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ORIGINAL ARTICLE

Effect of a Short Term Core and Lower Extremity Strengthening on the Functionality of Patients with Moderate Knee Osteoarthritis: A Comparative Trial

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ABSTRACT

Objective: This study compared the effect of a short term core and lower extremity muscle strengthening program on the overall functionality of moderate knee osteoarthritis (OA) patients.

Methods: This randomized trial was conducted at Department Of Physiotherapy Guru Jambheshwar University Of Science and Technology Hisar, India from May to September 2022. Both male and female participants within the age group of 40-60 years, with moderate knee OA grade II and III based on Kellgren and Laurence radiological classification were included. Subjects were divided equally into three intervention groups (hip, core and ankle strengthening exercises). The exercises were performed twice a week for a short term of 6 weeks. The outcome was functionality of moderate knee OA and to assess functionality of moderate knee OA, Knee Injuries and Osteoarthritis Scale (KOOS) and Chair stand test were measured at baseline, 3rd and 6th week of exercise.

Results: Of total 66 participants, the mean age was 51.33 ± 6.42 years. After intervention at 3rd week, between-group comparison showed that hip exercise group significantly improved in symptoms (p-value <0.001) and combined KOOS scores (p-value 0.016). Comparison of difference (baseline and 6th week) in between group showed that pain, sport and recreation function, knee related quality of life (QOL), chair stand test and overall KOOS score (p-value <0.001 respectively) significantly improved in hip exercise group.

Conclusion: This study revealed that hip muscle strengthening exercises are effective in short term reduction of pain, symptoms, QOL, and improving function in patients with moderate knee OA.

Keywords: Function, Knee, Muscle Strengthening Exercises, Osteoarthritis.

Clinical Trial Registry#: CTRI/2022/05/054396

INTRODUCTION

Knee osteoarthritis (OA) is a degenerative joint condition associated with wear and tear along with progressive loss of articular cartilage. It is a painful, long-term joint condition that affects not only the knees but also the hips, hands, and spine. It is most commonly observed among the elderly people in the fourth and fifth decade of life.[1-3] The intensity of the symptoms varies from person to person and normally progresses slowly. In Knee OA with higher grades, the working capability is reduced and can result in absence from work.[4] Knee OA with age-standardized symptoms was estimated to affect 3.8 % of the global population[2] with pain being the commonest clinical characteristic especially when performing weight-bearing activities.[5]

In knee OA weakness of adjacent joint muscles could result in pelvic drop leading to increased load on the medial knee compartment. So the lumbo-pelvic stability is vital to support loads on the knee joint.[6] Patients with knee OA pain have benefitted from a combination of proximal muscles rehabilitation program that reduced pain intensity and improved function in the short term with moderate evidence for long and medium term.[7] Also the ability to produce a larger hip abduction moment during walking protects the ipsilateral knee against OA development in the medial femorotibial compartment while the activation of primary core muscles such as the transverse abdominis and multifidus provides stability to the trunk and maintains the balance of the lumbopelvic hip complex.[6,8] People with medial compartment OA are

also reported to have more pronated feet, while those with lateral compartment OA have more of supinated feet.[9]

However, there is not enough relevant literature available that compared the effectiveness of specific hip, ankle and core muscle strengthening exercises in addition to knee strengthening exercises in improving functionality of moderate knee OA patients in the short term. Owing to the benefits of these strengthening exercises in moderate knee OA, there was a need to compare interventions showing the specific short term effects of these muscle groups on functionality of moderate knee OA patients. Therefore, the aim of the present study was to examine the effect of short term hip, core and ankle with knee muscular strength, on discomfort, function, and quality of life (QOL) in people with moderate knee OA.

METHODS

This randomized trial was conducted in the Department Of Physiotherapy Guru Jambheshwar University Of Science And Technology Hisar (Haryana), India from May to September 2022. The ethical approval for the study was obtained from the Institutional Ethical Committee, Department of Physiotherapy, vide letter no.PTY/2022/155. The Research protocol was registered in the clinical trial registry of India with registration number CTRI/2022/05/054396.

