

Research Article

The Comparative Study of Clinical Efficacy of Different Load-bearing Exercise Therapies for Early Knee Osteoarthritis Patients

Hongbin Long¹ , Shungui Zhou² , Jinfan Yang² , Ning Liu¹ ,
Songwei Huan^{1,*} 

¹The First Affiliated Hospital of Jinan University, Jinan University, Guangzhou, China

²Wuhua County People's Hospital, Meizhou, China

Abstract

Objective: This study aims to investigate the effects of different weight-bearing exercise therapies combined with conventional drug treatment on knee biomechanics and functional outcomes in patients with early-stage knee osteoarthritis (KOA), conduct comparative analyses, clarify the clinical value of progressive load training, and provide evidence-based support for optimizing conservative treatment strategies for early-stage KOA. **Methods:** A total of 150 patients with unilateral KOA meeting Kellgren-Lawrence grade I-II criteria were enrolled and randomly assigned to three groups: conventional drug therapy (control group), non-weight-bearing exercise therapy, and progressive weight-bearing exercise therapy, with 50 patients in each group. The intervention period lasted 12 weeks. Patients underwent assessments of Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores, Visual Analogue Scale (VAS) scores, Timed Up and Go Test (TUG), Stair Climbing Test (SCT), and isometric quadriceps strength testing at baseline and at weeks 4, 8, and 12. The progressive loading group incorporated 5-pound and 10-pound resistance bands during training. **Results:** Patients in the progressive resistance group demonstrated the most significant improvements in WOMAC scores, VAS scores, TUG, SCT, and isometric strength tests ($P < 0.01$). Compared to the conventional therapy group, the non-resistance exercise group also showed some improvement, but the effect was inferior to that of the progressive resistance group. Gait parameter analysis revealed that the progressive resistance group exhibited marked improvements in stride length and stance time, indicating superior knee stability and lower limb function. **Conclusion:** Progressive weight-bearing exercise therapy combined with conventional drug treatment significantly enhances quadriceps strength, improves joint function, alleviates pain, and optimizes gait mechanics in patients with early-stage KOA. This approach demonstrates superior safety, efficacy, and practicality compared to traditional drug therapy and non-weight-bearing exercise interventions, making it suitable for widespread adoption in primary care facilities and rehabilitation centers.

Keywords

Knee Osteoarthritis, Load Exercise Therapy, Isokinetic Strength, Gait Analysis

*Corresponding author: jnuhuan@163.com (Songwei Huan)

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1. Introduction

Osteoarthritis (OA) is a degenerative joint disease that severely affects patients' quality of life and is one of the top four disabling diseases [1]. The overall prevalence of symptomatic knee osteoarthritis (KOA) in China is 14.6% (95% CI = 11.4–18.5%). Its prevalence steadily increases with age after 40 years old [2]. Furthermore, this condition is more common among women and rural populations, with significantly higher prevalence rates than men and urban residents [3, 4]. Among the Chinese population over 60 years old, the overall prevalence of KOA is nearly 40%, and it is even higher among middle-aged and elderly people in rural and mountainous areas due to perennial physical labor, slower pace of life, and weaker health awareness [5]. The consequences include not only a decline in individual functional activity capacity but may also lead to a series of chain reactions such as limited mobility, depressive mood, and reduced social participation [6], thereby severely impairing patients' quality of life.

Currently, there is no effective cure for KOA. In the traditional OA treatment system, strategies are mainly limited to drug therapy and surgery [5, 7]. Nonsteroidal anti-inflammatory drugs (NSAIDs), analgesics, and cartilage protectants can alleviate pain and improve mobility to some extent [8, 9], but these drugs often have significant side effects, particularly impacting the gastrointestinal tract, renal function, and other vulnerable systems in the elderly. Surgical treatments such as arthroscopic debridement, high tibial osteotomy, and knee arthroplasty can significantly relieve symptoms in the short term, but they are invasive, expensive, have long postoperative recovery periods, and are not suitable for all patients [10]. Therefore, for patients with early KOA, how to slow disease progression through conservative interventions in the initial stages and avoid surgical pathways has become a key issue urgently needing resolution in clinical and rehabilitation medicine.

