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Physical therapy vs. glucocorticoid injection in patients with meniscal tears and knee osteoarthritis: a multi-center, randomized, controlled trial

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Abstract

Background Physical therapy is commonly recommended for treating meniscus tears and knee osteoarthritis (KOA). However, data from randomized trials that compare the effectiveness of this treatment with that of glucocorticoid injections are lacking.

Methods This randomized, single-blind, multicenter trial included 273 patients with KOA who were divided into either the physical therapy group ($n=133$) or the glucocorticoid injection group ($n=140$). The physical therapy included kinesiology tape, exercise protocols, and exercise training programs to increase core stability and peripros-thetic muscle strength. The primary endpoint was the overall Western Ontario and McMaster Universities Osteoarthri-tis Index (WOMAC) score at 1 year. Additionally, proprioception and safety were assessed. All analyses were performed with the use of the intention-to-treat approach. The data are reported as percentages (%) (*n*), and the threshold for statistical significance was $p<0.05$.

Results There was no significant difference in the baseline characteristics between the two groups ($p>0.05$). The average (± SD) WOMAC score at 1-year was 76.85 ± 2.50 in the physiotherapy group. And 99.55 ± 2.09 in the gluco-corticoid injection group (mean difference = − 22.70; 95% confidence interval [95% CI] − 23.43 to − 21.96; $p<0.001$). Compared with the glucocorticoid injection group, the physical therapy group exhibited superior performance in terms of proprioception, especially in the eyes-closed in situ stepping test (14.27 ± 0.75 versus 5.98 ± 0.74; mean difference = 8.29; 95% CI 8.09–8.50; $p<0.001$). The incidence of serious adverse events at the 1-year follow-up was comparable between the two groups. Most of these events were determined to be complications arising from physical therapy and glucocorticoid injection.

Conclusions The results revealed that pain, quality of life, and balance were greater in the physiotherapy group than in the glucocorticoid injection group within the 1-year study period. However, the long-term effects beyond this timeframe remain unknown, and future studies with extended follow-up times are needed to confirm the sustainability of these benefits.

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Trial registration The protocol was approved by the local ethics committee of the ethical commission of the Hebei Sports Science Research Institute (SEC20200213019) and Ethics Committee of Sichuan Taikang Hospital (SCTK-IRB-032). The study was registered at the Chinese Clinical Trial Registry (ChiCTR2000032508).

Keywords Physical therapy, Glucocorticoid injection, Meniscal tear, Knee osteoarthritis

Background

A meniscal tear is a common degenerative alteration of the knee that can be caused by minor twisting or stress while the individual is participating in competitive sports. Degenerative tears in the knee are more common in older individuals because of the age-related loss of elasticity in the menisci [1]. Previous studies have shown that severe meniscus injuries can lead to knee osteoarthritis (KOA) [2]. Furthermore, deterioration of the meniscus has been associated with the deterioration of cartilage in the knee joint, indicating a significant relationship between these two forms of joint pathology. Meniscal tears are particularly common among individuals who suffer from KOA [3], which is a common cause of joint pain and dysfunction among middle-aged and older people [4]. The scourge of plagiarism afflicts countless individuals globally, imposing immense strain upon both those affected directly and our collective social fabric through its pervasiveness and financial implications [5]. Furthermore, previous research has indicated that KOA may increase the risk of cardiovascular disease and all-cause mortality [6].

The most common approach for managing meniscus injuries usually focuses on addressing symptoms alone until the injuries progress to the point where knee replacement is necessary due to the worsening of KOA [7]. Intra-articular glucocorticoid injections are commonly administered to treat degenerative meniscus injuries associated with KOA [8, 9]. A variety of treatment methods, such as intra-articular injections of corticosteroids, hyaluronic acid, and platelet-rich plasma, have been proposed for the nonsurgical management of KOA [10]. These therapeutic approaches are designed to alleviate pain and enhance functionality in individuals who are affected by KOA [11].

Intra-articular corticosteroids are highly effective anti-inflammatory agents that are injected directly into the knee joint. These injections can help alleviate inflammation and provide significant relief for individuals who suffer from KOA [12]. Nonetheless, intra-articular corticosteroid injections are associated with certain risks, such as infection, joint cartilage deterioration, and subchondral insufficiency fractures. Therefore, it is important for patients to discuss these risks with them healthcare provider before proceeding with treatment [13–15]. Exercise-based physical therapy has become the cornerstone for treating osteoarthritis [16]. Studies have shown that physical therapy provides both short-term and long-term pain relief and improves functionality [17, 18]. Both physical therapy and steroid injections have been recommended by medical professionals for the treatment of knee arthritis. However, there is no consensus about which method is more effective for relieving pain and improving joint function over time. Previous clinical trials have shown that physical therapy combined with glucocorticoid injections does not provide further benefits [19].

Furthermore, there is no effective protocol for exercise-based physical therapy; thus, the optimal exercise types, exercise durations, and exercise frequencies have yet to be determined. In clinical settings, patients experience not only knee muscle weakening but also decreases in proprioception and balance. Therefore, physical therapy alone, which mainly focuses on peripheral knee muscle strength training, may not be sufficient to improve a patient's condition [20].

Core stability training is widely used to treat musculoskeletal disorders such as chronic lower back pain [21]. The prevalence of low back pain and KOA has increased independently of population aging [22, 23], and intervertebral disc degeneration and KOA may have significantly similar characteristics. For example, both conditions are characterized by the destruction of cartilage, changes to the subchondral bone, the formation of osteophytes, and a reduction in the joint space. These similarities highlight the need for a comprehensive understanding of degenerative joint conditions, as insights into one condition may inform treatment strategies for the other [24]. Notably, core stability training has been shown to improve the stability of the trunk and pelvis, which in turn can lead to kinematic abnormalities in the lower limbs during exercise, and core stability training may help reduce the force and load on the patellofemoral joints of patients [25, 26]. Through the modulatory effects of neural control subsystems, improvements in the body's proprioceptive functions, coordination, and balance may be related to the mechanism underlying the effects of core stability training [27, 28].