A total of 66 patients were recruited and randomly allocated to three groups with an allocation ratio of 1:1:1. Sample size was calculated by the standard formula using the minimal clinical important differences (MCID) value of KOOS of 16.74.[10] The final calculated sample after dropout rate was 22 for each group. All the participants were randomly allocated by lottery method into three intervention groups as shown in figure 1. The study was conducted and reported as per Consolidated Standards of Reporting Trials (CONSORT) guidelines.[11]

Both male and female participants within the age group of 40-60 years, with moderate knee OA grade II and III based on criteria of the American College of Rheumatology of Kellgren and Laurence radiological classification were included in the study. Participants with any history of cardiovascular conditions, taking steroid injections in the last 2-3 months, neurological or musculoskeletal conditions that could hinder their participation, pregnancy and uncooperative patients were excluded from the study.

In group A, hip abductors, hip external rotators strengthening exercises were used as well as the conventional knee strengthening exercises i.e. Hamstring and Quadriceps Isometrics, Vastus medialis obliquues (VMO) strengthening and Straight leg raise.[12] In group B, core stability strengthening exercises (Multifidus and transverse abdominis) as well as conventional knee strengthening exercises were performed.[13] In group C, ankle dorsiflexors and planter flexors strengthening exercises and conventional knee strengthening exercises were performed.[14]

The primary outcome of the study was to assess the functionality of moderate knee OA after intervention. Knee Injuries and Osteoarthritis Scale (KOOS) and Chair stand test were measured for the assessment of the functionality of the knee OA. KOOS has five subscales that separately rate for pain, symptoms, activities of daily living (ADL's) function, sports and recreation functions, and for QOL. Each item has five options, ranging from 0 (no problems) to 4 (extreme problems), and each of the five scores is worth one point. Scores were calculated for each subscale as well as a combined score for KOOS scale. The KOOS subscale is shown to have good reliability and validity with all interclass correlation (ICC) values >0.90 (range, 0.91-0.99).[15] Chair stand test was used to assess lower-body strength and function. Adequate lower body strength is required for tasks like ascending stairs, getting into and out of a car or chair. It is quite similar to squat test to assess leg strength in which the participant stands to erect repeatedly from a chair for 30 seconds. The 30 seconds chair stand test is designed to measure lower extremity strength and dynamic balance ICC (2, 1)= 0.84-0.92.[16] The patient was instructed to sit comfortably in a chair with their arms crossed against their chest. They were instructed to keep their feet flat on the floor and then stand up from the chair with their back straight. They had to sit down and then stand up again without support for 30 seconds. The number of times they were able to stand up and sit back properly was measured.

Data were collected at three time points i.e., at baseline, at 3rd week and at 6th week of intervention. The total treatment duration was for six weeks with intervention given twice a week. Each group performed 4-5 different lower limb and core muscle strengthening exercises. All exercises were performed with 10 repetitions of one set and with a 5 second hold between each repetition.

The Statistical Package for Social Sciences (SPPS) Version 21 was used to analyze the study. Normality of the data were checked using the Shapiro-Wilk test. Mean ± SD were calculated for quantitative variables such as age, height, weight, body mass index (BMI) and study outcome variables like pain, symptoms, ADL's,

sports and recreation, knee related QOL, chair stand test and combined KOOS score. Inferential statistics were explored using paired t-test and one-way ANOVA for within group and between group comparison of KOOS score and chair stand test score respectively. The p-value of ≤0.05 was considered as significant.

RESULTS

A total 66 participants were included in the current study and divided equally into three groups. The mean age, height, weight and BMI of the study participants were 51.3 ± 6.4 years, 1.6 ± 0.1 m, 70.1 ± 27.0 kg, and 26.2 ± 4.5 kg/m^2 respectively. At baseline an insignificant between group comparison found with pain (p-value 0.372), symptoms (p-value 0.062), ADL's (p-value 0.139), sport and recreation function (p-value 0.765), knee related QOL (p-value 0.902), chair stand test (p-value 0.376), and overall KOOS score (p-value 0.748) (Table 1).

After intervention at 3rd week, symptoms and combined KOOS scores significantly improved in the hip exercise group as compared to the core exercise group and ankle exercise group i.e., 60.2 ± 9.6 vs. 51.2 ± 14.1 vs. 43.3 ± 10.5 (p-value <0.001) and 56.9 ± 17.3 vs. 50.0 ± 5.5 vs. 47.7 ± 3.6 (p-value 0.016) respectively.

