×20)/100 = 9.94

Difference = 9.94 (As expected)

As per reference article,

\[ N_1 = 2 \times \left( (1.64 + 0.84)2(17)2/(9.94)2 \right) = 36 \]

Total samples required = 40 per Group.

Considering 10% drop out = 4

Total sample size required = 40 per group

Notations:

\[ Z_{\alpha} = 1.64 \]
\[ \alpha = \text{Type I error at 5\% (at both side) total 10\%} \]
\[ Z_\beta = 0.84 (1 - \beta) = \text{Power at 80\%} \]
\[ \sigma = \text{standard deviation} \]

**Reference article:** “Concentric or eccentric physical activity for patients with symptomatic osteoarthritis of the knee: a randomized prospective study”.$^{17}$

**Analysis**
The results of the quantitative assessment of the demographic data (age, height, weight, and body mass index [BMI]) will be used to determine the minimum and maximum observational values for the mean standard deviation. Calculations for qualitative evaluation will be based on frequency and percentage. The Kolmogorov-Smirnov test will be used to determine the normality of the data for inferential statistics. If the distribution of the data for the outcome variable on quantitative measurement follows normal distribution, a parametric test will be conducted. If data follows non-normal distribution, then mathematical algorithms like log function, exponential, or box cox transformation will be used to transform it to normal distribution. If data still continues with non-normal distribution, then an alternate parametric test will be used.

Primary outcome: Using a linear mixed model, inferential statistics will be utilised to compare the mean change in the major variable (VAS, Hand-held Dynamometer, WOMAC) between baseline, six weeks during treatment and one week after completion of the study for follow-up assessment between two groups (Experimental treatment versus Control treatment). Participants will be evaluated for the outcomes taking into account the major variable’s variation from baseline to the study’s timeline (visit 1 and after the conclusion of six weeks and post follow-up at one week after completion of the study) will be measured. A generalised effect model will be run on study subjects to find the effect of treatment, visits and treatment plus visits as fixed variables as well as to find the other random effect of confounding variables like age, sex, hypertension, diabetes and any other co-morbidities. The effect size across mean change difference on the major variable from baseline to end line visit at six weeks and one week after completion of the study will be calculated, along with a matching 95\% confidence interval (CI).

Primary end point (Description): The aforementioned linear mixed model impact will be examined to predict the effect size difference between the experimental and control groups for secondary outcomes (2MWT). If the data has a normal distribution, the T-test (Unpaired) will be used to determine whether there is a significant difference between the means in comparison between the two groups. Mathematical procedures will be employed to convert the data from a non-normal distribution to a normal distribution. We will employ an alternative non-parametric test (such as the Chi-square, Mann-Whitney U, or Wilcoxon test) if the data over the major variable still follows a non-normal distribution.

**Dissemination**
The authors are preparing to present the work in National Conference Proceedings and publish in an index journal.

**Study status**
The process of recruiting individuals has not yet begun.

**Discussion**
People all over the world are impacted by the serious medical condition known as OA.$^{18}$ One of the treatment choices is orthopaedic assistance, along with medication, surgery, and physical therapy.$^{6}$ OA treatment depends on how serious the disease is. Physical therapy and medication are helpful in the early stages of OA. Muscle strength is increased by exercise, which improves life quality.$^{19}$ Numerous studies have been conducted to demonstrate the effectiveness of various physiotherapy methods in treating knee OA.$^{20}$ Similar to this, numerous studies have been conducted on eccentric exercise, demonstrating its usefulness in treating patients with knee OA.$^{21}$ Low-intensity plyometric training on individuals with knee OA has not been the subject of any studies. Low-intensity plyometric training has been the subject of numerous research on a variety of populations like Anterior Cruciate ligament injury population, etc., but not on knee OA.$^{22}$ We’ll be able to create a low-intensity plyometric training programme for this group of individuals with the aid of this study. Second, no comparisons between the two aforementioned methodologies have been made. This study will enable us to assess which training programme is more successful with this demographic.

**Ethical considerations**
Institutional Ethical Committee approval number: DMIHER (DU)/IEC/2023/803
IEC approval date: 21/03/2023

Data availability
Underlying data
No data are associated with this article.

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References
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