The effects of kinesiotaping (KT) on skin deformation are the result of changes in the stress strain of the skin, suggesting that kinesiotaping may play a prestressing role in the dynamic deformation of the skin [29]. Previous meta-analyses concluded that the KT group showed

significant improvements in self-reported pain during activity, knee-related health status, and proprioceptive sensitivity [30]. However, a meta-analysis revealed that the therapeutic effects of KT were no better than those of sham-taping or conventional therapies in terms of pain intensity, disability, quality of life, return to work, and the global impression of recovery in patients with different musculoskeletal problems [31]. Thus, whether KT is effective in patients with KOA is still controversial.

Core stability training and KT have the potential to be used as exercise modalities for the treatment of meniscal tears and KOA. However, few studies have investigated the efficacy of core stability training in the treatment of KOA; additionally, its mechanism of action is still unclear and deserves in-depth study.

This research aims to compare the treatment efficacy of physical therapy and intra-articular glucocorticoid injections among individuals suffering from meniscal tears and KOA. By comparing the outcomes of these two treatment approaches, this study seeks to provide insight into which method yields better results in terms of managing pain and improving function in this patient population.

Methods

Study design

This multicenter, randomized controlled trial was registered at the Chinese Clinical Trial Registry (ChiCTR2000032508), and the study protocol was approved by the Ethics Committee of Hebei Sports Science Research Institute (SEC20200213019) and Ethics Committee of Sichuan Taikang Hospital (SCTK-IRB-032). Patients were enrolled from June 10, 2021, to July 10, 2021. All patients provided written informed consent. This study was conducted at clinical medical centers in 2 regions in China (Hebei Sports Science Research Institute and Sichuan Taikang Hospital) (Additional file 1: CONSORT list).

Inclusion and exclusion criteria

The inclusion criteria were as follows: radiographically diagnosed with KOA classified as Kellgren-Lawrence scale grades 1–4 (Additional file 2: Table S1), aged between 50 and 70 years, and exhibited symptoms consistent with meniscal injuries, including positive results on the Lachman and McMurray tests. Eligible participants had to exhibit at least one of the following knee symptoms: clicking, catching, popping, a sense of instability, or pain during pivoting or twisting movements. Furthermore, eligible participants had to show signs of osteophytes, signs of a complete cartilage defect evident on knee magnetic resonance imaging (MRI), or radiographic signs of osteophytes or narrowing of the joint space. Moreover, patients had to have a confirmed meniscal tear that extended to the surface of the meniscus on knee MRI (Additional file 2: Figure S1). Finally, all the participants were required to be able to provide informed consent.

The exclusion criteria were as follows: mental inability to participate; inflammatory joint diseases, such as rheumatoid arthritis; crystal arthropathies, such as gout and pseudogout, that specifically affect the knees; recent infections within the last year associated with knee inflammation; or limitations or pain during activities such as sitting, standing, walking, or climbing stairs that were typically more severe than their KOA. Each patient's medical history was screened for any previous allergic or adverse reactions to corticosteroids; corticosteroid injections were not administered if a patient had a history of allergic or adverse reactions to steroids or steroid injections, had received multiple corticosteroid injections in the same area (even if not within the last year), or had uncontrolled diabetes mellitus. Further exclusion criteria were a history of total knee arthroplasty (TKA) or uncompartmentalized knee arthroplasty (UKA); severe organ dysfunction, such as cardiovascular diseases classified as class III or higher by the New York Heart Association; chronic kidney disease at level III or above on the basis of their outcome conditions; liver disease with a Model of End-Stage Liver Disease score of 20 or greater; or a lack of informed consent.

Trial procedures

Participants were recruited via hospital advertising and clinician referrals. All advertising strategies directed potential participants to a preliminary online screening form on the clinician. Those who passed the initial screening underwent full screening over the telephone with a member of the research team. All the participants received education classes, with the aim of providing abasic understanding of meniscus tears and knee osteoarthritis and reducing the degree of fear associated with pain symptoms. Simple strategies to reduce the risk of pain and improve function and instructions on how to self-manage any minor symptoms were discussed.

We performed block randomization at a 1:1 ratio, and we used a central computer-generated randomization scheme based on an electronic data capture (EDC) system. The randomization list was securely locked away and stored on EDC servers, and the allocation information was kept hidden. An investigator who was not involved in the randomization procedure prepared all sequentially numbered, opaque, sealed envelopes containing the assigned interventions to ensure that the sequence was concealed. After the sample size was determined, a third party randomly opened the envelopes to

assign participants to either the physical therapy group or the glucocorticoid injection group sequentially.

To minimize bias and ensure the integrity of the study, in this study, the two groups of patients were blinded to the other treatment groups, as they were treated in different departments and rooms. As masking participants to their treatment assignment was impossible, participants were reminded to avoid discussing their treatment assignment with assessors or other participants. Physiotherapists delivered the intervention but played no role in data collection other than recording session attendance.

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Glucocorticoid injections

Orthopedists or rheumatologists perform intra-articular injections according to clinical standards [32]. One of the orthopedic providers administered an injection into one knee. The injection included 1 ml of triamcinolone acetonide (at a concentration of 40 mg per milliliter) combined with 7 ml of 1% lidocaine [33]. A sterile technique was used. This injection aimed to reduce inflammation and pain while ensuring patient safety during the procedure [34]. The same treatment providers examined patients again at 2 months and 6 months to discuss the continued plan of care, including the appropriateness of additional glucocorticoid injections. Patients could receive up to three injections over the 1-year trial period at the discretion of the clinician. Satisfactory treatment adherence in the glucocorticoid injection group was defined as the completion of the injection.

Physical therapy

The physical therapy included kinesiology tape (LP POINTIQUE INTL LTD., specification: 5 m ×5 cm) and exercise protocols. The most effective procedure for applying kinesiology tape was as follows. The patients were asked to lay in a supine position with their knees and hips slightly flexed for comfort and support. The "anchor" point was positioned on the patella approximately 10 cm from the top of the patella. The two tails were then carefully wrapped around the patella and its sides, stopping approximately 2 cm from the patellar edge to ensure precise alignment [35].