Similarly, at 6th week symptoms and combined KOOS scores significantly improved in the hip exercise group as compared to the core exercise group and ankle exercise group i.e., 82.7 ± 9.9 vs. 74.9 ± 8.8 vs. 68.1 ±1 5.1 (p-value <0.001) and 80.7 ± 4.8 vs. 73.6 ± 6.2 vs. 68.1 ± 5.4 (p-value <0.001) respectively (Table 2).

The within group comparison for all three groups at baseline and at 6 weeks of intervention showed significant change in all the study variables (p-value <0.001) (Table 3). Comparison of baseline and 6th week difference in between group showed that pain (p-value <0.001), sport and recreation function (p-value 0.002), knee related QOL (p-value 0.024), chair stand test (p-value <0.000) and overall KOOS score (p-value <0.001) significantly improved in the hip exercise group (Table 4).

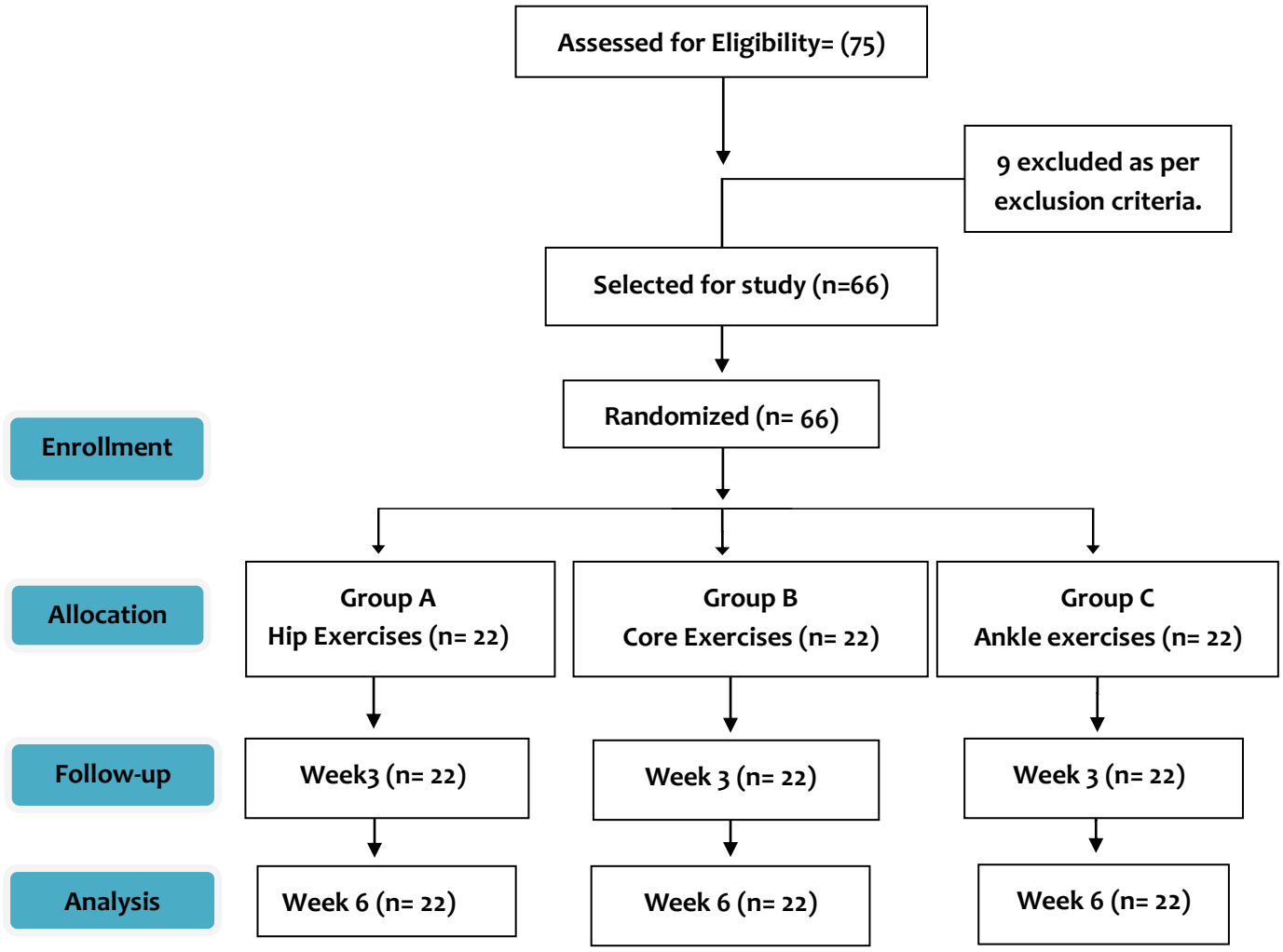

Figure 1: Shows the flow of study as per CONSORT guidelines.

