



Comparing the Effects of Maitland Grade II & III versus Kaltenborn Grade I & II Mobilization in Reducing Pain and Improving Range of Motion in Patients with Knee Pain: A Randomized Clinical Trial

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CONFLICT OF INTEREST

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ABSTRACT

Background: Knee pain associated with osteoarthritis and other mechanical knee disorders is frequently accompanied by pain, stiffness, and restricted range of motion. Joint mobilization is commonly used as an adjunct to exercise, although direct comparisons of Maitland and Kaltenborn grading approaches remain limited.

Objective: To compare Maitland Grade II and III mobilization with Kaltenborn Grade I and II mobilization for reducing resting knee pain and improving active knee flexion and extension range of motion.

Methods: This randomized parallel-group clinical trial analyzed 40 adults aged 30–60 years with chronic knee pain. Twenty participants received Maitland Grade II and III mobilization plus exercise (Group A), and 20 received Kaltenborn Grade I and II mobilization plus the same exercise program (Group B). Treatment was delivered three times weekly for four weeks (12 sessions). Resting pain was assessed using the Numeric Pain Rating Scale (NPRS), and active knee flexion and extension were measured by goniometry at baseline and after four weeks.

Results: Baseline between-group differences were not significant for resting NPRS, knee flexion, or knee extension. At four weeks, resting pain was lower in Group B than Group A (0.85 ± 0.81 vs 1.65 ± 1.03 ; $p=0.010$). Knee flexion was greater in Group B ($117.90 \pm 3.97^\circ$ vs $114.50 \pm 4.85^\circ$; $p=0.020$), and the flexion improvement was larger in Group B ($9.50 \pm 2.11^\circ$ vs $7.55 \pm 1.63^\circ$; $p=0.002$). Post-treatment knee extension also differed between groups ($1.80 \pm 2.52^\circ$ vs $0.05 \pm 2.08^\circ$; $p=0.022$), although the change in extension did not differ significantly ($5.30 \pm 1.65^\circ$ vs $4.80 \pm 1.67^\circ$; $p=0.347$).

Conclusion: Both treatment protocols were associated with reduced pain and improved knee range of motion over four weeks. Under the dosages used in this trial, Kaltenborn Grade I and II mobilization combined with exercise produced lower post-treatment resting pain and a greater improvement in knee flexion than Maitland Grade II and III mobilization combined with the same exercise program. The modest between-group differences and short follow-up warrant cautious interpretation.

Keywords

Joint mobilization; Kaltenborn technique; Knee pain; Maitland technique; Numeric Pain Rating Scale; Randomized clinical trial; Range of motion

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Fatima K et al. Short Title

Maitland versus Kaltenborn Mobilization for Knee Pain





INTRODUCTION

Knee pain is a common musculoskeletal complaint and a major contributor to limitations in walking, stair negotiation, squatting, and other weight-bearing activities. Knee osteoarthritis is particularly important because its prevalence rises with age and it contributes substantially to disability worldwide (1,2). Pain, joint stiffness, loss of motion, muscle weakness, and reduced activity can interact to produce progressive functional limitation. Contemporary conservative management of knee osteoarthritis emphasizes education, exercise, weight management when appropriate, and individualized non-surgical care (3,4). Manual therapy is frequently incorporated into physiotherapy programs to modulate pain and improve joint mobility. Clinical trials and systematic reviews indicate that manual therapy can produce short-term improvements in pain and function, although the magnitude and durability of benefit vary and the certainty of evidence is not uniformly high (5–9). Manual therapy is therefore best interpreted as an adjunct within an active rehabilitation program rather than as a stand-alone intervention.

The Maitland concept uses rhythmic passive oscillations graded according to symptom irritability and resistance. Grade II consists of relatively large-amplitude oscillations within the available range and is commonly used for pain modulation, whereas Grade III uses large-amplitude oscillations into resistance to address stiffness. Recent randomized studies have demonstrated short-term improvements in pain sensitivity and functional measures after end-range Maitland mobilization in knee osteoarthritis (10,11). The Kaltenborn approach emphasizes traction and translational joint gliding based on joint play. Grade I traction applies a small distraction force to reduce joint compression, whereas Grade II takes up slack in periarticular tissues without a sustained stretch. In clinical practice, these grades are commonly used for pain-dominant or irritable presentations before stronger mobilization is introduced. Evidence supporting manual therapy in patellofemoral and other mechanical knee pain also favors its use as part of a multimodal program rather than in isolation (12,13).