For the second stage, the octopus-type patch was selected, and it was seamlessly interlocked. This patch was strategically placed on the area that caused the most pain, thus providing targeted relief where it was needed most. The muscle patch was maintained for a full 24 h before being replaced the next day. This routine was performed five times a week for 6 weeks to maximize the therapeutic benefits [36].

The exercise protocol included core stability exercises and knee mobilizations. The core stability exercises were as follows. (1) Lunge: The patient stood with the affected side forward, ensuring that the angle of the stride did not exceed 45°. The patient was asked to maintain this position for 3 s before standing. The exercise was performed 15 times per set, a total of 3 sets were performed, and the patient rested for 1 min between sets. (2) Prone bridge. The patient assumed a prone posture with flexed elbows at 90° and was supported below the shoulder joints to maintain a stable torso. This posture was supported by the elbows and feet. The exercise was repeated 15 times per set, a total of 3 sets were performed, and the patient rested for 1 min between sets. (3) Double bridge exercise: The patient laid on their back with their arms at their sides and raised their pelvis while keeping their shoulders, hips, and ankles in a straight line. This position was held for 30 s, after which patients lowered themselves back down. This exercise was repeated 15 times per set, a total of 3 sets were performed, and the patient rested for 1 min between each set.

During training, it was important for patients to maintain their trunk in a neutral position while performing each movement (Additional File 2: Figure S2).

The knee mobilization and muscle strength training exercises were as follows. (1) Straight leg raise exercise: This exercise was performed in the supine position by straightening the leg on the affected side and slowly raising it upward to 45°. The position was maintained for 3 s before the leg was slowly lowered. (2) Seated knee extension exercise: The patient sat on a quadriceps chair and slowly extended the knee within the pain-free range. (3) Clam training: The patient assumed a lateral position, and an elastic band was placed around both knee joints to increase resistance. The heels were placed together, and the knees were bent upward. This exercise was repeated 15 times per set, a total of 3 sets were performed, and the patient rested for 1 min between each set (Additional File 2: Figure S3).

The participants underwent exercise training four times a week for 6 weeks, and they were all guided by the same rehabilitation physician and followed the same rehabilitation protocol. The patients were monitored before and after treatment, and adverse event data were recorded. During the study, participants were provided with standardized exercise logs to record the frequency, duration, and perceived intensity of their home-based exercises. Additionally, supervised sessions were conducted biweekly at the clinical centers to reinforce proper technique and monitor progress. Training was immediately stopped if any adverse reactions, such as pain or

swelling, occurred. Satisfactory treatment adherence in the physical therapy group was defined as attendance at 3 or more of the 6 weeks.

If, after a period of at least 6 weeks of physical therapy, the participant continued with symptomatic knee instability or symptoms related to associated pathology (i.e., pain or locking), physical management was considered unsuccessful. This intermediate outcome was confirmed at a review clinical appointment, and the following criteria were confirmed: continued feeling of knee instability or symptoms (i.e., pain or locking) related to the associated pathology and at least two episodes of giving way to the knee.

Assessments and outcomes

We assessed outcome measures for pain, function, and serious adverse events according to current recommendations [37]. Outpatient follow-up, telephone-based follow-up and online follow-up assessments were conducted at 2, 4, 6, and 12 months. Those months were selected for the primary outcome assessment, as knee function typically improves significantly in the first 2 and 4 months after the intervention, shows slight improvements between 6 months, and then tends to stabilize at 12 months [14, 38].

The primary outcome of the study was the total score on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) at 12 months. The WOMAC effectively measures three critical dimensions—knee pain, stiffness, and physical function—on a scale ranging from 0 to 240. A higher score indicates more severe knee disease. This index allows an assessment of the effectiveness of the treatment interventions over time [39]. The reliability and validity of the WOMAC total score have been used in many behavioral interventions for OA trials. Studies have shown that the intraclass correlation coefficients for the WOMAC pain, stiffness, and physical function subscales are 0.81, 0.76, and 0.85, respectively [40, 41].

The secondary outcome included quality of life, which was measured with the SF-36 scale. This scale includes four dimensions: physical functioning, physical functioning, somatic pain, and social functioning. Higher scores on the SF-36 indicate a better quality of life [42] (Additional File 2: Figure S4).

The treatment efficacy of the two interventions was evaluated by examining changes in range of motion and the total effective rate (which was calculated as the basic disappearance of knee pain symptoms and a reduction in the 100-mm visual analog scale (VAS) pain score by at least 30%) between the pre- and postintervention timepoints. The treatment efficacy was calculated as follows: [(preintervention VAS score − postintervention VAS score)/preintervention VAS score] × 100%.

Both groups of patients were subjected to assessments of joint balance before and after treatment. The balance assessments were as follows. (1) Eye-closed single-leg standing test: The patients were asked to stand on one leg with their eyes closed, and the length of time until the other leg fell to the ground or the length of time until the patient stood on the ground and stepped out of the test area (40 cm in diameter) was recorded (Additional File 2: Figure S5). (2) Eye-closed in situ stepping test: The patient was asked to stand in the center of the test area (40 cm in diameter) with their eyes closed and step in situ at a frequency of 120 steps/min (Additional File 2: Figure S6). The two tests were repeated three times, and the maximum value of the results was taken. These forms of testing have been extensively used in assessments of balance and exercise with elderly individuals, and an internal consistency reliability of 0.85 to 0.95 has been reported for this method [43].

The Copenhagen Knee ROM Scale (CKRS) was used to assess patient-reported passive range of motion (ROM), i.e., flexion (60–135) and extension (45–50), as well as estimated proportions of patients with flexion or extension deficits (Additional File 2: Figure S7). This scale appears reliable and valid compared with reports of similar tools (for flexion < 110, the sensitivity of patient estimates was 88%, and the specificity was 88%), and patient estimates are better correlated with goniometer measurements [44].