In recent years, the gradual rise of exercise therapy for KOA has provided a new approach for clinical diagnosis and treatment [6]. In this context, the value of exercise therapy is being re-evaluated and widely recognized. In the past, it was often believed that OA patients should "rest more and move less" to avoid aggravating wear and tear. However, recent studies indicate that scientific and reasonable exercise interventions not only do not increase the burden on the knee joint but can significantly delay the joint degeneration process by enhancing the strength of the muscles around the knee, improving joint stability, improving proprioceptive function, and remodeling the lower limb kinetic chain [11, 12]. Exercise therapy can improve lower limb strength and range of motion, effectively relieve joint pain, improve knee function, and delay the disease process of KOA, making it a safe and effective conservative treatment method [13]. Huang et al. [10] randomly assigned 250 KOA patients to a conventional therapy group and an exercise therapy group, with a 3-month

follow-up. Results showed that the Visual Analogue Scale (VAS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores of the exercise therapy group decreased significantly after 1 month, and after 3 months, the exercise therapy group showed significantly better improvement in both pain relief and knee function compared to the control group. Cao Manlin et al. [14] applied exercise therapy to 72 OA patients and reached similar conclusions, finding that adding exercise therapy significantly improved clinical treatment outcomes and promoted the recovery of knee function.

Furthermore, a normal biomechanical environment plays an important role in maintaining the integrity of articular cartilage [15]. Abnormal and excessive stress, as well as disordered joint load transmission, can lead to an imbalance in the synthesis-degradation coupling of chondrocytes, extracellular matrix, and subchondral bone, thereby contributing to the development and progression of KOA [16]. Recent research results [17] show that enhancing the strength of peri-knee muscles can reduce the peak knee flexion-extension and adduction moments, shift the point of action of the ground-reaction force lever outward, and reduce the pressure load on the medial compartment of the tibiofemoral joint. This, to some extent, helps relieve knee pain and improve knee function. On the other hand, improved peri-knee muscle strength enables patients to perform more daily activities, such as painless stair climbing and increased walking distance. The consequent improvements in mental and psychological states, such as depressive mood, self-efficacy evaluation, overall health status, and reduced exercise avoidance, are also potential reasons mediating symptom relief [11, 16, 17]. Additionally, increased quadriceps strength enhances the congruence of the patellofemoral joint [8]. Increased benign compressive stress on the joint surface can improve cartilage nutrition, positively affect cartilage quality, alleviate cartilage inflammation, and to some extent, prevent or delay further degenerative changes in cartilage [17].

Based on the above issues, this study attempts to explore the clinical value of different load-bearing exercise therapies in the intervention of early KOA from a new perspective. This project quantitatively evaluates the clinical efficacy of non-load and enhanced-load exercise therapies on knee joint biomechanics and function through a comparative study, focusing on changes in quadriceps strength, improvement in daily knee joint function, degree of osteoarthritis progression, and gait analysis. It aims to thoroughly investigate the impact of different exercise loads on knee joint function in KOA patients, providing a scientific basis for clinical practice. The goal is to explore a convenient, effective, economical, and promotable comprehensive treatment plan for early and middle-stage osteoarthritis.

2. Materials and Methods

2.1. Study Participants

This study included 150 patients with unilateral KOA.

2.1.1. Inclusion Criteria

1) Meeting the diagnostic criteria for KOA, unilateral onset; 2) No restriction on gender, age between 45 and 65 years inclusive; 3) Meeting the Kellgren & Lawrence (K-L) grade I–II criteria.

2.1.2. Exclusion Criteria

1) Comorbidities such as severe hypertension, diabetes, cardiovascular and cerebrovascular diseases, or severe liver and kidney dysfunction affecting the use of study medications; 2) History of surgery around the affected knee, significant muscle atrophy around the joint, scar formation affecting joint movement; 3) Previous medical history affecting lower limb strength, such as sequelae of poliomyelitis, Parkinson's disease, or diseases affecting subjective cognitive function, such as Alzheimer's disease, brain atrophy, etc.; 4) Diagnosis of Charcot joint disease, lower limb valgus deformity, or severe varus deformity (greater than 30°), or extra-articular deformity of the lower limb greater than 10°; 5) Patients with mental disorders or psychiatric diseases.

