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Educational Significance of Therapeutic Exercise in the Functional Recovery of Patients with Knee Osteoarthritis: A Multidimensional Perspective

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Abstract: *Knee osteoarthritis (OA) is a prevalent degenerative joint disorder significantly affecting mobility, functional independence, and quality of life, particularly in older adults. This study investigated the role of therapeutic physical exercise, integrated with pharmacological treatment, in restoring joint mobility and reducing pain and stiffness in patients diagnosed with knee OA. A two-year intervention involving 52 participants was conducted, comparing a control group undergoing pharmacological treatment alone with an experimental group following a combined rehabilitation program. Functional outcomes were assessed using goniometric measurements and the WOMAC scale. Results demonstrated statistically significant improvements in the experimental group across all indicators-flexion amplitude, extension deficit, pain, stiffness, and functional status-validating the efficacy of therapeutic exercise. Moreover, educational strategies enhanced treatment adherence and outcomes. The study highlights the international relevance of integrating exercise and patient education in OA management and proposes a replicable, evidence-based model for rehabilitation programs.*

Keywords: *knee osteoarthritis, therapeutic exercise, joint mobility, patient education, physical therapy.*

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Introduction

Functional limitations resulting from chronic joint conditions, particularly knee osteoarthritis (OA), represent a major challenge to both individual quality of life and public health systems globally. As the prevalence of OA continues to rise due to aging populations, sedentary behavior, and obesity, there is growing recognition of the need for comprehensive, interdisciplinary approaches to treatment (Levangie & Norchin, 2011; Kisner et al. 2018, Kisner et al., 2023; Bruyère et al., 2019). Beyond clinical recovery, educational interventions that support patient autonomy, engagement, and health literacy are becoming essential components of modern rehabilitation strategies (GBD 2021 Osteoarthritis Collaborators, 2023; Kisner et al., 2023). These educational components align with international guidelines such as those from the American College of Rheumatology and OARSI, which recommend self-management programs and structured exercise as first-line therapies for knee osteoarthritis (Bannuru et al., 2019; Kolasinski et al., 2020).

Recent epidemiological data indicate that over 595 million people worldwide live with some form of osteoarthritis, with knee OA being the most common and impactful. From 1990 to 2020, the prevalence of knee OA increased by over 74.6%, with further projections showing continued growth until 2050 (GBD 2021 Osteoarthritis Collaborators, 2023). These trends highlight the urgent need for cost-effective and scalable solutions that go beyond pharmacological or surgical care, focusing instead on prevention, functional restoration, and educational empowerment.

Mobility is a fundamental attribute of the human body, enabling the execution of tasks that are essential for daily living, occupational roles, and social engagement. In the context of knee osteoarthritis, mobility is compromised, resulting in limitations of functional capacity and a decrease in quality of life. The knee joint-being biomechanically central in locomotion-is particularly vulnerable to degenerative changes due to overuse, trauma, or biomechanical misalignment (Fransen et al., 2015a; Fransen et al., 2015b). These functional losses emphasize the need for therapeutic strategies that restore not only joint function, but also the individual's ability to engage actively in everyday life.

In this context, therapeutic physical exercise (TPE) is gaining ground not only as a clinical tool but also as an educational and behavioral intervention. It promotes physical autonomy, engages patients in active learning about their own bodies, and supports the development of long-term health behaviors. The role of physiotherapists and physical education professionals is increasingly recognized in delivering structured, evidence-

based exercise programs that integrate biomechanical, physiological, and educational goals (Brosseau et al., 2017; Raposo et al., 2021).

The educational relevance of therapeutic interventions lies in their potential to enhance health outcomes by equipping patients with the knowledge and skills necessary to manage their condition. Programs based on guided movement, feedback, goal-setting, and self-efficacy are associated with improved functional status and reduced healthcare dependency (misalignment (Fransen et al., 2015a; Fransen et al., 2015b; Kisner et al., 2023). Moreover, these interventions contribute to enhancing the perception of the importance of the field of sports science and physical education, particularly in contexts that promote an integrated, preventive approach focused on lifelong physical activity and the strengthening of resilience in the face of health challenges.

Thus, the present study investigates the role of therapeutic physical exercise not only in the recovery of joint mobility and reduction of pain in patients with knee OA, but also in fostering educational outcomes related to patient empowerment, functional independence, and interdisciplinary learning. Emphasis is placed on the international relevance of integrating therapeutic movement into health education systems and professional rehabilitation practice.

Problem statement: educational and functional challenges in managing knee osteoarthritis

Knee osteoarthritis (OA) is one of the most prevalent and disabling musculoskeletal conditions globally, with significant implications for both clinical practice and health education. It is widely recognized that individuals affected by knee OA face progressive functional limitations, reduced autonomy, and diminished quality of life. However, beyond medical management, there remains a critical gap in patient education, self-management training, and public health strategies that emphasize movement, prevention, and lifelong physical competence.

While pharmacological treatments are commonly used, they do not address the underlying biomechanical dysfunctions, nor do they empower patients to manage their condition independently. Research increasingly shows that therapeutic physical exercise (TPE) is one of the most effective non-surgical interventions for OA, capable of improving enhancing joint range of motion, alleviating pain, and supporting the recovery of functional capacity (Bartholdy et al., 2017; Skou & Roos, 2019; Uivaraseanu et al., 2022). Importantly, TPE also plays a formative role, helping patients understand the mechanics of movement, the importance of consistency, and the value of health-related decision-making.

From an educational perspective, the absence of structured, evidence-based physical activity programs for patients with OA is a missed opportunity. Such programs could serve not only as rehabilitation tools but also as platforms for health education, behavioral change, and lifelong learning about movement, function, and joint care. Patients often lack guidance on proper movement techniques, the value of joint-friendly activities, or how to integrate therapeutic routines into daily life — areas where educational strategies can make a meaningful difference (Dulay et al., 2015; Dunleavy & Slowik, 2017; Kisner et al., 2023; Si et al., 2023).

Moreover, this problem extends beyond the individual. In many countries, the training of physical education teachers and rehabilitation specialists does not sufficiently address the integration of therapeutic exercise into educational frameworks. There is a need to prepare future professionals who are competent in both teaching and applying therapeutic exercise techniques, promoting a preventive and restorative culture of movement across age groups and populations.