The minimal clinically important difference between the total WOMAC score and the SF-36 score has been reported to be a 12 or 16% improvement from baseline [45]. A minimum clinically important difference of > 50% reduction on the VAS scale (score of 1.5–3) has been proposed in clinical trials [46, 47]. The point estimates for the minimum clinically important difference in knee flexion ranged from 3.8° to 6.4° [48].

There is no published minimal clinically important difference for the balance control test. Estimates of clinically important improvements in the eyes-closed single-leg standing test and eyes-closed in situ stepping test range from least a 10% improvement (3–10 s) [49, 50].

In addition to the occurrence of serious adverse events, including death, infection, and fracture, the definition of an adverse event included persistent exacerbation of symptoms and the emergence of complications necessitating further treatment beyond the confines of the trial. At each follow-up visit, patients were asked to disclose any perceived adverse outcomes related to their treatment, including any complications, signs, or symptoms they might have observed.

Statistical analysis

We carefully determined the required sample size by performing a power analysis via PASS software version 11.0, with power = 0.80 and a significance level (alpha) of 0.05. The sample size was calculated via the WOMAC, with a standard deviation of 30.70 [14].

This process revealed that the required sample size was 87 participants. Owing to the use of two distinct groups within the study design as well as the risk of a 10% dropout rate [51], we determined that the required sample size was 287 individuals across the intervention and control cohorts. This sample size ensured robust statistical validity and minimized potential bias due to attrition.

Statistical evaluations were performed with SPSS version 29.0 (IBM Corp., Inc., Chicago, IL, USA) and R software (version 4.2.1). All analyses were performed with the use of the intention-to-treat approach. The data were documented as percentages (%) alongside their respective sample sizes (*n*). To account for the longitudinal nature of the data, repeated-measures ANOVA and mixed-effects models were employed to analyze within-group and between-group differences over time. These models were chosen to analyze repeated measurements and account for potential correlations within subjects across follow-up intervals.

Effect sizes were calculated via Cohen's *d* for continuous outcomes to assess the clinical significance of the findings. Cohen's *d* was calculated as the mean difference between groups divided by the pooled standard deviation, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effect sizes, respectively. Chi-square tests were performed to analyze categorical data across the groups. Sensitivity analyses were performed to address the issue of missing data via multiple imputations, incorporating covariates associated with baseline characteristics and missing values at the 12-month mark. Variables related to missing data and baseline characteristics were included as covariates in the mixed-model approach, with the Markov chain Monte Carlo method being used with 20 imputations in the sensitivity analyses.

Outcome analyses highlighted mean differences between groups, with insights provided through least squares means and 95% confidence intervals. For categorical outcomes, relative risks and risk reductions were calculated. Statistical significance was determined at $p < 0.05$. However, p values and their corresponding 95% confidence intervals for post hoc pairwise comparisons for all outcomes are reported with Bonferroni adjustment.

Results

Patient characteristics

From June 10, 2021, to July 10, 2021, 310 individuals with osteoarthritis and meniscus tears were evaluated; 287 individuals were selected for our research. A total of 14 patients were lost to follow-up, including 10 patients in the physical therapy group (unfollowed rate of 7.5%) and 4 patients in the glucocorticoid injection group (unfollowed rate of 2.9%). The primary reasons for exclusion included an unwillingness to complete follow-up assessments and a change in telephone number. Therefore, a total of 273 patients completed the study, including 133 individuals in the physical therapy group and 140 in the glucocorticoid injection group (Fig. 1).

In the physical therapy group, the mean age of the participants was 57.68 years. Women accounted for 42% of the patients in this group. The average body mass index (BMI) value, which is calculated by dividing weight (in kilograms) by the square of height (in meters), was found to be approximately 27.68. Additionally, there was a predominance of right knee injuries in the physical therapy group (Table 1).

There were no significant differences between the two groups in terms of age, sex, BMI, duration of symptoms, or measures ($p > 0.05$). Compared with the glucocorticoid injection group, the physical therapy group presented higher rates of knee buckling and knee locking, whereas the glucocorticoid injection group presented a greater proportion of patients with symptoms in both knees.

Primary and secondary outcomes

The mean (± SD) total WOMAC score at 1 year was 76.85 ± 2.50 in the physical therapy group and 99.55 ± 2.09 in the glucocorticoid injection group (mean difference = − 22.70; 95% confidence interval [95% CI] −23.43 to −21.96; $p < 0.001$). The results revealed that the physical therapy group had lower WOMAC scores, particularly at 8 to 12 months, thus indicating improvements in pain, function, and stiffness (Fig. 2). The WOMAC can be divided into the pain subscale, physical function subscale, and stiffness subscale. Analyses of the subscales revealed that the physical therapy group had better scores than the glucocorticoid injection group did, especially at 6 to 10 months (Additional File 2: Fig. 8).

In this study, the mean VAS score was 1.44 ± 0.69 in the physical therapy group and 3.66 ± 0.77 in the glucocorticoid injection group (mean difference = − 2.22; 95% CI −2.44 to −1.98; $p < 0.001$). At 1 year, patients in the physical therapy group had better SF-36 scores than patients in the glucocorticoid injection group did (91.27 ± 3.59 versus 79.16 ± 1.63; mean difference = 12.11; 95% CI 11.36–12.85; $p < 0.001$) (Table 2). A comparison of

Fig. 1 Flowchart of enrollment, randomization, follow-up, and analysis

the SF-36 score improvement benchmarks at 1 year in this trial revealed that in the physical therapy group, 63 patients achieved at least a 50% improvement, whereas in the glucocorticoid injection group, 34 patients failed to achieve a 50% improvement (RR = 1.78; 95% CI 0.22–7.11) (Additional File 2: Table S2).