2.1.3. Elimination Criteria

1) Incomplete clinical data; 2) Inability to continue the study as planned; 3) Participants who withdrew midway; 4) Those lost to follow-up, dropped out, or terminated early during the study.

2.2. Grouping and Intervention

Enrolled patients underwent X-ray examination, were graded according to the K-L grading standard, and randomly divided into an exercise therapy group, an enhanced-load group, and a conventional therapy group, with 50 patients in each group.

The exercise therapy group received a combined treatment of non-load exercise therapy and conventional drugs. The enhanced-load group received a combined treatment of progressively increased load-bearing exercise therapy and conventional drugs. The conventional therapy group received only conventional drug therapy.

All patients received standardized treatment according to the protocol and were followed up at 1 month, 2 months, and 3 months after treatment. Assessments performed at the initial visit and during follow-ups included: ① Osteoarthritis pro-

gression evaluation: WOMAC score, VAS score; ② Knee joint biomechanical evaluation: Quadriceps isokinetic strength test, lower limb gait analysis; ③ Knee joint daily function evaluation: Stair Climbing Test (SCT), Timed Up and Go Test (TUG).

Inter-group and intra-group difference analyses were conducted on the above assessments to explore: differences between exercise therapy and conventional drugs, differences between different load-bearing exercise therapies, and differences between different degrees of osteoarthritis (K-L grade 1 and K-L grade 2).

2.3. Treatment Protocols

2.3.1. KOA Exercise Therapy (Non-load)

This primarily involves strengthening the muscles around the knee joint, exercising lower limb muscle groups such as the quadriceps, hamstrings, triceps surae, tibialis anterior, and hip abductors, to restore muscle strength, improve knee joint stability, thereby alleviating pain and delaying the progression of osteoarthritis. To ensure clinical consistency and patient compliance, this study selected the following representative exercises:

(1) Isometric Contraction Training: Tension generated without change in muscle fiber length, not accompanied by joint movement, is a static training. Includes:

1) Quadriceps Isometric Contraction: Lie flat or sit, keep the lower limb straight, fix the knee joint, dorsiflex the ankle. Contract the quadriceps to tighten the thigh muscles, move the patella upward, feel pressure on the knee, hold for 1–2 seconds, then relax. 20 repetitions per set, 20 sets per day.

2) Straight Leg Raise Training: Lie flat, on side, or prone, keep the lower limb straight, fix the knee joint, dorsiflex the ankle, keep lower limb muscles tense. Lift the lower limb off the bed surface to an angle of about 20 degrees with the bed, or lift the heel about 20 cm off the bed, hold for 8–10 seconds, relax and rest for 3–5 seconds. 10 repetitions per set, 5 sets per session, 2–4 sessions per day.

3) Clam Shell Exercise: Lie on side, body perpendicular to the bed. Bend both knees at 90 degrees, keep the inner sides of the feet together. Abduct the hip joint, open the knees to an angle of 30–40 degrees, hold the highest point with lower limb tension for 3–5 seconds, relax and return to the starting position. 10 repetitions per set, 5 sets per session, 2–4 sessions per day.

(2) Isotonic Contraction Training: Muscle contraction movement under constant resistance load.

1) Seated Knee Extension Training: Sit naturally, knee flexed at 90°. Keep lower limb muscles tense, dorsiflex the ankle, slowly extend the knee, hold for 8–10 seconds, slowly flex the knee back to the starting position. Keep lower limb muscles tense throughout. 10 repetitions per set, 5 sets per session, 2–4 sessions per day.

2) Terminal Knee Extension Training: Lie flat, place a soft

pillow under the knee to keep it flexed at 30°. Keep lower limb muscles tense, dorsiflex the ankle, slowly extend the knee, hold for 8-10 seconds, slowly flex the knee back to the starting position. Keep lower limb muscles tense throughout. 10 repetitions per set, 5 sets per session, 2-4 sessions per day. Gradually increase the knee flexion angle.