Therefore, the present study addresses not only a medical issue, but a multidimensional educational challenge: how can therapeutic physical exercise be better understood, implemented, and promoted as a means of education, rehabilitation, and long-term functional health? By analyzing the effects of an exercise-based intervention on patients diagnosed with knee OA, the study also aims to contribute to the development of internationally relevant educational frameworks in physical rehabilitation and health literacy.

Meta-analyses further validate this approach, showing that educational programs, especially when combined with exercise therapy, significantly improve functional outcomes in patients with knee osteoarthritis (Fransen et al., 2015a; Fransen et al., 2015b; Kroon et al., 2014).

The role of therapeutic exercise in the management of knee osteoarthritis

Knee osteoarthritis (OA) is a progressive degenerative disorder that presents not only a clinical challenge but also a significant public health concern, due to its high prevalence and disabling outcomes. Traditional management strategies have heavily relied on pharmacological treatments and surgical interventions, often overlooking the essential role of functional rehabilitation and patient education (Uivaraseanu et al., 2022).

Among the various interventions used in continuous care, kinesiotherapy-particularly through isotonic, isokinetic, and postural therapeutic exercises-plays a crucial role in programs aimed at strengthening periarticular muscles, improving mobility and stability, reducing pain, and restoring patient participation in meaningful daily activities. These therapeutic

exercises can be categorized based on their specific objectives and physiological effects (see Table 1).

Table 1. Categories of Therapeutic Physical Exercises

No.	Name	Effect
1	Warm-up exercises	Help relax muscles and warm up joints, such as stretching and knee rotation.
2	Resistance exercises	Strengthen the muscles that support the knee joint.
3	Correction exercises	Correct knee alignment and movements to improve mobility/flexibility.
4	Stabilization exercises	Aim to stabilize the knee joint.

Therapeutic physical exercise (TPE) has emerged as a cornerstone of conservative treatment, with strong evidence supporting its effectiveness in reducing pain, improving joint mobility, and enhancing muscle stabilization (Bonan et al., 2009; Segal et al., 2010; Bandy & Sanders, 2013; Brosseau et al., 2017; Bartholdy et al., 2017; Nelson & Kokkonen, 2022; Skou & Roos, 2019; Raposo et al., 2021; Kisner et al., 2023; Si et al., 2023).

Aerobic exercises, especially when combined with weight loss, offer additional benefits by improving cardiovascular health and decreasing mechanical stress on affected joints through reduced body weight (Messier et al., 2005; Fitzgerald et al., 2004; Fransen et al., 2015a; Kisner et al., 2023).

However, the value of TPE extends beyond clinical outcomes. Such programs serve as educational platforms, helping patients better understand their condition, adopt healthy behaviors, and take an active role in self-care. This dual role-therapeutic and educational is central to modern rehabilitation philosophy and aligns with WHO recommendations on integrated care and movement-based health promotion.

Numerous studies confirm that structured, professionally guided movement programs improve proprioception, joint stability, and overall physical function. Moreover, by promoting patient engagement, providing regular feedback, and encouraging home-based continuation, these programs foster greater autonomy and motivation, making rehabilitation a multidimensional and sustainable process (Brosseau et al., 2017; Dunleavy & Slowik, 2018; Skou & Roos, 2019; Raposo et al., 2021; Si et al., 2023).

Mobility as a functional and educational concept

Joint mobility refers to the ability of body segments to perform movements across various spatial planes, allowing for an optimal range of motion-essential for maintaining the functionality and health of the musculoskeletal system. This ability reflects an individual's capacity to initiate, control, and sustain movements at both joint and segmental levels through voluntary muscle contractions and is closely tied to the concept of functional mobility. From a functional perspective, mobility is correlated with the integrity of joints as well as with the elasticity of periarticular soft tissues-muscles, ligaments, and tendons-that cross or surround these structures (Levangie & Norchin, 2011; Germain-Calais & Germain, 2024; Herbert et al., 2011; Shumway-Cook et al., 2023).

Mobility directly influences the process of acquiring and refining motor skills. Well-developed mobility contributes to energy efficiency, movement precision, and adaptability to physical demands. Conversely, limited mobility acts as a restrictive factor, impairing motor performance and increasing the risk of locomotor dysfunctions and injuries. Studies and observations in physical therapy reveal that even optimal muscular qualities-speed, strength, or endurance-cannot compensate for the lack of adequate mobility (Bean et al., 2002; La Grow et al., 2013; Dulay et al., 2015; Kalu et al., 2022).

Reduced range of motion in the knee joint often leads to functional limitations in adjacent joints, particularly the hip and ankle. Recovery from such deficits, especially in the context of degenerative conditions, requires integrated and sustained interventions: kinesitherapy, physiotherapy, massage, and long-term complementary treatments (Albu et al., 2004).

Table 2. Categories of Activities of Daily Living (ADLs)

No.	ADL Type	Description
1	Personal care	Feeding, dressing, hygiene, toileting, sleeping, moving around the home.
	Instrumental	Shopping, using appliances, managing finances, using keys, phone, computer.
2	Productivity and work	Paid or volunteer work, child or dependent care, household management, education.
3	Leisure	Hobbies, travel, phone calls, correspondence.

Mobility is classified into three main forms: active, passive, and functional.

Active mobility refers to a joint's capacity to move under its own muscular control, without external assistance, and is influenced by the flexibility of the antagonistic muscles.

Passive mobility exceeds active mobility and involves external forces (therapist, device, or body weight).

Functional mobility refers to the ability to perform movements necessary for daily living (ADLs-Activities of Daily Living), as presented in Table 2.

The literature identifies four primary factors that influence joint mobility (McGregor et al., 2014; Hunter & Bierma-Zeinstra, 2019; Sowers & Karvonen-Gutierrez, 2010):

a. Anatomical factors – congenital deformities, skeletal abnormalities, and postural misalignments that alter muscle length and tone.

b. Pathological factors – rheumatic diseases, muscle fibrosis, neuromuscular disorders, post-traumatic deformities.

c. Lifestyle-related factors – physical inactivity, poor nutrition, prolonged immobilization, repetitive or sedentary work habits.

d. Age-related factors – physiological tissue degeneration associated with aging.

This classification allows health professionals and educators to set realistic goals and design multilevel interventions that combine physical recovery with life-skills education (Bean et al., 2002).

Therefore, mobility should not be understood merely as a biomechanical trait, but rather as a dynamic functional capacity that can be actively developed and maintained through specific physical activities. Recognizing its educational dimension allows rehabilitation programs to shift from passive treatment methods to active patient involvement, supporting autonomy and promoting long-lasting behavioral changes (Germain-Calais & Germain, 2024; Kisner et al., 2023).