In patients with improved knee function, the mean range of motion was 121.21 ± 3.21 in the physical therapy group and 111.21 ± 1.96 in the glucocorticoid injection group (mean difference = 10.00; 95% CI 9.30 to 10.70, $p < 0.001$). The trial results indicated that patients who received physical therapy had better proprioception than those who received glucocorticoid injections did, especially in the eyes-closed in situ stepping test (14.27 ± 0.75 versus 5.98 ± 0.74; mean difference = 8.29; 95% CI: 8.09–8.50, $p < 0.001$) (Figs. 3 and 4).

The treatment efficacy was examined among patients with KOA and degenerative meniscus injuries who underwent physical therapy intervention and those who underwent control intervention. The results revealed

Table 1 Baseline characteristics of the patients

Characteristics	Glucocorticoid $_{injection}$ (*N*=140)	^{Physical} therapy	*P* values	*t* values
		(*N* = 133)		
Age, years	58.11 ± 4.68	57.68 ± 4.01	0.47	0.72
Female sex, no. ((%))	60 (43)	54 (41)	0.50	2.31
Body mass index (BMI)	28.03 ± 2.56	27.68 ± 3.22	0.44	0.78
Duration of symptoms, mo[a]	66.71 ± 9.23	66.88 ± 8.95	0.91	0.11
Baseline symptoms, no./total no. (%)				
Knee swelling	37/140 (26)	51/133 (38)	0.05	1.21
Knee giving way	53/140 (38)	61/133 (46)	0.05	0.88
Knee locking	67/140 (48)	59/133 (44)	0.05	2.30
More symptomatic knee, no. (%)				
Right knee	51 (36)	58 (44)	0.05	1.55
Left knee	48 (34)	47 (35)	0.53	3.37
Equal	41 (29)	28 (21)	0.05	2.22
Symptoms in both knees, no./total no. (%)	81/140 (58)	73/133 (55)	0.04	1.96
Kellgren-Lawrence grade, no. (%)[b]				
1	35 (25)	40 (30)	0.03	2.78
2	67 (48)	63 (47)	0.15	0.81
3	30 (21)	21 (16)	0.03	2.26
4	8 (5.7)	9 (6.8)	0.01	0.45
Baseline measures				
WOMAC total score[c]	107.73 ± 5.54	114.86 ± 7.27	0.41	0.82
VAS score[d]	6.77 ± 0.74	6.85 ± 0.67	0.53	0.63
SF-36 score[e]	74.06 ± 3.66	74.90 ± 3.44	0.19	1.34
Range of motion (°)	111.06 ± 3.63	110.92 ± 2.65	0.80	0.25
Eyes-closed single-leg standing test	4.07±0.99	4.22±0.92	0.38	0.89
Eyes-closed in situ stepping test	5.90 ± 0.68	5.92 ± 0.65	0.90	0.13

[a] Duration of symptoms reported by the patients; [b]Grades on the Kellgren–Lawrence scale ranging from 0 (no radiographic evidence of osteoarthritis) to 4 (large osteophytes, marked narrowing of the joint space); [c]The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) total scores range from 0 to 240, with higher scores indicating worse pain, function, and stiffness; [d]100-mm visual analog scales range from 0 to 10, with higher scores indicating worse pain; [e]The SF-36 scale consists of eight dimensions of physical functioning, physical functioning, somatic pain, and social functioning; the higher the score is, the greater the improvement in quality of life

that 83 patients (80%) in the physical therapy group had excellent outcomes, 26 patients in this group had good outcomes, 51 patients (52%) in the control group had excellent outcomes, and 22 patients in this group had good outcomes. Therefore, the treatment response was significantly better in the physical therapy group than in the glucocorticoid injection group, indicating that there were meaningful disparities in the results. A greater number of patients in the glucocorticoid injection group reported moderate to unsatisfactory outcomes than did those in the physical therapy group. This finding suggests that treatment modality may influence patient outcomes (Table 3).

The overall direction of the primary outcome results remained unchanged after three post hoc sensitivity analyses. These analyses were performed in the following ways: first, with imputation for missing data; second, with the exclusion of 14 participants without WOMAC data at one year; and third, with adjustment for differences in radiographic severity and duration of symptoms at baseline (Additional File 2: Table S3). The physical therapy group showed an improvement in the total WOMAC score, SF-36 score of at least 12%, knee flexion improvement of at least 3.8%, a reduction of > 50% on the VAS scale, and a balance control test score of least 10% improvement from the follow-up (with the minimal clinically important difference).

Adverse events were monitored throughout the study. In the glucocorticoid injection group, minor side effects, such as transient pain at the injection site (n = 10) and allergic reactions (n = 5), were reported. In the physical therapy group, aggravation of pain (n = 14) and knee swelling (n = 3) were the most commonly reported adverse events, and these symptoms were relieved by the application of ice packs. No serious complications were observed in either group. These findings suggest

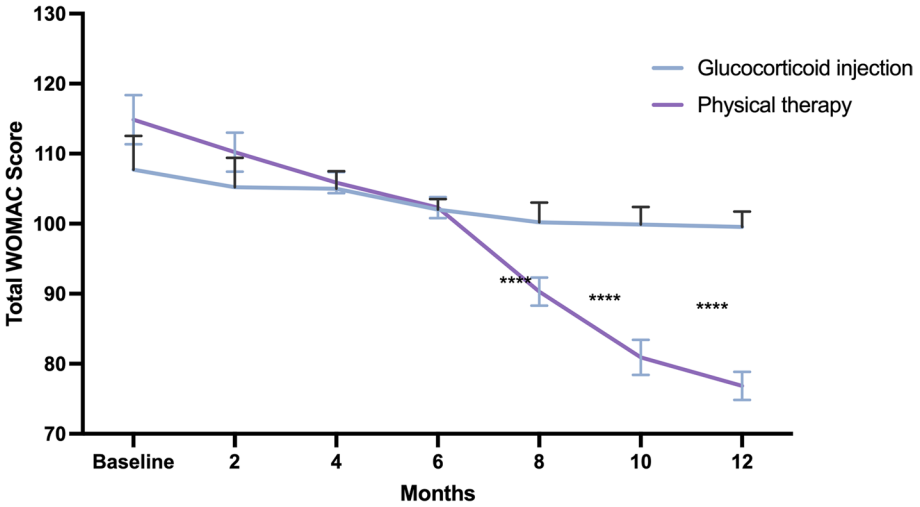

Fig. 2 Total Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores over the 12-month follow-up period. ****: $P < 0.001$; all 273 participants were included in the analysis. The total scores of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) range from 0 to 240, with higher scores indicating worse pain, function, and stiffness