Despite the widespread use of both systems, direct clinical comparisons of Maitland Grade II–III and Kaltenborn Grade I–II mobilization for chronic knee pain are limited. Because the two approaches differ in movement pattern, loading strategy, and treatment intent, a head-to-head comparison may help guide clinical selection. The present study therefore compared Maitland Grade II and III with Kaltenborn Grade I and II mobilization, with both groups receiving the same exercise program, for effects on resting pain and active knee range of motion over four weeks.

MATERIALS AND METHODS

Study design and setting

A randomized, parallel-group clinical trial was conducted in an outpatient physiotherapy department over a four-month period. Participants were recruited using non-probability purposive sampling and then allocated to one of two intervention groups using sealed opaque envelopes. The analyzed sample consisted of 40 participants, with 20 participants in each group.

Participants

Adults aged 30–60 years were eligible if they had unilateral or bilateral knee pain lasting more than three months, an NPRS pain score of at least 4/10, a reduction in knee range of motion of more than 10° compared with the opposite side, and a clinical diagnosis of non-specific knee pain or mild-to-moderate knee osteoarthritis (Kellgren–Lawrence grade 1–3). Exclusion criteria were knee surgery within the preceding six months, ligamentous instability, fracture, tumor, rheumatoid arthritis, gout, neurological deficit, or intra-articular injection during the preceding three months.

Interventions

Both groups attended three treatment sessions per week for four weeks, giving a total of 12 sessions. Group A received Maitland Grade II and III mobilization in addition to the common exercise program. After assessment of irritability and accessory movement, Grade II oscillations were applied to the tibiofemoral joint in the mid-range for two sets of two minutes. Grade III oscillations were then applied toward end range for two sets of two minutes to address stiffness. Anterior–posterior and medial–lateral glides were selected according to the direction of restriction. Group B received Kaltenborn Grade I and II mobilization in addition to the same exercise program. Grade I traction was applied for two sets of one minute for pain modulation. Grade II traction combined with glide was applied for two sets of two minutes to take up slack and improve joint play in the direction of restriction. The common exercise program included quadriceps sets and straight-leg raises (3 sets of 10 repetitions), hamstring and calf stretching (30 seconds, repeated three times), 10 minutes of stationary cycling, and a home exercise program. Exercise is a core component of knee osteoarthritis rehabilitation, and combining active rehabilitation with education or adjunctive manual therapy is consistent with contemporary evidence (3,4,14,15).

Outcome measures

Resting knee pain was measured with the 0–10 Numeric Pain Rating Scale (NPRS), where 0 represents no pain and 10 represents the worst pain. Numerical pain scales demonstrate high test–retest reliability for osteoarthritic knee pain and are suitable for repeated clinical assessment (16). Active knee flexion and extension range of motion were measured in supine using goniometry and recorded in degrees. Outcomes were assessed at baseline and after the four-week intervention period.





Statistical analysis

Data were analyzed using SPSS version 26. Continuous variables are presented as mean±standard deviation (SD), and sex is presented as frequency. The Shapiro–Wilk test was used to assess normality. Between-group differences in NPRS scores were evaluated with the Mann–Whitney U test. Independent-samples t-tests were used for between-group comparisons of continuous normally distributed variables and knee range-of-motion outcomes. Mean change scores for knee flexion and extension were compared between groups using independent-samples t-tests. Sex distribution was compared using the Pearson chi-square test. Statistical significance was set at $p < 0.05$, and all p values were interpreted two-sided.

RESULTS

Forty participants were included in the analysis, with 20 participants in each treatment group. The demographic values reported for age and body mass index (BMI) were similar between groups, and sex distribution did not differ significantly (Table 1). Baseline resting pain, knee flexion, and knee extension were also comparable between groups.

Table 1. Baseline demographic characteristics of the participants

Characteristic	Group Maitland (n=20) + exercise	Group Kaltenborn (n=20) + exercise	p value
Age (years), mean±SD	34.90±7.32	36.85±6.69	0.385
Sex (male/female), n	4/16	6/14	0.465
BMI (kg/m ²), mean±SD	25.41±2.84	27.08±3.14	0.086

Age and BMI were compared with independent-samples t-tests; sex distribution was compared with the Pearson chi-square test.

Resting pain decreased in both groups over the treatment period. At baseline, there was no significant between-group difference in NPRS ($p = 0.295$). At four weeks, Group B had a lower resting NPRS score than Group A (0.85 ± 0.81 vs 1.65 ± 1.03 ; $p = 0.010$), indicating a greater reduction in pain under the Kaltenborn-based protocol (Table 2 and Figure 1).