Knee osteoarthritis: a multidimensional condition with global relevance

From a biomechanical perspective, the knee joint occupies an intermediate position between the hip and ankle, constantly subjected to torsional forces-such as internal rotation of the femur and external deviation of the tibial tuberosity. It is part of the kinetic chain of the lower limb and plays a crucial role in functional activities such as standing, walking, and other movements requiring mobilization or controlled deceleration.

Knee osteoarthritis (OA), or gonarthrosis, is a progressive degenerative condition characterized by the gradual deterioration of the structural and functional integrity of the joint. It is among the most common chronic musculoskeletal disorders worldwide, with an insidious onset and slow progression over several months to 3–5 years, significantly impairing patients' quality of life.

The etiology of knee OA is complex and multifactorial, involving aging, trauma, genetic predisposition, obesity, poor joint alignment, hormonal imbalances, and lifestyle factors. The incidence is estimated at approximately 240 cases per 100,000 people annually, with higher prevalence among women. Recent data show that the condition affects around 10% of men and 13% of women between the ages of 60 and 75, rising to over 40% in individuals over 70. However, only 15% of those with radiographic evidence of OA report clinical symptoms (Magnusson et al., 2019).

Knee OA is classified into two main types: primary (idiopathic) and secondary, the latter being associated with trauma, mechanical imbalances, or metabolic disorders. Depending on the compartment affected, it may be femoropatellar, femorotibial, or bicompartmental (femuro-patello-tibial). In early stages, the degenerative process may remain localized, but in advanced stages, the entire joint becomes involved. Bilateral involvement is common, and unilateral cases are often associated with pre-existing joint damage (Altman et al., 1986; Altman & Gold, 2007).

Once considered merely a mechanical wear-and-tear condition, osteoarthritis is now recognized as a complex joint disease involving the cartilage, subchondral bone, and synovial membrane-structures essential for joint stability and function (Berenbaum & Walker, 2020). Thus, cartilage is not the only structure affected, and in early stages, it cannot trigger pain or inflammation due to its avascular and aneural nature. Pain-whether during movement or at rest-results from pathological changes in non-cartilaginous structures such as ligaments, subchondral bone, joint capsule, periarticular muscles, and synovial tissue (Bruyère et al., 2011; Ayhan et al., 2014). As the disease progresses, these components degrade, resulting in muscle weakening, bone remodeling, synovial effusion, ligament laxity, and osteophyte formation.

Joint pain is the predominant symptom, varying in intensity from intermittent to constant, and from mild to severe. Other symptoms include crepitus, decreased muscle strength, joint locking, swelling, and instability. These manifestations reduce the range of motion and limit involvement in personal, social, and professional activities, significantly lowering quality of life (McWilliams et al., 2011; Mahir et al., 2016).

Clinical diagnosis is based on detailed patient history and physical examination, assessing flexion, extension, rotation, and tenderness. Imaging investigations, especially radiographs, are essential in identifying joint space narrowing, osteophyte formation, subchondral cysts, and deformities such as genu valgum or varum. Disease severity is typically classified using the Kellgren–Lawrence scale (Kellgren, & Lawrence, 1957; Braun & Gold, 2012).

Recent research confirms the systemic and multifactorial nature of knee OA, emphasizing the roles of inflammation, metabolic disturbances, biomechanical stress, and biochemical changes in disease progression (Bruyère et al., 2019; Ayhan et al., 2014; Berenbaum & Walker, 2020).

This complexity of risk factors highlights the need for personalized interventions that are not only medical but also educational, tailored to the individual's context (Blagojevic et al., 2010; Rayahin et al., 2014; Rosadi et al., 2022). A concise summary of the major risk factors can be found in Table 3. The global burden of the disease places significant pressure on healthcare systems. According to the Global Burden of Disease study (2020), knee OA ranks among the top 10 causes of years lived with disability (YLD) in people over 70, with projections indicating further increases by 2050 (GBD 2021 Osteoarthritis Collaborators., 2023).

From a global health education perspective, managing knee OA requires more than medical treatment-it demands educational strategies that help patients and communities live with the condition, adapt to it, and prevent further disability. These include:

- Public education on joint health and injury prevention;
- Training of specialists in physical therapy and physical education;
- Implementation of community-based movement programs coordinated by professionals in physical therapy and physical education, ensuring accessibility and continuity of care.

Thus, the issue addressed in this study is not exclusively medical, but also educational, functional, and social. The aim of the research is to demonstrate that therapeutic physical exercise, when embedded within an educational and rehabilitative framework, represents an effective intervention-locally applicable and internationally transferable.

Table 3. Risk Factors Associated with Knee Osteoarthritis

Risk Factor	Description
Age-related factors	Older individuals are more frequently affected due to chronic wear of the joints.
Gender-related factors	More frequent in women; aging and menopause lead to decreased estrogen levels, affecting bone protection.
Genetic factors	Genetic predispositions and congenital disorders (e.g., Ehlers-Danlos syndrome) contribute to the onset of gonarthrosis.
Biomechanical factors	Improper alignment and inadequate muscular support cause uneven pressure and premature cartilage wear.

Together, Tables 3 and 4 illustrate the multifactorial landscape of knee osteoarthritis and underscore the need for multidisciplinary interventions. A detailed classification of primary and secondary causes contributing to knee OA can be found in Table 4.

Table 4. Primary and Secondary Causes of Knee Osteoarthritis

Type	Cause	Description
Primary	Abnormal joint development	Conditions like hip dysplasia or genu varum can lead to early joint wear.
	Obesity	Excess weight increases pressure on the knees and accelerates cartilage degeneration through mechanical and metabolic effects.
	Excessive physical activity	Overuse in high-impact sports can cause microtrauma and early degeneration.
Secondary	Occupational or sports injuries	Ligament tears or fractures may trigger degenerative processes.
	Inflammatory arthritis	Autoimmune inflammation accelerates cartilage damage (e.g., rheumatoid arthritis).
	Endocrine/metabolic disorders	Conditions like hypothyroidism, diabetes, and hyperlipidemia contribute to joint degeneration.

Research methodology: interdisciplinary framework and ethical considerations

Purpose and educational relevance

The primary objective of this study is to assess the role of therapeutic physical exercise in restoring knee joint mobility and alleviating pain in patients diagnosed with knee osteoarthritis (OA). Additionally, the research emphasizes the educational importance of involving patients in structured physical activity programs that foster long-term self-management, enhance health literacy, and support autonomy - key pillars of multidimensional health education.