Table 2 Primary and secondary outcomes at 1 year[a]

Outcomes	Glucocorticoid injection	Physical therapy	Mean between-group difference (95% CI)	*P* Values	Cohen's *d*
Total WOMAC Score	99.55 ± 2.09	76.85 ± 2.50	− 22.70 (− 23.43 to − 21.96)	< 0.001	1.12
VAS Score	3.66 ± 0.77	1.44 ± 0.69	− 2.22(− 2.44 to − 1.98)	< 0.001	0.89
SF-36 Score	79.16 ± 1.63	91.27 ± 3.59	12.11 (11.36–12.85)	< 0.001	1.05
Range of Motion	111.21 ± 1.96	121.21 ± 3.21	10.00 (9.30–10.70)	< 0.001	0.92
Eyes-Closed Single-Leg Standing Test	4.53 ± 1.05	12.63 ± 1.31	8.10 (7.80–8.41)	< 0.001	1.18
Eyes-Closed In Situ Stepping Test	5.98 ± 0.74	14.27 ± 0.75	8.29 (8.09–8.50)	< 0.001	1.23

[a] All 273 patients were included in the analyses. The 95% confidence intervals and reported *P* values were adjusted with the use of Bonferroni correction for multiple comparisons

that both interventions are generally safe, but clinicians should be aware of potential minor side effects.

During the treatment and follow-up periods, the Hamilton Depression Scale (HAMD-24) was used to assess pain-related distress and psychogenic pain. All the participants received careful clinical examinations to identify features indicative of somatic disease, functional somatic disorders, or mental disorders, and no pain-related distress or mental disease was recorded.

Discussion

This study aimed to compare the effects of physical therapy and glucocorticoid injections in patients exhibiting clinical and radiographic signs of meniscal tears along with KOA in one or both knees. The findings revealed that after 1 year of follow-up, physical therapy was more beneficial than were glucocorticoid injections. These findings suggest that physical therapy may offer greater long-term benefits for managing symptoms in this patient group.

The objective of this analysis was to evaluate the overall WOMAC score after 1 year. The WOMAC assesses knee pain, stiffness, and physical function. Our findings revealed that the physical therapy group had significantly lower WOMAC scores, particularly between 8 and 12 months. After 1 year, the median visual analog scale (VAS) score was notably lower in the physical therapy group than in the glucocorticoid injection group. This finding, namely, that participants who received physical therapy reported less pain and discomfort, highlights the potential advantages of this treatment approach in terms of managing KOA and its associated symptoms over time. Patients receiving physical therapy achieved better SF-36 scores and a greater range of motion than those receiving glucocorticoid injections did. In this trial, we observed

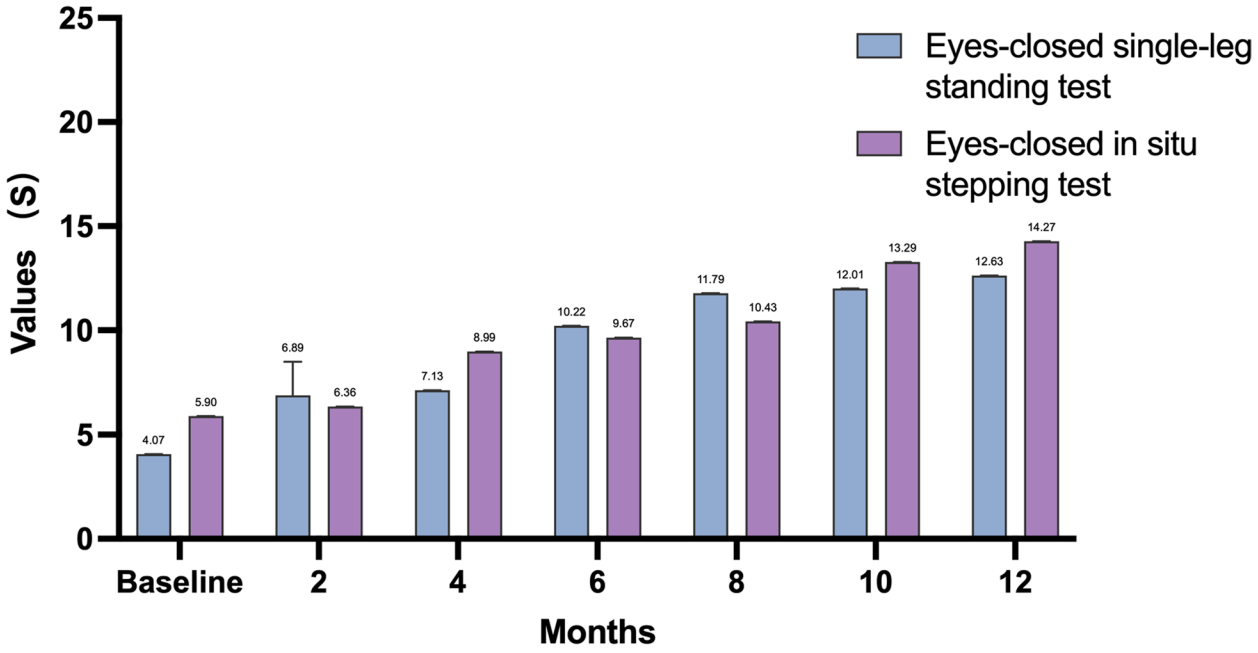

Fig. 3 Eye-closed single-leg standing test and eyes-closed in situ stepping test results in the physical therapy group over the 12-month follow-up period