3) Simulated Bicycling Exercise: Lie flat, flex hips and knees, simulate a bicycling motion with both lower limbs. 10 repetitions per set, 5 sets per session, 2-4 sessions per day.

During the diagnosis and treatment process, physicians developed exercise prescriptions for patients based on the severity of their condition and individual circumstances. The effective exercise time should be ≥ 3 days/week.

2.3.2. Progressive Load-Bearing Exercise Therapy Protocol

The exercises were the same as above, but during straight leg raise training, clam shell exercise, seated knee extension training, and terminal knee extension training, latex elastic bands were worn to increase the load. The specific protocol was: 0-4 weeks elastic band load 0 (not worn), 5-8 weeks elastic band load 5 pounds, 9-12 weeks elastic band load 10 pounds.

2.3.3. Conventional Drug Therapy Protocol

K-L Grade 1: Celecoxib, 200 mg, twice daily, orally for 2 consecutive weeks;

Glucosamine, 750 mg, twice daily, orally for 2 consecutive months.

K-L Grade 2: Based on Grade 1 treatment, add intra-articular sodium hyaluronate injection, 25 mg, once weekly, for 5 consecutive weeks.

2.4. Clinical Evaluation Indicators

All patients received standardized treatment according to the protocol and were followed up at 1 month, 2 months, and 3 months after treatment. The following clinical items were evaluated at the initial visit and during follow-ups:

WOMAC: WOMAC is a valid and reliable disease-specific measure for assessing pain, stiffness, and physical function in patients with KOA. Higher scores on the WOMAC scale indicate greater severity of symptoms or functional limitations. This score assesses knee function based on symptoms and signs occurring in daily life, used to evaluate the severity of arthritis and/or treatment efficacy.

VAS: VAS is used to assess the degree of pain, using a 10 cm long scale with ten gradations, where the ends represent the "0" end (representing no pain) and the "10" end (representing the most severe pain imaginable).

SCT: Under the doctor's instruction, the patient will perform a test of ascending and descending nine steps, allowed to hold the handrails on both sides of the staircase to maintain body stability. The time for both ascending and descending the stairs is recorded.

TUG: During the TUG test, the patient is required to wear shoes and sit in a chair with a backrest. A mark is made on the ground 3 meters away from the chair, and the patient is reminded of its location. When the test starts, the patient stands up from the chair, walks forward 3 meters at their usual walking speed, stops at the mark, turns around, walks back to the chair, and sits down. The test ends here, and the test score is the time taken from standing up to sitting down.

Quadriceps Isokinetic Strength Test: This test used the A8-3 Multi-joint Isokinetic Strength Testing and Training System produced by Guangzhou Yikang Medical Equipment Industrial Co., Ltd. This device can measure muscle strength through constant velocity joint resistance movement, providing quantitative data analysis of muscle strength changes before and after treatment. Taking the right knee as an example, the patient sits on a chair, back tight against the chair, the chair rotated left 40°, the machine head rotated left 40°. Use accessories to fix the lower third of the right calf. Only knee flexion and extension movements are performed during exertion, with the range of motion controlled between 0~90°.

Lower Limb Gait Test: This test used the Gait and Balance Function Training Assessment System from Anhui Aili Intelligent Technology Co., Ltd., product number YZB/Wan XXX-2012. This device can perform gait analysis by analyzing foot pressure sensing, stride length, and joint displacement, thereby quantitatively evaluating changes in joint function caused by exercise therapy. The patient first performs a walking warm-up on the assessment system, then undergoes three rounds of walking tests on the pressure sensing device, after which the system automatically generates a gait report.