Research hypotheses

This study is guided by the following hypotheses:

1. Knee osteoarthritis is the most prevalent joint disorder among older adults, with incidence increasing with age due to cumulative degenerative changes.
2. Participation in kinesiotherapy programs based on therapeutic physical exercise significantly improves functional recovery and reduces pain in patients with knee osteoarthritis.

Participants, group allocation, inclusion criteria, exclusion criteria and ethics

The study involved a total of 52 patients (both male and female) clinically and radiologically diagnosed with knee osteoarthritis. Participants were randomly assigned to two equal groups:

- Control Group (n = 26): Received pharmacological treatment only.
- Experimental Group (n = 26): Received a combined intervention consisting of pharmacological treatment and a therapeutic exercise program.

Inclusion criteria included:

- Confirmed diagnosis of knee OA (both radiologically and clinically)
- Age over 50 years
- Voluntary participation and signed informed consent

Exclusion criteria included:

- Comorbid pulmonary conditions (e.g., bronchial asthma or chronic bronchitis)
- Neurological disorders
- Recent surgical intervention on the knee joint

Furthermore, individuals diagnosed with chronic bronchitis or bronchial asthma were excluded due to the risk of triggering exercise-induced bronchial spasms. It should also be noted that, from a pharmacological standpoint, all participants followed treatment regimens tailored to their age and associated comorbidities.

All participants provided written informed consent prior to enrollment. The study protocol received ethical approval from a local institutional review board, in accordance with the principles of the Declaration of Helsinki.

Depending on the knee joint compartments affected by the degenerative process, the distribution of osteoarthritis types among participants was as follows (see Figure 2):

- Femoral-patellar osteoarthritis was diagnosed in 39% of participants in the control group and 38% in the experimental group.
- Femoral-tibial osteoarthritis was present in 46% of the control group and 49% of the experimental group.
- The remaining 15% (control group) and 13% (experimental group) were diagnosed with bicompartmental (femoro-patello-tibial) osteoarthritis.

These distributions, categorized by the type and etiology of knee osteoarthritis, are illustrated in Figure 1.

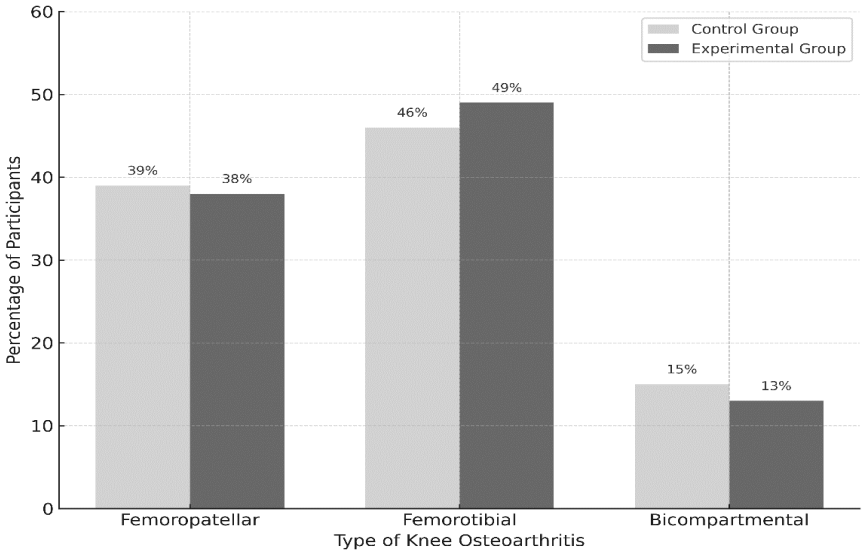


Figure 1. Types of Knee Osteoarthritis According to Etiology
Author's own elaboration. This figure presents the distribution of participants by OA type (femoropatellar, femorotibial, bicompartmental), highlighting the predominance of secondary osteoarthritis among the enrolled subjects.

Intervention program

The experimental group followed a structured kinesiotherapy program, designed and supervised by certified physical therapists. The program was carried out daily for one hour over a period of six months, in individualized and group sessions, and included:

- Warm-up routines for mobility and circulation;
- Isotonic and postural therapeutic exercises for periarticular muscles;
- Bicycle ergometry and assisted movements in various positions (supine, prone, sitting, standing);
- Functional training for daily activities and balance.

Special attention was paid to educational aspects during sessions, including:

- Movement awareness and proprioception;
- Patient feedback and goal-setting;
- Progress tracking and self-management strategies.

The physical therapists also provided patients with simple illustrated guides to promote continuation of exercises at home, reinforcing behavioral and educational goals.

Environmental conditions were standardized (adequate ventilation, temperature, and humidity) to ensure safety and comfort during sessions.

Tools and data collection

The following validated tools and procedures were used:

- Goniometric evaluation of knee mobility (flexion, extension, extension deficit);
- WOMAC Index (Western Ontario and McMaster Universities Osteoarthritis Index) for assessing pain, stiffness, and functional status;
- Ultrasound and radiological imaging to assess joint integrity.

Structured interviews and observation logs for recording patient feedback and functional changes.

Statistical processing was performed using the KY-POT software, and included:

- Descriptive indicators (mean, SD, amplitude);
- Student's **t** test for significance;
- Pearson's correlation coefficient for intra-group comparisons.

Findings

Imaging and diagnostic relevance

Radiological examination indicated that 79% of participants showed narrowing of the tibiofemoral joint space, while 71% presented osteophyte formation and 75% exhibited subchondral sclerosis. Subcutaneous bone cysts were identified in 48%. Ultrasound revealed intra-articular fluid in 48%, medial meniscus protrusion in 62%, and Baker's cysts in 23%-conditions not detectable via clinical or radiologic examination alone. These results highlight ultrasound's diagnostic superiority, especially in patient education and individualized therapy.

Goniometric outcomes and statistical interpretation

The control group showed modest improvements (Table 5). Active flexion increased from 106.31° to 114.04°, passive flexion from 121.79° to 122.91°, and extension deficit decreased from 14.88° to 8.54°. These changes are statistically significant, confirmed by the Student's t-test ($P<0.001$ for active flexion and extension, $P<0.05$ for passive flexion).