Table 1: Between group comparison of KOOS score (its components) and chair stand test score at baseline (n= 66)

	Hip Exercise	Core Exercises	Ankle Exercises	p-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Age (years)	51.7 ± 5.9	51.7 ± 6.7	50.5 ± 6.4	0.781
Height (m)	1.6 ± 0.16	1.6 ± 0.1	1.6 ± 0.1	0.363
Weight (Kg)	69.5 ± 11.5	67.4 ± 12.1	73.5 ± 10.2	0.202
BMI (kg/m^2)	26.7 ± 4.1	25.6 ± 5.1	26.4 ± 4.3	0.612
Pain	15.9 ± 8.2	19.2 ± 12.4	20.3 ± 11.3	0.372
Symptoms	22.5 ± 14.9	19.9 ± 17.3	12.6 ± 8.7	0.062
Activities of Daily Living	18.3 ± 11.6	26.9 ± 17.8	23.3 ± 11.8	0.139
Sport and Recreation Function	17.7 ± 13.3	15.4 ± 12.7	17.7 ± 9.9	0.765
Knee-Related Quality of Life	20.4 ± 15.6	18.4 ± 15.7	19.6 ± 14.7	0.902
Chair Stand Test	5.8 ± 3.1	6.5 ± 3.0	7.0 ± 2.5	0.376
Combined KOOS Score at Baseline	19.0 ± 5.4	20.0 ± 6.6	18.7 ± 4.6	0.748

-KOOS: Knee injuries and osteoarthritis scale, SD: Standard deviation, Kg: Kilogram, m: meter
One-way ANOVA applied

Table 2: Mean comparison of KOOS score (its components) and chair stand test score among study groups after intervention (n= 66)

	Duration	Hip Exercise	Core Exercises	Ankle Exercises	p-value
		Mean ± SD	Mean ± SD	Mean ± SD	
Pain	3 week	59.9 ± 11.4	53.4 ± 10.2	62.7 ± 7.8	0.009*
	6 week	88.0 ± 7.7	79.2 ± 7.0	77.1 ± 8.8	<0.001*
Symptoms	3 week	60.2 ± 9.6	51.2 ± 14.1	43.3 ± 10.5	<0.001*
	6 week	82.7 ± 9.9	74.9 ± 8.8	68.1 ± 15.1	<0.001*
Activities of Daily Living	3 week	55.0 ± 11.5	62.7 ± 16.7	54.7 ± 14.1	0.115
	6 week	85.4 ± 6.3	87.4 ± 4.4	82.2 ± 5.7	0.010*
Sport and Recreation Function	3 week	45.6 ± 8.7	42.0 ± 13.7	40.4 ± 11.8	0.319
	6 week	72.5 ± 12.7	69.7 ± 12.8	55.6 ± 12.7	<0.001*
Knee-related Quality of Life	3 week	63.7 ± 83.2	40.6 ± 13.3	37.5 ± 10.3	0.161
	6 week	74. ± 14.	60.5 ± 15.9	57.6 ± 12.4	<0.001*
Chair Stand Test	3 week	9.3 ± 3.2	9.7 ± 3.1	10.0 ± 2.7	0.731
	6 week	14.0 ± 3.6	12.7 ± 4.0	12.5 ± 3.4	0.327
Combined KOOS Score	3 week	56.9 ± 17.3	50.0 ± 5.5	47.7 ± 3.6	0.016*
	6 week	80.7 ± 4.8	73.6 ± 6.2	68.1 ± 5.4	<0.001*

-KOOS: Knee injuries and osteoarthritis scale, SD: Standard deviation
One-way ANOVA applied, *p-value ≤ 0.05

Table 3: Within group mean comparison of KOOS score (its components) and chair stand test score at baseline and 6 th week (n= 66)