Table 2. Between-group comparison of resting NPRS scores

Time point	Group Mean±SD A	Group Mean±SD B	Group Mean rank A	Group Mean rank B	Z value	p value
Baseline	4.25±1.06	3.95±1.14	22.35	18.65	-1.04	0.295
Week 4	1.65±1.03	0.85±0.81	24.90	16.10	-2.49	0.010

NPRS, Numeric Pain Rating Scale. Mann–Whitney U test.

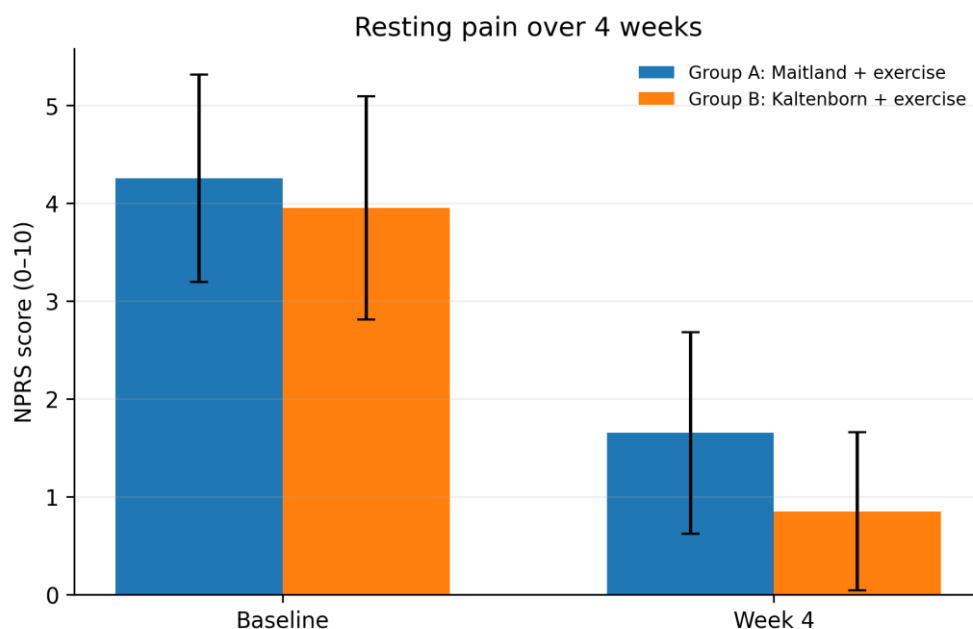


Figure 1. Mean±SD resting NPRS scores at baseline and week 4.



Active knee flexion increased in both groups. Baseline flexion was similar ($p=0.352$), whereas the week-4 mean was higher in Group B ($117.90\pm3.97^\circ$) than Group A ($114.50\pm4.85^\circ$; $p=0.020$). The mean increase in flexion was $9.50\pm2.11^\circ$ in Group B and $7.55\pm1.63^\circ$ in Group A; the between-group difference in change favored Group B ($p=0.002$) (Table 3 and Figure 2).

Table 3. Active knee flexion range of motion

Measure	Group A Mean $\pm$ SD	Group B Mean $\pm$ SD	p value
Baseline flexion ($^\circ$)	106.95 $\pm$ 5.17	108.40 $\pm$ 4.55	0.352
Week-4 flexion ($^\circ$)	114.50 $\pm$ 4.85	117.90 $\pm$ 3.97	0.020
Improvement from baseline ($^\circ$)	7.55 $\pm$ 1.63	9.50 $\pm$ 2.11	0.002

Independent-samples t-tests were used for between-group comparisons.