The standard deviation (S) values indicate a moderate variability of final scores (e.g., $S = 1.21$ for active flexion), while coefficients of variation (CV%) suggest relatively homogeneous performance: 1.66% (active flexion), 2.13% (passive), and 5.95% (extension). The Pearson correlation coefficient for extension (0.636 initially, dropping to –0.010) highlights variability in the relationship between measurements.

Table 5. Goniometric Examination – Control Group (Author's own elaboration)

Indicators/Type of motion	**Initial**			**Final**		
	Active flexion	Passive flexion	Extension deficiency	Active flexion	Passive flexion	Extension deficiency
Arithmetic mean X	106.31	121.79	14.88	114.04	122.91	8.54
Maximum Limit	108	129	17	116	134	9
Minimum Limit	105	118	13	112	120	8
Amplitude	3	11	4	4	14	1
Standard error of the mean	0.19	0.43	0.20	0.23	0.51	0.10
Standard deviation S	0.97	2.19	1.03	1.21	2.61	0.51
Coefficient of variation Cv%	0.91	1.80	6.94	1.66	2.13	5.95
Student's Test	P< 0.001	P< 0.05	P< 0.001	P< 0.001	P< 0.05	P< 0.001
Pearson correlation coefficient	0.0216	0.106	0.636	0.269	0.0160	-0.010

In contrast, the experimental group (Table 6) showed significant improvements: active flexion rose from 107.15° to 122.70°, passive flexion from 124.46° to 129.03°, and the extension deficit decreased from 17.30° to 6.04°. All indicators had P<0.001, confirming robust statistical significance.

The standard deviations at final testing (e.g., S = 1.82 for active flexion) indicate a slightly greater variability than in the control group, supported by a higher CV% of 15.16% for extension deficiency. Despite this, the Pearson coefficient for extension improved to 0.363, suggesting a moderate direct relationship between intervention and extension recovery.

Table 6. Goniometric Examination – Experimental Group (Author's own elaboration)

Indicators/Type of motion	**Initial**			**Final**		
	Active flexion	Passive flexion	Extension deficiency	Active flexion	Passive flexion	Extension deficiency
Arithmetic mean X	107.15	124.46	17.30	122.70	129.03	6.04
Maximum Limit	109	128	19	127	134	9
Minimum Limit	106	121	15	120	125	5
Amplitude	3	7	4	7	9	4
Standard error of the mean	0.19	0.40	0.24	0.35	0.46	0.17
Standard deviation S	1.0	2.04	1.25	1.82	2.34	0.91
Coefficient of variation Cv%	0.94	1.64	7,27	1.49	1.81	15,16
Student's Test	P< 0.001	P< 0.001	P< 0.001	P< 0.001	P< 0.001	P< 0.001
Pearson correlation coefficient	-0.031	0.233	0.403	0.011	0.312	0.363

Table 7. Comparative Goniometric Results (Author's own elaboration)

Indicators/Type of motion	**The experimental group n=26**			**The control group n=26**		
	Final			**Final**		
	Active flexion	Passive flexion	Extension deficiency	Active flexion	Passive flexion	Extension deficiency
Arithmetic mean X	122.70	129.03	6.04	114.04	122.91	8.54
Maximum Limit	127	134	9	116	134	9
Minimum Limit	120	125	5	112	120	8
Amplitude	7	9	4	4	14	1
Standard error of the mean	0.35	0.46	0.17	0.23	0.51	0.10
Standard deviation S	1.82	2.34	0.91	1.21	2.61	0.51
Coefficient of variation Cv%	1.49	1.81	15,16	1.66	2.13	5.95
Student's Test	P< 0.001	P< 0.001	P< 0.001	P< 0.001	P< 0.05	P< 0.001
Pearson correlation coefficient	0.011	0.312	0.363	0.269	0.0160	-0.010

Comparing both groups (Table 7), the experimental group outperformed across all metrics. Notably, the mean gain in active flexion was +8.66°, and the extension deficit was lower by 2.5°. CV% in the control group was lower, suggesting more consistent results but also possibly a smaller potential for improvement. Standard error of the mean (SEM) confirms statistical stability: 0.35 (experimental) vs. 0.23 (control) for active flexion.

WOMAC results and functional assessment

In the control group, pain scores decreased from 9.80 to 7.38, stiffness from 5.04 to 3.88, and functional impairment from 43.96 to 32.53 (Table 8). The CV% at final assessment remained moderate (e.g., 21.01% for stiffness), indicating variability in recovery. Standard deviation (S = 2.46 for function) and Student's test values (all P<0.001) confirm statistical significance. The Pearson coefficient for function (0.687) indicates a strong correlation in self-reported improvement (Table 8).

Table 8. WOMAC Scores – Control Group (Author's own elaboration)

Indicators/Type of motion	**Initial**			**Final**		
	Ache (0-20 points)	Inflexibility (0-8 points)	Functional status (0-68 points)	Ache (0-20 points)	Inflexibility (0-8 points)	Functional status (0-68 points)
Arithmetic mean X	9.80	5.04	43.96	7.38	3.88	32.53
Maximum Limit	12	6	48	10	5	39
Minimum Limit	8	4	40	5	3	30
Amplitude	4	2	8	5	2	9
Standard error of the mean	0.25	0.15	0.47	0.28	0.16	0.48
Standard deviation S	1.26	0.77	2.42	1.44	0.81	2.46
Coefficient of variation Cv%	12.90	15.35	5.51	19.55	21.01	7.58
Student's Test	P< 0,001	P<0,001	P<0,001	P< 0,001	P<0,001	P<0,001
Pearson correlation coefficient	0.122	0.778	0.875	0.766	0.820	0.687

The experimental group achieved larger improvements: pain decreased from 9.96 to 6.15, stiffness from 5.07 to 2.80, and function improved from 43.92 to 22.27 (Table 9). Despite a larger amplitude (10 points

for function), Standard deviation (S) and Standard error of the mean (SEM) values remained within acceptable limits (e.g., S = 2.30, SEM = 0.45), and CV% ranged between 10.36–24.7%, reflecting diverse patient responses. The negative Pearson coefficient for function (-0.359**)** suggests a less predictable relationship, possibly due to the subjective nature of functional self-assessment (Table 9).

Comparatively (Table 10), the experimental group showed superior results in all domains. Pain improved more substantially (6.15 vs. 7.38), stiffness reduced more (2.80 vs. 3.88), and functional ability was significantly better (22.27 vs. 32.53). Despite slightly higher CV%, the magnitude of improvement outweighs interindividual variability. Pearson coefficients indicate more consistent perception of pain and stiffness in the control group, but better actual performance in the experimental one.