		Hip Exercise Mean ± SD	p-value	Core Exercises Mean ± SD	p-value	Ankle Exercises Mean ± SD	p-value
Pain	Baseline	15.9 ± 8.2	<0.001*	19.2 ± 12.4	<0.001*	20.3 ± 11.3	<0.001*
	6th Week	88.0 ± 7.7		79.2 ± 7.0		77.1 ± 8.8	
Symptoms	Baseline	22.5 ± 14.9	<0.001*	19.9 ± 7.3	<0.001*	12.6 ± 8.7	<0.001*
	6th Week	82.7 ± 9.9		74.9 ± 8.8		68.1 ± 15.1	
Activities of Daily Living	Baseline	18.3 ± 11.6	<0.001*	26.9 ± 17.8	<0.001*	23.3 ± 11.8	<0.001*
	6th Week	85.4 ± 6.3		87.4 ± 0.4		82.2 ± 5.7	
Sport and Recreation Function	Baseline	17.7 ± 13.3	<0.001*	15.4 ± 2.7	<0.001*	17.7 ± 9.9	<0.001*
	6th Week	72.5 ± 12.7		69.7 ± 12.8		55.6 ± 12.7	
Knee-Related Quality of Life	Baseline	20.4 ± 15.6	<0.001*	18.4 ± 15.7	<0.001*	19.8 ± 13.1	<0.001*
	6th Week	74.9 ± 14.5		60.5 ± 5.9		57.6 ± 2.4	
Chair Stand Test	Baseline	5.8 ± 3.1	<0.001*	6.5 ± 3.0	<0.001*	7.0 ± 2.5	<0.001*
	6th Week	14.0 ± 3.6		12.7 ± 0.1		12.5 ± 0.4	
Combined KOOS Score at Baseline	Baseline	19.0 ± 5.4	<0.001*	20.0 ± 6.6	<0.001*	18.7 ± 4.6	<0.001*
	6th Week	80.7 ± 4.8		73.6 ± 6.2		68.1 ± 5.4	

-KOOS: Knee injuries and osteoarthritis scale, SD: Standard deviation
Paired Sample t-test applied, *p-value ≤ 0.05

Table 4: Between group comparison for differences (baseline and 6 th week) of KOOS score and chair stand test score (n= 66)

	Hip Exercises	Core Exercises	Ankle Exercises	p-value
Pain	72.8 ± 8.6	60.0 ± 14.9	56.8 ± 17.0	<0.001*
Symptoms	60.8 ± 14.2	55.0 ± 20.0	55.5 ± 18.3	0.484
Activities of Daily Living	65.3 ± 18.2	60.5 ± 19.7	58.8 ± 13.0	0.436
Sport and Recreation Function	54.7 ± 21.0	54.3 ± 18.0	37.9 ± 10.9	0.002*
Knee-related Quality of Life	54.5 ± 25.8	42.0 ± 21.3	37.7 ± 11.9	0.024*
Chair Stand Test	8.2 ± 2.7	6.1 ± 1.6	5.5 ± 2.1	<0.001*
Combined KOOS	61.7 ± 7.0	53.6 ± 9.3	49.3 ± 6.6	<0.001*

-KOOS: Knee injuries and osteoarthritis scale, SD: Standard deviation
One-way ANOVA applied, *p-value ≤ 0.05

DISCUSSION

The current findings showed that all three interventions improved patient symptoms, enhanced daily living activity, improved health and recreational activities, and QOL in patients with moderate knee OA. The combined KOOS score was also improved at both 3rd and 6th week of the intervention in all groups.

Between groups comparisons showed that the addition of hip muscle strengthening was most significantly effective in reducing pain in moderate knee OA followed by core and ankle muscle strengthening. A similar pattern was observed clinically for improving OA based symptoms and in ADL's too. Some studies reported that leg-strengthening exercises have also been associated with reductions in pain with improvements in biomechanical elements of gait, such as stride length, cadence, and velocity.[17,18] Even home-based knee-strengthening exercises are effective in the reduction of symptoms and can have a long-lasting impact on patients with knee OA.[19]

The knee related QOL was also significantly improved in the hip muscle group as compared to the core and ankle group and similar results were observed for chair stand test and overall combined KOOS score too. In contrast, Hernandez *et al*. 2019 reported that the addition of core muscle activation with conventional exercises was more effective than conventional exercises alone at reducing knee OA pain in short term.[20] The ability of the trunk and pelvis to hold their position during any movement and weight transfer while walking is referred to as core stability. Therefore, increasing the activity of the core muscles also increases the activity of the limbs, improving their stability and functionality.[21]