2.5. Statistical Methods

SPSS 21.0 software was used for statistical analysis. Measurement data conforming to normal distribution are expressed as $\bar{x} \pm s$. Intra-group and inter-group comparisons were performed using one-way analysis of variance (ANOVA), and pairwise comparisons were conducted using the Least Significant Difference (LSD) method. Intra-group and inter-group comparisons were also performed using the Wilcoxon signed-rank test. A $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of Patient Baseline Data

In this study, a total of 150 KOA patients were included. According to the K-L grading standard, patients were randomly divided into three groups: exercise therapy group, enhanced-load group, and conventional therapy group, with 50 patients in each group. The baseline characteristics of the patients in each group were compared (see Table 1). The

results showed no statistically significant differences among the three groups in basic characteristics such as age, gender distribution, body mass index (BMI), and K-L grade ($P >$

0.05), indicating the balance of random grouping. Specific data are shown in the table below:

Table 1. Comparison of Baseline Data.

Characteristic	Exercise Therapy (n=50)	Enhanced-load (n=50)	Conventional Therapy (n=50)	P value
Age (years)	63.2 ± 5.3	62.9 ± 5.1	63.5 ± 5.6	0.798
Gender (Male/Female)	20/30	19/31	21/29	0.889
BMI	27.1 ± 3.2	27.3 ± 3.1	27.0 ± 3.3	0.757
K-L Grade (1/2)	24/26	25/25	23/27	0.920

3.2. Research Results

By comparing the changes in quadriceps strength, knee function (WOMAC score), pain score (VAS), and other indicators before and after treatment, the therapeutic effect of exercise therapy on KOA was evaluated.

3.2.1. Quadriceps Isokinetic Strength Test Results (See Table 2)

The quadriceps strength in both the exercise therapy group and the enhanced-load group showed statistically significant improvement at all follow-up time points after treatment ($P < 0.01$), especially in the enhanced-load group, where the improvement in strength was most pronounced at the 12-week follow-up.

Table 2. Quadriceps Isokinetic Strength Test Results (Unit: Nm).

Group	Baseline Level	1 Month	2 Months	3 Months	P value
Exercise Therapy	21.3 ± 5.2	25.1 ± 5.7	27.8 ± 5.4	29.4 ± 5.3	0.008
Enhanced-load	20.7 ± 5.1	26.0 ± 5.5	29.2 ± 5.1	31.5 ± 5.0	0.006
Conventional Therapy	21.1 ± 5.3	22.5 ± 5.4	23.4 ± 5.3	23.6 ± 5.5	0.208

3.2.2. WOMAC Score (See Table 3)

After 3 months of treatment, the WOMAC scores (pain, stiffness, functional difficulty scores) in each group significantly decreased. The improvement in the exercise therapy

group and the enhanced-load group was significantly better than that in the conventional therapy group ($P < 0.01$). Particularly in terms of functional difficulty scores, the enhanced-load group showed the greatest improvement.

Table 3. WOMAC Score.

Group	Pain Score (0-20)	Stiffness Score (0-8)	Functional Difficulty Score (0-68)	Total WOMAC Score (0-96)	P value
Exercise Therapy	14.8 ± 3.9	5.4 ± 2.2	39.6 ± 6.3	59.8 ± 8.2	0.008
Enhanced-load	15.2 ± 4.0	5.2 ± 2.1	38.2 ± 5.9	58.6 ± 7.6	0.004

Group	Pain Score (0-20)	Stiffness Score (0-8)	Functional Difficulty Score (0-68)	Total WOMAC Score (0-96)	P value
Conventional Therapy	16.5 ± 4.3	6.1 ± 2.4	43.3 ± 6.8	65.9 ± 9.3	0.129

3.2.3. VAS Pain Score (See Table 4)

After 3 months of treatment, the VAS pain scores in the exercise therapy group and the enhanced-load group significantly decreased, while there was no significant change in the conventional therapy group.

Table 4. Changes in VAS Pain Score.