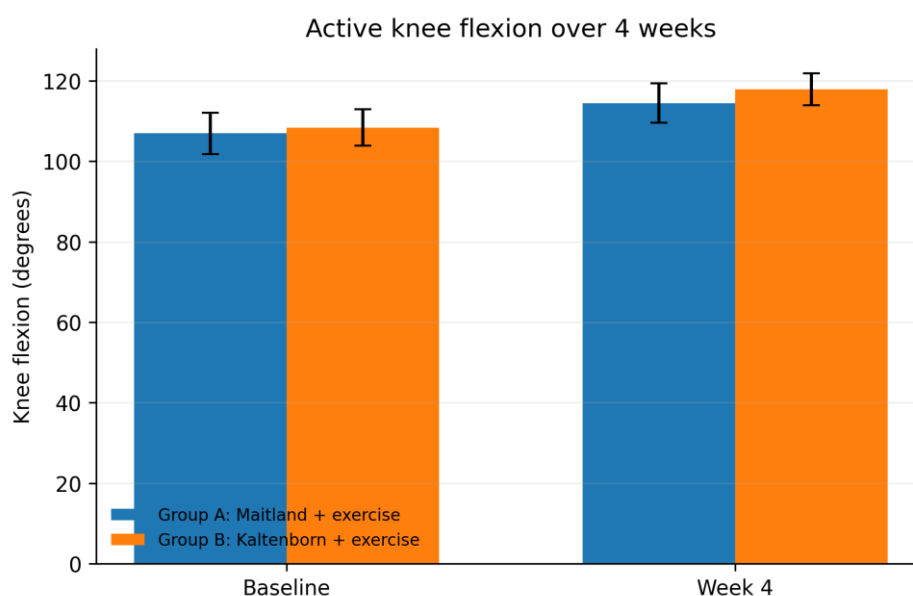


Figure 2. Mean $\pm$ SD active knee flexion at baseline and week 4.

Active knee extension improved in both groups. Baseline extension values did not differ significantly ($p=0.133$). At week 4, Group B had a higher mean extension value than Group A ($1.80\pm2.52^\circ$ vs $0.05\pm2.08^\circ$; $p=0.022$). However, the mean improvement from baseline was $5.30\pm1.65^\circ$ in Group B and $4.80\pm1.67^\circ$ in Group A, and this change-score difference was not statistically significant ($p=0.347$). Accordingly, the data do not demonstrate a clear between-group advantage for extension improvement (Table 4 and Figure 3).

Table 4. Active knee extension range of motion

Measure	Group A Mean $\pm$ SD	Group B Mean $\pm$ SD	p value
Baseline extension ($^\circ$)	-4.75 $\pm$ 2.46	-3.50 $\pm$ 2.68	0.133
Week-4 extension ($^\circ$)	0.05 $\pm$ 2.08	1.80 $\pm$ 2.52	0.022
Improvement from baseline ($^\circ$)	4.80 $\pm$ 1.67	5.30 $\pm$ 1.65	0.347

Independent-samples t-tests were used for between-group comparisons.

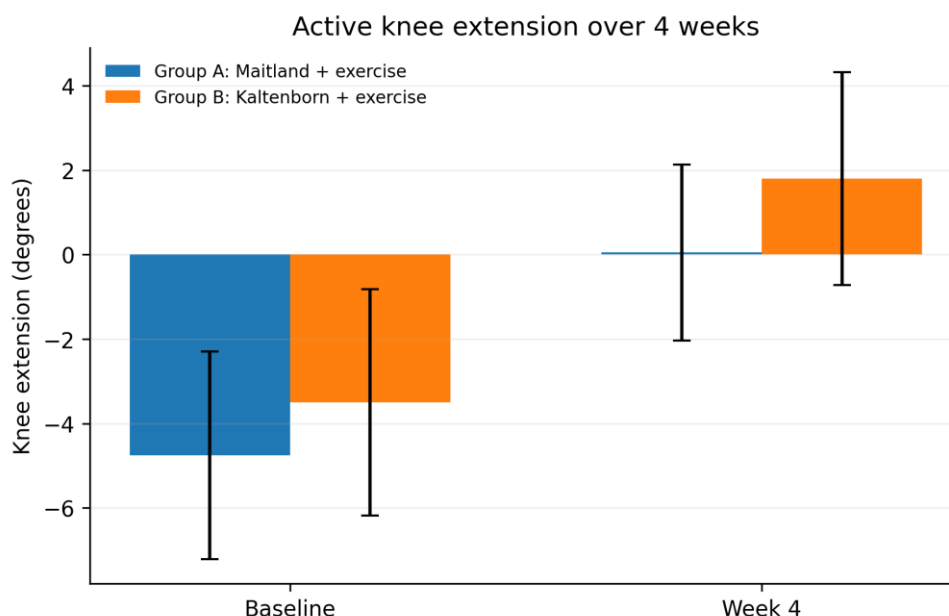


Figure 3. Mean±SD active knee extension at baseline and week 4.