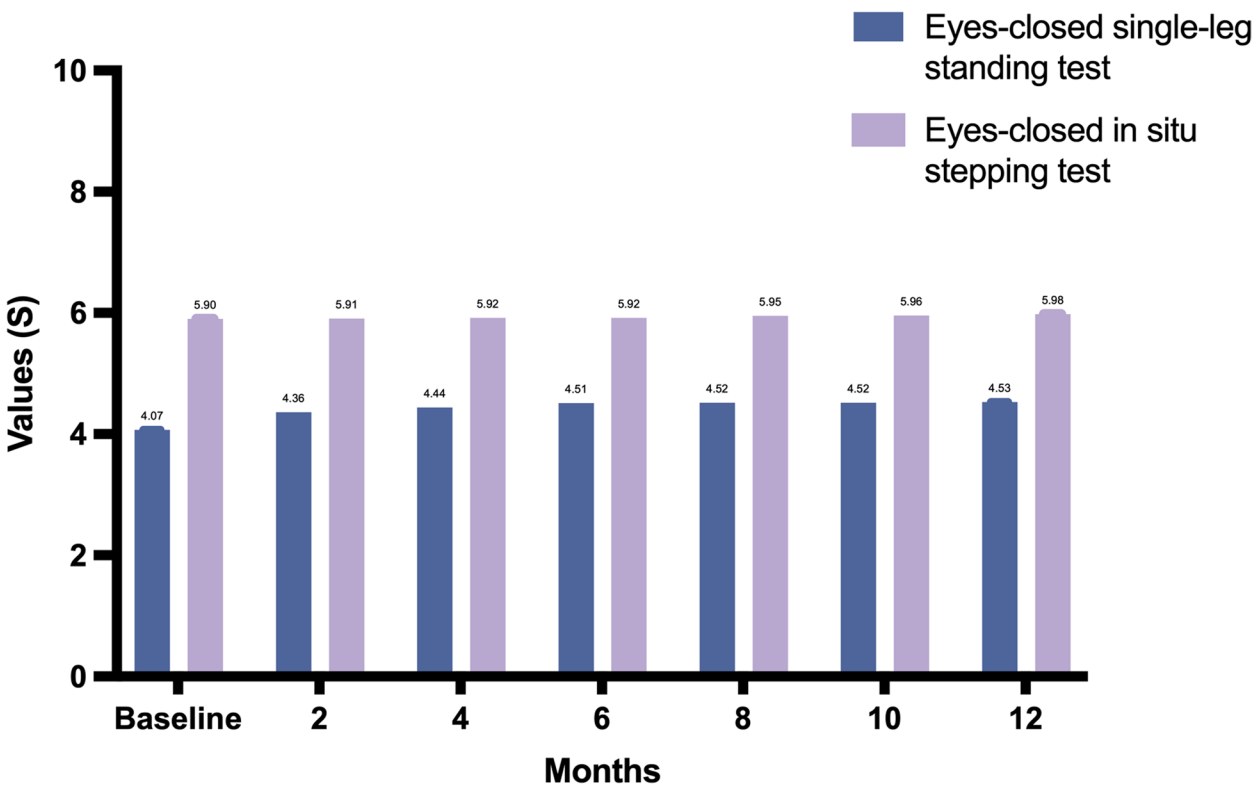

Fig. 4 Eye-closed single-leg standing test and eyes-closed in situ stepping test results in the glucocorticoid injection group over the 12-month follow-up period

Table 3 Comparison of efficacy 1 year after treatment[a]

Physical therapy group, no./total		Glucocorticoid injection	
Grade	**no. (%)**	**Group, no./total no. (%)**	***P* values**
Excellent	83/133 (62)	51/140 (36)	< 0.001
Good	24/133 (18)	22/140 (16)	< 0.001
Medium	13/133 (10)	26/140 (19)	< 0.001
Poor health	13/133 (10)	41/140 (29)	< 0.001

[a] All 273 patients were included in the analyses. The total effective rate was calculated as the basic disappearance of knee pain symptoms and a reduction in the pain score (VAS) of at least 30%

improvements in patient-reported and functional performance outcomes after physical therapy or glucocorticoid injection that were similar to those reported in previous studies [52, 53]. Although our results favor treatment with physical therapy for most outcomes, they do not oppose the use of glucocorticoid injection as a treatment option.

Previous studies examining the effects of physical therapy on KOA and meniscal tears have demonstrated substantial short-term benefits that exceed the thresholds for minimal clinically important differences when comparing changes in primary outcomes from baseline [54, 55].

Furthermore, these studies suggested that the positive effects of physical therapy were not just temporary but persisted even up to the 1-year timepoint, thus indicating a durable impact on patient recovery and symptom management [56, 57]. In this study, we observed immediate benefits from physical therapy; however, 1 year later, the average WOMAC, VAS, and SF-36 scores and the range of motion significantly decreased from the baseline measurements. These findings suggest that physical therapy not only provides immediate benefits but also leads to superior long-term outcomes with respect to function and quality of life. Recent advances have also shown that exercise can suppress inflammation and catabolic activity while promoting anabolic processes, thereby contributing to the maintenance of metabolic homeostasis. This finding highlights the potential of exercise not only as a means of improving physical function but also as a crucial component for managing inflammatory responses and promoting overall metabolic health. Exercise has been shown to increase lubricin, mitigate the risk of osteoarthritis [58], significantly decrease the concentration of the anti-inflammatory mediator IL-10 [59], and affect the concentration of the cartilage degradation marker COMP [60].

Exercise has long been known to have beneficial effects on articular cartilage health. However, it remains unclear which specific types of exercise are most beneficial, as well as the optimal magnitude, duration, and frequency of exercise required to achieve improvements in patients with meniscal tears and KOA. Further research is needed to address these questions to inform tailored exercise recommendations for this patient population [61]. In our study, we investigated the implementation of an evidence-based rehabilitation regimen aimed at tailoring the specific type, intensity, and frequency of exercise to individuals who suffer from both meniscal tears and KOA.