Group	Baseline Level	1 Month	2 Months	3 Months	P value
Exercise Therapy	7.2 ± 1.5	5.8 ± 1.3	4.3 ± 1.1	3.6 ± 1.0	0.005
Enhanced-load	7.4 ± 1.6	5.6 ± 1.2	4.1 ± 1.0	3.4 ± 0.9	0.004
Conventional Therapy	7.1 ± 1.5	6.5 ± 1.4	6.3 ± 1.3	6.2 ± 1.5	0.154

3.2.4. Improvement in TUG and SCT Functional Assessment Indicators After Intervention (See Table 5)

After 3 months of intervention, we performed TUG and SCT tests again on the three groups of patients to observe changes in their knee joint function and conducted inter-group comparisons.

Table 5. Comparison of TUG and SCT Results Before and After Intervention in Each Group.

Indicator	Time Point	Conventional Therapy Group	Non-load Exercise Group	Enhanced-load Group	P value
TUG Time (seconds)	Baseline	14.1 ± 1.2	14.2 ± 1.3	14.0 ± 1.1	0.778
	3 Months	13.5 ± 1.3	12.2 ± 1.0	10.8 ± 1.2	< 0.01
TUG Improvement Value (seconds)		0.6 ± 0.4	2.0 ± 0.5	3.2 ± 0.6	< 0.01
SCT Time (seconds)	Baseline	21.6 ± 2.5	21.3 ± 2.3	21.7 ± 2.4	0.823
	3 Months	20.4 ± 2.2	17.6 ± 2.1	15.3 ± 1.9	< 0.01
SCT Improvement Value (seconds)		1.2 ± 0.5	3.7 ± 0.7	6.4 ± 0.8	< 0.01

4. Discussion

Osteoarthritis is a degenerative disease characterized mainly by knee pain and joint dysfunction [18]. According to 2019 statistics, China accounted for the highest number of OA cases globally, with an estimated 132.81 million individuals affected, followed by India (62.36 million) and the United States (51.87 million) [19]. The rise of exercise therapy for KOA provides a new approach for clinical diagnosis and treatment. However, most existing domestic studies on exercise therapy are limited to research on body-weight-bearing exercise, lacking comparative analysis of the efficacy between body-weight-bearing and en-

hanced-load exercise therapies. Evaluation indicators are mostly subjective and qualitative, lacking objective quantitative analysis, leading to an incomplete and insufficient evaluation of the clinical efficacy of exercise therapy for osteoarthritis [20].

Current research findings on this issue are inconsistent both domestically and internationally. On one hand, low-load exercise is often recommended for patients with moderate to severe OA due to its low joint wear [21], but for young and middle-aged patients with early-stage disease and adequate muscle strength, the training stimulus may be insufficient, limiting rehabilitation efficiency. On the other hand, while load-bearing exercise holds promise for improving muscle strength and function, its safety and applicability remain

questionable. Especially in primary healthcare institutions, the lack of systematic rehabilitation assessment tools and training guidance equipment significantly restricts the clinical application of load training. It is noteworthy that existing literature on exercise intervention studies generally suffers from several core problems. First, the standardization of intervention methods is low, with significant variations in training load, frequency, duration, and other parameter settings, affecting the comparability and generalizability of results [22]. Second, most studies focus on verifying the effectiveness of a single intervention method, lacking systematic comparisons of efficacy differences between different exercise loads [23]. Third, there is limited use of quantitative data on biomechanical indicators, with reliance mostly on subjective questionnaires or clinical scores, restricting a deeper understanding of changes in knee joint function. This trend of "emphasizing perception over mechanism" somewhat hinders the standardized and precise development of exercise intervention in OA treatment [24].

Through a 12-week intervention and assessment of 150 patients with grade I–II KOA, we found that progressive load-bearing exercise therapy (especially the enhanced-load group) demonstrated significantly better effects in improving joint pain, functional activity capacity, and peri-knee muscle strength compared to conventional therapy and non-load exercise therapy.

First, based on WOMAC and VAS scores, the enhanced-load group showed the most significant improvement in joint pain and dysfunction. The WOMAC scale is a core tool for assessing symptom severity in KOA patients, while VAS reflects the patient's subjective pain level. The enhanced-load group showed a continuous and significant downward trend in both indicators, suggesting that pain control and functional improvement are synergistic results based on systematic strength training. This also corroborates the current theoretical mechanism that strength training can enhance dynamic stability around the knee, reduce the accumulation of abnormal micro-stresses in the joint, thereby alleviating pain [13].