These findings, statistically supported by means (X), variation indices (CV%), dispersion (S, SEM), and correlations (r), confirm the educational and therapeutic value of structured physical exercise. Improvement in objective function and subjective wellbeing demonstrates the multidimensional impact of such programs, both clinically and behaviorally, reinforcing the need for their systematic integration into osteoarthritis rehabilitation.

Table 9. WOMAC Scores – Experimental Group (Author's own elaboration)

Indicators/Type of motion	**Initial**			**Final**		
	Ache (0-20 points)	Inflexibility (0-8 points)	Functional status (0-68 points)	Ache (0-20 points)	Inflexibility (0-8 points)	Functional status (0-68 points)
Arithmetic mean X	9.96	5.07	43.92	6.15	2.80	22.27
Maximum Limit	11	6	46	8	4	25
Minimum Limit	8	4	40	4	1	15
Amplitude	3	2	26	4	3	10
Standard error of the mean	0.18	0.14	0.36	0.23	0.13	0.45
Standard deviation S	0.91	0.74	1.85	1.19	0.69	2.30
Coefficient of variation Cv%	9.19	14.65	4.21	19.33	24.7	10.36
Student's Test	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Pearson correlation coefficient	0.134	0.295	0.076	-0.092	0.132	-0.359

Table 10. Comparative WOMAC Scores (Author's own elaboration)

Indicators/Type of motion	The experimental group n=26			The control group n=26		
	Final			Final		
	Ache (0-20 points)	Inflexibility (0-8 points)	Functional status (0-68 points)	Ache (0-20 points)	Inflexibility (0-8 points)	Functional status (0-68 points)
Arithmetic mean X	6.15	2.80	22.27	7.38	3.88	32.53
Maximum Limit	8	4	25	10	5.00	39
Minimum Limit	4	1	15	5	3.00	30
Amplitude	4	3	10	5	2.00	9
Standard error of the mean	0.23	0.13	0.45	0.28	0.82	0.48
Standard deviation S	1.19	0.69	2.30	1.44	0.81	2.46
Coefficient of variation Cv%	19.33	24.7	10.36	19.55	0.64	7.58
Student's Test	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
Pearson correlation coefficient	-0.092	0.132	-0.359	0.766	0.820	0.687

Discussions

Relevance at the international level

Knee osteoarthritis (OA) represents a major challenge in global public health, ranking among the top 10 causes of disability-adjusted life years (DALYs) in older adults (GBD 2021 Osteoarthritis Collaborators., 2023). Its increasing prevalence, projected to affect over 1 billion individuals by 2050, underscores the urgency of cost-effective and non-invasive treatment strategies that are scalable across healthcare systems. Therapeutic physical exercise has emerged as a universally accessible and adaptable solution, offering both clinical and economic benefits. The findings of this study reinforce global recommendations by the World Health Organization (WHO), the European League Against Rheumatism (EULAR), and the American College of Rheumatology (ACR), which endorse structured physical activity as a first-line intervention in OA management (Bartholdy et al., 2017; Skou & Roos, 2017).

This study contributes to the international discourse by providing statistically validated evidence of the effectiveness of structured exercise programs in improving joint mobility, reducing pain, and enhancing daily function. Its design-based on a clear rehabilitation protocol, objective measurements, and longitudinal observation—allows replication in diverse

healthcare environments, making it highly relevant for countries pursuing integrated rehabilitation models. Furthermore, the results support the development of international clinical guidelines and public health policies that promote early physical activity interventions to delay the progression of OA and reduce healthcare system burden.

Own scientific contribution

The present research offers several original contributions:

- Demonstration of the superior effectiveness of combined medical and physical-exercise-based intervention versus pharmacological therapy alone.
- Integration of educational strategies within rehabilitation, such as patient feedback, symptom monitoring, and participatory motor learning.
- Use of goniometry and WOMAC indicators in a longitudinal, real-world urban setting over a six-month period.
- Quantitative evidence that structured, guided exercises produce consistent and statistically significant improvements in extension deficit, flexion amplitude, and self-perceived functional status.
- Observation that the most significant gains were recorded in patients with initially severe functional deficits, indicating the responsiveness of joint structures to targeted rehabilitation.
- Identification of an optimal intervention frequency (daily 60-minute sessions over 6 months) as a benchmark for future rehabilitation protocols.

Quantitative data collected in this study support these conclusions. In the experimental group, active knee flexion improved by 15.55°, passive flexion by 4.57°, and the extension deficit decreased from 17.3° to 6.04°. In contrast, the control group showed smaller gains, with extension deficits reduced from 14.88° to only 8.54°.

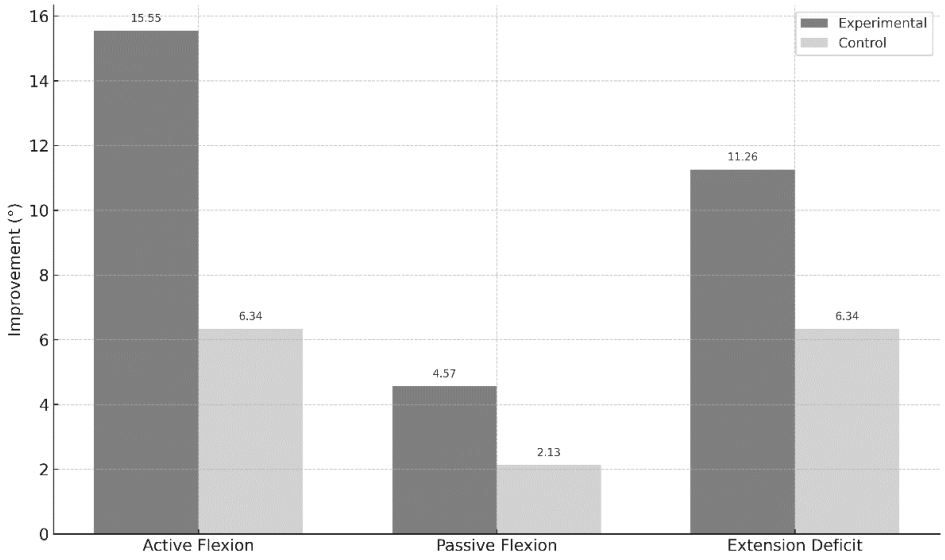


Fig. 2. Goniometric examination results for the experimental and control groups.