DISCUSSION

This randomized clinical trial compared two commonly used joint-mobilization approaches delivered with the same exercise program. The principal finding was that the Kaltenborn Grade I–II group had lower resting pain at four weeks and a larger gain in knee flexion than the Maitland Grade II–III group. Both groups improved descriptively across pain and range-of-motion outcomes. For knee extension, although the week-4 group means differed, the change from baseline did not differ significantly; therefore, a treatment-specific advantage for extension cannot be concluded from these data. The improvement observed in both groups is consistent with the broader literature supporting multimodal physiotherapy for knee osteoarthritis. Deyle et al. demonstrated meaningful outcomes from a physical-therapy program incorporating manual therapy and exercise, while systematic reviews have reported short-term improvements in pain, range of motion, and function with manual-therapy approaches (5–9). At the same time, recent reviews emphasize heterogeneity in techniques and generally low-to-moderate certainty for many manual-therapy comparisons, which supports cautious interpretation of small between-group differences (7–9).

Maitland mobilization remains biologically and clinically plausible for pain modulation and mobility restoration. Randomized trials by Pozsgai and colleagues found immediate improvements in pain sensitivity and function-related measures after end-range Maitland mobilization in knee osteoarthritis (10,11). Those studies compared Maitland mobilization with sham or different mobilization intensities rather than with Kaltenborn mobilization. The present findings therefore do not contradict evidence that Maitland mobilization can be effective; rather, they suggest that under the present four-week dosing protocol, Kaltenborn Grade I–II mobilization combined with exercise produced somewhat better pain and flexion outcomes. The pain result should also be interpreted clinically rather than only statistically. The week-4 between-group difference in NPRS was 0.80 points. In a psychometric study of osteoarthritic knee pain, the minimum detectable change for the numerical rating scale was approximately 1.33 points (16). Thus, although the post-treatment difference was statistically significant, its clinical magnitude may be modest. A similar caution applies to range of motion because small angular differences may approach normal measurement variability in routine goniometry.

Exercise likely contributed importantly to improvement in both groups. Current guidelines identify exercise as a core intervention for knee osteoarthritis, and systematic evidence supports combining active rehabilitation with education and, when clinically indicated, adjunctive manual therapy (3,4,14,15). For patellofemoral pain, contemporary guidance likewise places exercise and education at the center of treatment and considers manual therapy a supporting intervention tailored to the individual presentation (12,13). Direct evidence comparing Maitland and Kaltenborn mobilization at the knee remains sparse. Other mobilization paradigms, such as mobilisation with movement, have demonstrated sustained improvements when added to usual care in knee osteoarthritis (17). Future comparative trials should use clearly defined diagnostic subgroups, concealed randomization, assessor blinding, standardized treatment progression, functional outcome measures, adherence monitoring, and longer follow-up to determine whether one mobilization strategy offers a clinically important advantage.

CONCLUSION

Maitland Grade II–III and Kaltenborn Grade I–II mobilization, each combined with the same exercise program, were associated with reduced resting pain and improved knee range of motion over four weeks. The Kaltenborn group demonstrated lower post-treatment





resting pain and a greater improvement in knee flexion. Although post-treatment extension values differed, the change in extension was not significantly different between groups. These findings support the use of joint mobilization as an adjunct to exercise while suggesting a possible short-term advantage of the Kaltenborn Grade I–II protocol for pain and flexion in this sample. The modest effect magnitude and short follow-up should be considered when applying the results clinically.

LIMITATIONS

The study had a relatively small analyzed sample and was conducted in a single outpatient setting, limiting generalizability. The four-week follow-up does not establish whether treatment effects were sustained. The inclusion of participants with non-specific chronic knee pain as well as mild-to-moderate osteoarthritis increased clinical heterogeneity. Therapist and participant blinding is difficult in manual-therapy trials and may introduce performance-related bias. Pain and range of motion were the principal outcomes, so broader functional effects were not captured. Variability in adherence to the home exercise program could also have influenced treatment response. Finally, the study used non-probability sampling before random allocation, which may limit representativeness of the sample.

RECOMMENDATIONS

Future adequately powered randomized trials should compare standardized Maitland and Kaltenborn protocols in diagnostically homogeneous knee-pain populations, incorporate validated functional outcomes such as WOMAC or KOOS, document adherence and treatment fidelity, and include longer follow-up. Reporting of effect sizes and confidence intervals would further clarify whether statistically significant differences are clinically meaningful.