Second, in functional tests such as TUG and SCT, the performance of the enhanced-load group was superior to the other two groups, indicating the practical significance of this intervention method in improving dynamic activity capacity and daily living function in KOA patients. We observed that these improvements are not limited solely to increased muscle strength but may also be closely related to enhanced neuromuscular control and improved joint proprioception.

The quadriceps isokinetic strength test results further support this view. Knee joint stability largely depends on the support of quadriceps strength [25]. The significant improvement in muscle strength output in the enhanced-load group indicates that targeted, progressive load training can effectively activate and strengthen the quadriceps, thereby improving the dynamic stability of the knee joint. This is also the practical embodiment of the "strong muscles protect

the knee" strategy widely advocated in the field of sports rehabilitation [26]. Progressive enhanced-load exercise therapy shows significant clinical advantages in the treatment of early KOA, effectively enhancing peri-knee muscle strength, improving joint function, and relieving pain without increasing the risk of joint injury. Compared to conventional drug therapy and non-load exercise therapy, enhanced-load exercise therapy has higher therapeutic potential and is suitable for promotion and application among young and middle-aged OA patients and those with better physical fitness.

When comparing the conventional therapy group with the non-load exercise group, we also found that although the non-load group (e.g., unweighted stretching, active movement) showed some improvement in certain indicators compared to conventional therapy, its efficacy was still significantly weaker than that of the enhanced-load group. This may be because exercise without load stimulation cannot effectively recruit high-threshold motor units to participate in training, making it difficult to truly improve the patient's lower limb muscle strength and exercise endurance.

This study has certain limitations. On one hand, the three-month follow-up period is still relatively short for a chronic degenerative disease and cannot reflect medium- to long-term structural cartilage damage changes. On the other hand, although isokinetic testing improves assessment accuracy, strategies still need to be optimized to address its cost and equipment accessibility barriers for widespread promotion, such as introducing technical solutions like simplified mobile device versions. Furthermore, the establishment of exercise intensity has not yet formed precise dosage curves; future studies with more subgroups and time-intensity interactions are required for clarification.

Compared to traditional treatment paths dominated by drug interventions, exercise therapy is more easily accepted by patients, has lower costs, and higher compliance. By developing individualized "exercise prescriptions" combined with controllable tools like elastic bands, patients' ability for independent exercise and self-management in home environments can be greatly enhanced, thereby fundamentally delaying the worsening of KOA condition and reducing the rate of surgical intervention.

5. Conclusion

Progressive load-bearing exercise therapy is significantly superior to non-load exercise and conventional drug therapy in improving pain, function, and biomechanical indicators in patients with KOA. In clinical practice, it is recommended to develop reasonable load intensities based on individual patient conditions for early and middle-stage KOA patients and implement phased exercise interventions. This is expected to become a safe, efficient, low-cost, and easily promotable rehabilitation strategy.

Abbreviations

K-L	Kellgren & Lawrence
ANOVA	One-Way Analysis of Variance
KOA	Knee Osteoarthritis
LSD	Least Significant Difference
NSAIDs	Nonsteroidal anti-Inflammatory Drugs
OA	Osteoarthritis
SCT	Stair Climbing Test
TUG	Timed Up and Go Test
VAS	Visual Analogue Scale
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index

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Author Contributions

Hongbin Long: Methodology, Writing – original draft

Shungui Zhou: Methodology, Writing – original draft

Jinfan Yang: Methodology, Writing – original draft

Ning Liu: Methodology, Software

Songwei Huan: Conceptualization, Supervision, Writing – original draft, Writing – review & editing

Data Availability Statement

The data supporting the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Biography



Hongbin Long, Master's candidate in Orthopedics at Jinan University, Research focus: Osteoarthritis

Songwei Huan, Corresponding author, Doctoral candidate, Associate Chief Physician in the Department of Orthopedics at the First Affiliated Hospital of Jinan University, Research focus: Osteoarthritis