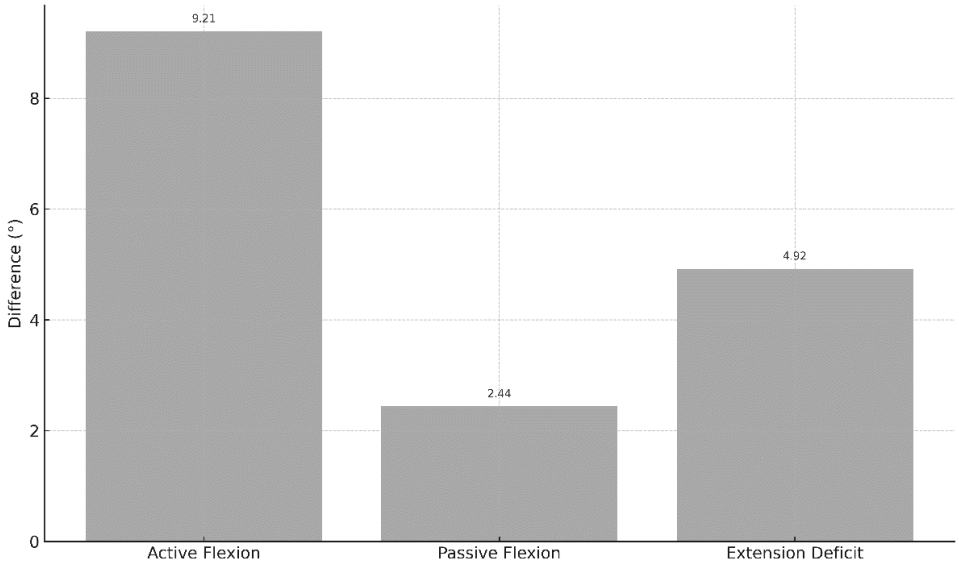


Fig. 3. Differences in goniometric improvement between experimental and control groups.

Additionally, the WOMAC scale revealed greater symptom relief in the experimental group. Knee pain decreased from 9.96 to 6.15 points, stiffness from 5.07 to 2.8 points, and functional limitation from 43.92 to 22.27 points. In comparison, the control group improved only modestly (pain from

9.8 to 7.38; stiffness from 5.04 to 3.88; functional score from 43.96 to 32.53), underscoring the superior effectiveness of the combined intervention.

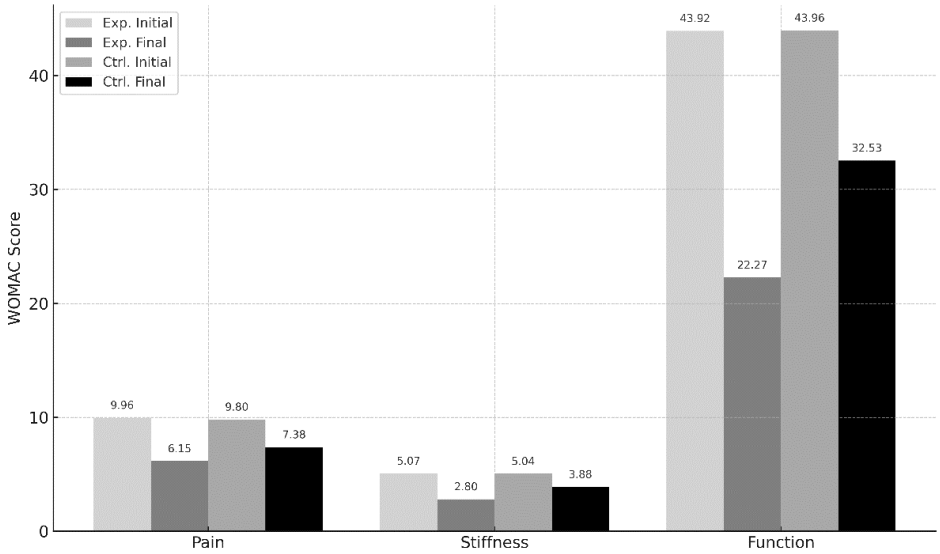


Fig. 4. WOMAC scale scores – initial and final comparisons for both groups.

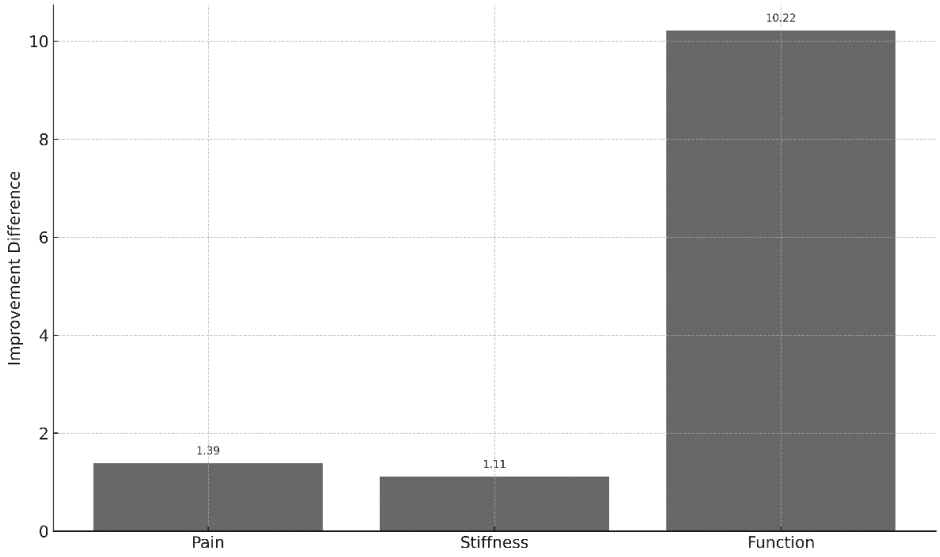


Fig. 5. Difference in improvement between experimental and control groups – WOMAC indicators.

This multidimensional approach validates the hypothesis that therapeutic exercise is not merely supportive, but central to the functional and psychosocial recovery of individuals with knee OA.

Connection with recent literature

Recent literature strongly supports the use of exercise-based interventions in OA management. Si et al. (2023) confirmed that home-based and supervised exercise programs are equally effective in reducing pain and improving function, while Skou & Roos (2019) emphasized the need for exercise as part of standardized treatment protocols. Uivaraşeanu et al. (2022) highlighted the relevance of biomechanical, neuromuscular, and postural corrections through tailored exercise routines, aligning with the findings of the present study. Successful educational-exercise hybrids like the GLA:D® program in Denmark and the Chronic Disease Self-Management Program have demonstrated sustained improvements in mobility, self-efficacy, and healthcare use among OA patients (Lorig et al., 2001; Skou & Roos, 2017).