When compared to baseline, symptoms improved significantly after 3 and 6 weeks of intervention in the hip group followed by the core group and ankle exercise group. However, there was no statistical significant difference seen between the core and ankle exercise group. Yuenyongviwat *et al*. 2020 also reported a similar result that hip abductor exercises when performed with quadriceps exercises help in reducing symptoms and discomfort in patients of knee OA.[22] After hip muscle strengthening, core exercises were also effective in knee OA. The transverse abdominis provides proximal stability for distal mobility during lower extremity motions and is the first muscle to contract. A core strengthening exercise program helps patients have more unrestricted mobility in their knee joint while reducing the symptoms of knee OA.[23]

The findings of the current study revealed that ADL's were maximally improved in the core exercise group followed by hip and ankle exercises. However, there was no significant improvement after 3rd week, but significant improvement was observed after 6th week of the training regimen. Hoglund *et al*. 2018, conducted a 6-week supervised study on the patellofemoral knee joint OA group which showed the effect of the supervised hip and core muscle strengthening versus core stabilization intervention alone. Transverse abdominis contracts bilaterally to form a musculo-fascial band that appears to tighten like a corset and improves the stability of lumbopelvic region. The improvement in terms of pain, symptoms, ADL's, exercise/rest, and QOL were more in the hip and core exercise group than core alone.[24] Leg strengthening activities in patients with knee OA increase the ability of the quadriceps to support functional joint stability, shock absorption, and ground reaction forces during ADL's, such as walking.[17,25]

A study conducted in 2018 included hip and core stabilization exercises for knee OA patients. They concluded that pain, function, physical performance, hip external rotator muscle strength, and QOL were significantly improved at 6 weeks in the intervention group as compared with the control group, which had conventional exercises. However, the same findings at 6 months of follow-up did not show any significant improvement.[24] In the present study, the effect of exercises was seen in all groups as early as 3 weeks and in the majority of variables at 6 week. This shows the early effects of the intervention which could help in reducing pain and improving function in moderate knee OA patients. However, we did not follow up on the patients up till 6 months hence the efficacy of the intervention for a long term cannot be evaluated here.

In our study, patients in all groups were able to perform the chair-stand test with good posture, less support, and with increased number of repetitions. The chair stand test score was maximally improved at 3 weeks in the ankle exercise group followed by both hip and core exercises which showed comparable improvement. At 6 weeks of intervention maximally improvements in chair stand score were seen in hip exercise group followed by core and ankle exercise group. Thong *et al.* 2019 reported that strengthening of hip and leg muscles significantly reduces pain, and improves function and QOL in patients with knee OA.[17]

There were some limitations of the current study like the effects could not be categorically seen for males and females separately owing to their uneven distribution in groups. Similarly, as most of the variables showed significant differences at 6 weeks rather than 3rd week of intervention, a longer follow-up for the study could be planned to assess the long term effects of the interventions. Also, protocols that could work in a shorter time i.e. upto 3 weeks could be devised and worked upon to provide early relief and improve overall functionality. Finally, more research is required to determine how a combination of various rehabilitation programs including hip, knee and ankle exercises could help individuals with knee OA. Since all the interven-

tions had knee strengthening exercises as a common protocol, there are need for studies to assess the individual effect of hip, core and ankle exercises alone on moderate knee OA patients too.

CONCLUSION

Knee function can be improved by including simple strengthening exercises of adjoining muscles like hip, ankle and core too. The addition of these muscles in strengthening programs gives better and faster results in moderate knee OA patients. A 6-week regimen of lower extremity and core strengthening exercises combined with knee-strengthening exercises is beneficial in treating moderate knee OA symptoms. However, it is also found that the addition of hip strengthening had a higher and earlier advantage than core and ankle strengthening activities in reducing pain and enhancing functional performance in patients with moderate knee OA.

ETHICAL APPROVAL: The ethical approval for the study was obtained from Institutional Ethical Committee, Department of Physiotherapy, Department of Physiotherapy, Guru Jambheshwar University Science & Technology, Hisar, Haryana, India (Ethical Approval Number: PTY/2022/155, dated 20-04-2022).

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