REFERENCES

1. Cui A, Li H, Wang D, Zhong J, Chen Y, Lu H. Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies. *EClinicalMedicine*. 2020;29-30:100587. doi:10.1016/j.eclinm.2020.100587.
2. Sharma L. Osteoarthritis of the knee. *N Engl J Med*. 2021;384(1):51-59. doi:10.1056/NEJMcp1903768.
3. Kolasinski SL, Neogi T, Hochberg MC, Oatis C, Guyatt G, Block J, et al. 2019 American College of Rheumatology/Arthritis Foundation guideline for the management of osteoarthritis of the hand, hip, and knee. *Arthritis Care Res (Hoboken)*. 2020;72(2):149-162. doi:10.1002/acr.24131.
4. Bannuru RR, Osani MC, Vaysbrot EE, Arden NK, Bennell K, Bierma-Zeinstra SMA, et al. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. *Osteoarthritis Cartilage*. 2019;27(11):1578-1589. doi:10.1016/j.joca.2019.06.011.
5. Deyle GD, Allen CS, Allison SC, Gill NW, Hando BR, Petersen EJ, et al. Physical therapy versus glucocorticoid injection for osteoarthritis of the knee. *N Engl J Med*. 2020;382(15):1420-1429. doi:10.1056/NEJMoa1905877.
6. Tsokanos A, Livieratou E, Billis E, Tsekoura M, Tatsios P, Tsepis E, et al. The efficacy of manual therapy in patients with knee osteoarthritis: a systematic review. *Medicina (Kaunas)*. 2021;57(7):696. doi:10.3390/medicina57070696.
7. Runge N, Aina A, May S. The benefits of adding manual therapy to exercise therapy for improving pain and function in patients with knee or hip osteoarthritis: a systematic review with meta-analysis. *J Orthop Sports Phys Ther*. 2022;52(10):675-684. doi:10.2519/jospt.2022.11062.
8. Feng T, Wang X, Jin Z, Qin X, Sun C, Qi B, et al. Effectiveness and safety of manual therapy for knee osteoarthritis: an overview of systematic reviews and meta-analyses. *Front Public Health*. 2023;11:1081238. doi:10.3389/fpubh.2023.1081238.
9. Zhu B, Ba H, Kong L, Fu Y, Ren J, Zhu Q, et al. The effects of manual therapy in pain and safety of patients with knee osteoarthritis: a systematic review and meta-analysis. *Syst Rev*. 2024;13(1):91. doi:10.1186/s13643-024-02467-7.
10. Pozsgai M, Péter IA, Farkas N, Than P, Nusser N. End-range Maitland mobilization decreasing pain sensitivity in knee osteoarthritis: randomized, controlled clinical trial. *Eur J Phys Rehabil Med*. 2022;58(3):442-451. doi:10.23736/S1973-9087.22.06680-1.
11. Pozsgai M, Udvarács K, Péter IA, Than P, Nusser N. Effect of single end-range and not end-range Maitland mobilization on pressure pain threshold and functional measures in knee osteoarthritis: randomised, controlled clinical trial. *Eur J Phys Rehabil Med*. 2022;58(5):774-783. doi:10.23736/S1973-9087.22.07506-2.
12. Wallis JA, Roddy L, Bottrell J, Parslow S, Taylor NF. A systematic review of clinical practice guidelines for physical therapist management of patellofemoral pain. *Phys Ther*. 2021;101(3):pzab021. doi:10.1093/ptj/pzab021.





13. Neal BS, Lack SD, Bartholomew C, Morrissey D. Best practice guide for patellofemoral pain based on synthesis of a systematic review, the patient voice and expert clinical reasoning. *Br J Sports Med.* 2024;58(24):1486-1495. doi:10.1136/bjsports-2024-108110.
14. Goff AJ, De Oliveira Silva D, Merolli M, Bell EC, Crossley KM, Barton CJ. Patient education improves pain and function in people with knee osteoarthritis with better effects when combined with exercise therapy: a systematic review. *J Physiother.* 2021;67(3):177-189. doi:10.1016/j.jphys.2021.06.011.
15. Mo L, Jiang B, Mei T, Zhou D. Exercise therapy for knee osteoarthritis: a systematic review and network meta-analysis. *Orthop J Sports Med.* 2023;11(5):23259671231172773. doi:10.1177/23259671231172773.
16. Alghadir AH, Anwer S, Iqbal A, Iqbal ZA. Test-retest reliability, validity, and minimum detectable change of visual analog, numerical rating, and verbal rating scales for measurement of osteoarthritic knee pain. *J Pain Res.* 2018;11:851-856. doi:10.2147/JPR.S158847.
17. Nigam A, Satpute KH, Hall TM. Long term efficacy of mobilisation with movement on pain and functional status in patients with knee osteoarthritis: a randomised clinical trial. *Clin Rehabil.* 2021;35(1):80-89. doi:10.1177/0269215520946932.