This comprehensive approach involved increasing lower limb muscular strength through targeted workouts, honing proprioceptive acuity, and bolstering core resilience—a multifaceted strategy designed to optimize therapeutic outcomes while mitigating potential risks associated with these coexisting conditions (Additional File 2: Table S4).

Despite advances in patellofemoral pain, however, studies of core stability training in patients with osteoarthritis are still scarce. This study suggests that core stability training can effectively enhance patients' proprioception and balance, thereby reducing the risk of falls. Some researchers have also reported that core stability training can improve joint function and significantly improve dynamic and static balance in older women, which is consistent with the findings of this study [62].

The strengths of this trial include not only that the intervention groups had statistically significant results but also that the minimum clinically important difference was achieved. In clinical trials, the results are usually reported as the means of outcomes at the group level, which is difficult to interpret for patients. The concept of minimal clinically important difference (MICD), which is defined as the smallest improvement in the domain of interest that patients perceive as beneficial, was proposed to present the effect of intervention at the individual level. An advisable design using MICD is based on a "responder analysis," namely, comparing the proportion of patients with each intervention who experienced a change greater than MICD. This type of data presentation can provide patients with more straightforward information to decide whether a treatment should be used [63].

There are limitations to this study. Importantly, the sample size of the study was limited, indicating that further research is necessary to investigate the relationship between follow-up duration and patient outcomes. Second, the relationship between the treatment period and the frequency of patient outcomes remains unclear. The study indicated that individuals who were treated with physiotherapy had a higher incidence rate than those who were treated with glucocorticoid injections did (Additional File 2: Table S5).

However, the overall direction of the primary outcome results remained unchanged after three post hoc sensitivity analyses. This study design specifically focused on comparing two commonly used clinical interventions (physical therapy vs. glucocorticoid injection) to address practical decision-making needs in real-world practices, and the absence of a no-treatment control may limit definitive conclusions about absolute efficacy versus natural history. Thus, in the future, three-arm trials including sham/no-treatment groups should be conducted. Although interpretation of the magnitude of improvement is challenging without a sham control, our results suggest that physical therapy, especially core stability training, may be a viable treatment option for some patients with meniscus tears and knee osteoarthritis, as suggested by a previous randomized trial [53]. Additionally, a greater percentage of patients in the glucocorticoid injection group than in the physical therapy group exhibited severe arthritis (i.e., Kellgren–Lawrence grades 3 and 4). This disparity suggests that the glucocorticoid injection group may have included patients with more advanced disease, which could influence treatment outcomes and responses to therapy. Additionally, although the main findings provide valuable insights into the population studied, caution should be exercised when extrapolating these results to other ethnic or geographic groups. Differences in genetic background, environmental factors, and healthcare practices may influence the results and generalizability of the findings.

Furthermore, future multicenter, multinational studies are needed to validate these findings in diverse populations, including Western populations. Such studies would help to determine the wider applicability of the findings and identify potential variations between different populations. Moreover, the use of self-reported exercise logs in this study may have introduced recall bias, and future studies could benefit from objective adherence monitoring (e.g., wearable sensors or telehealth check-ins).

Conclusions

In conclusion, the findings of the present study indicated that physical therapy further ameliorated the degree of osteoarthritis-associated pain, quality of life, joint mobility, and balance in the physical therapy group. Accordingly, physical therapy, particularly core stability training, can significantly increase function and mobility in patients with meniscal tears in conjunction with KOA. This type of targeted exercise regimen helps strengthen the supporting muscles, improve balance, and promote overall joint stability, thereby leading to better movement and reduced pain in these patients.

Abbreviations

CI	Confidence interval
KOA	Knee osteoarthritis
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index score
KT	Kinesiotaping
MRI	Magnetic resonance imaging
TKA	Total knee arthroplasty
UKA	Uncompartmentalized knee arthroplasty
EDC	Electronic data capture
SF-36	SF-36 Health Survey
VAS	Visual analog scale
CKRS	The Copenhagen Knee ROM Scale
ROM	Range of motion
BMI	Body mass index
HAMD-24	Hamilton Depression Scale
MCID	Minimal clinically important difference

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12916-025-04113-y.

Additional file 1. CONSORT checklist.

Additional file 2. Table S1. [The Kellgren & Lawrence classification of osteoarthritis]. Figure S1. [Confirmation of meniscal tear and knee osteoarthritis via magnetic resonance imaging (MRI)]. Figure S2. [Core stability exercises]. Figure S3. [Knee mobilizations and muscle strength training]. Figure S4. [SF-36 health survey]. Figure S5. [Eye-Closed Single-Leg Standing Test]. Figure S6. [Eye-Closed in Situ Stepping Test]. Figure S7. [Copenhagen knee ROM scale]. Figure S8. [Scores on the WOMAC subscales over the 12-month follow-up period]. Table S2. [Group comparison for SF-36 score improvement benchmarks at 1-year]. Table S3. [Sensitivity analyses for primary outcome]. Table S4. [The physical therapy protocol]. Table S5. [Dosing and timing of care delivered to trial subject].

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Plans to give access to the full protocol, participant-level data and statistical code

The study protocol is publicly available on the website Chictr.org.cn with registration number: ChiCTR2400089758. The trial datasets generated or analyzed during the current study during the study are not publicly available.

Authors' contributions

ML, CJ were involved in made protocol and participated in the conception, study design, assessments, data interpretation, wrote the main manuscript. CJ and KNL development of intervention methods. KNL took part in management, analysis and data interpretation. All authors read and approved the final manuscript.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The trial had been conducted in accordance with the Declaration of Helsinki. The protocol has been approved by the Ethics Committee of Hebei Sports Science Research Institute on 13 Feb 2020 (ethical approval number: SEC20200213019) and approved by the Ethics Committee of Sichuan Taikang Hospital (SCTK-IRB-032). All participating patients had provided written informed consent.

Consent for publication

This manuscript does not contain individual personal data from patients.

Competing interests

The authors declare no competing interests.

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