Further, GBD 2021 Osteoarthritis Collaborators (2023) identified high BMI, sedentary lifestyle, and limited joint education as key modifiable risk factors in OA development. These insights reinforce the need for therapeutic programs that not only address symptoms but also empower patients through knowledge and movement retraining. Additionally, Raposo et al. (2021) and Brosseau et al. (2017) emphasized that adherence to structured programs correlates directly with long-term improvements in quality of life, especially when paired with educational interventions—an outcome also observed in the current research.

The role of education in prevention and management

Beyond the clinical dimension, this study reaffirms the pivotal role of education in the prevention and management of musculoskeletal disorders. The participants in the experimental group were not passive recipients of therapy, but active learners-engaged in understanding their condition, adapting exercises, and monitoring progress.

The inclusion of education in therapeutic protocols promotes autonomy, enhances adherence, and improves long-term outcomes. Patients learn not only what to do, but why and how to do it, leading to behavioral transformation. Practical strategies included in this study, such as weekly exercise diaries, interactive demonstrations, and guided goal-setting, enhanced patient engagement and accountability.

From a broader perspective, health education campaigns addressing joint health, ergonomics, weight management, and physical activity can serve

as primary prevention tools, particularly in aging populations at high risk for OA. As healthcare systems increasingly recognize the importance of lifestyle modification, embedding educational components into rehabilitation programs becomes not only beneficial but essential.

In sum, the present study aligns with and advances international trends that emphasize the integration of education and exercise in the holistic treatment of knee osteoarthritis, offering a viable model for interdisciplinary, patient-centered care.

The educational strategies employed in our intervention reflect broader models validated in international literature, particularly those emphasizing behavioral change, patient empowerment, and neuromuscular re-education (Bannuru et al., 2019; Lorig et al., 2001).

Study limitations

Despite the significant findings, this study presents several limitations that should be acknowledged:

- Sample size and geographic scope**:** The research included 52 participants from a limited urban area, which may affect the generalizability of results to rural or international populations.
- Lack of long-term follow-up: Although the six-month intervention yielded significant improvements, the absence of data beyond this period limits understanding of the sustainability of the therapeutic gains.
- Absence of blinding: Patients were aware of their group allocation, which may have introduced performance bias or affected self-reported outcomes such as pain and function.
- Variability in adherence: Although all participants received the same exercise protocol, differences in motivation, comprehension, and home practice may have influenced individual results.
- Limited diversity in clinical presentation: The study did not differentiate results by OA severity stages, gender, or comorbid conditions, which could be relevant for tailoring future interventions.

Future studies should address these limitations by expanding the sample size, including multi-center and multi-national collaborations, implementing blinded assessments, and exploring outcomes in more diverse and stratified patient groups. Moreover, including digital monitoring tools and tele-rehabilitation platforms could enhance adherence and allow for longer-term follow-up.

Practical and educational implications

The outcomes of this research emphasize the critical importance of integrating therapeutic physical exercise with patient education for the successful management of knee osteoarthritis. From a practical standpoint, the structured 6-month intervention program used in the experimental group can serve as a replicable model for clinical application in rehabilitation centers and physical therapy practices worldwide.

In educational terms, the study demonstrates how knowledge transfer regarding body mechanics, posture, and movement planning can positively influence compliance and recovery. This underscores the need to embed musculoskeletal health education in school curricula, health promotion campaigns, and patient-centered care pathways. Instructors and therapists should be trained not only in exercise techniques but also in communication strategies that promote self-efficacy and health autonomy.

Conclusions

Knee osteoarthritis is a progressive condition with significant consequences for mobility, functionality, and overall quality of life, particularly among older adults. The results of this study provide compelling evidence that therapeutic physical exercise, when integrated into a structured and individualized program, can serve as a central component of conservative management for knee OA.

The experimental group, which received both pharmacological and exercise-based interventions, showed greater improvements across all outcome measures compared to the control group. These included significant reductions in pain and joint stiffness, as well as enhanced joint flexibility and overall functional capacity. The WOMAC scale and goniometric measurements confirm these improvements statistically and clinically.

Additionally, this study reaffirms the importance of patient education as a key facilitator of recovery and long-term adherence. Empowering patients with knowledge, skill, and motivation enhances therapeutic outcomes and contributes to sustainable health behavior changes. The practical structure of the intervention, supported by educational and motivational strategies, can be easily adapted in physiotherapy clinics, rehabilitation centers, or community programs.

From a research standpoint, this study offers a replicable model that can inform clinical practice guidelines, educational curricula for physiotherapists and kinesiologists, and preventive healthcare policies aimed at musculoskeletal health. As the global burden of osteoarthritis continues to grow, non-invasive, low-cost, and patient-centered solutions like the one proposed in this study are increasingly valuable.

Further research should explore long-term outcomes, variations across demographic and clinical subgroups, and the integration of digital tools for remote monitoring and patient engagement. Nonetheless, the present results strongly advocate for the inclusion of therapeutic physical exercise and patient education in multidisciplinary approaches to knee osteoarthritis treatment.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this research.

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References

Albu, A., Albu, C., & Vlad, T.L. (2004). *Kinetoterapia pasivă.* Polirom.

Altman, R. D., & Gold, G. E. (2007). Atlas of individual radiographic features in osteoarthritis, revised. *Osteoarthritis and Cartilage, 15*(Suppl A), A1–A56. https://doi.org/10.1016/j.joca.2006.11.009

Altman, R., Asch, E., Bloch, D., Bole, G., Borenstein, D., Brandt, K., Christy, W., Cooke, T. D., Greenwald, R., Hochberg, M., Howell, D., Kaplan, D., Koopman, W., Longley, S., Mankin, H., McShane, D. J., Medsger, T., Meenan, R., Mikkelsen, W., & Wolfe, F. (1986). Development of criteria for the classification and reporting of osteoarthritis: Classification of osteoarthritis of the knee. *Arthritis & Rheumatism, 29*(8), 1039–1049. https://doi.org/10.1002/art.1780290816

Ayhan, E., Kesmezacar, H., & Akgun, I. (2014). Intraarticular injections (corticosteroid, hyaluronic acid, platelet rich plasma) for the knee osteoarthritis. *World journal of orthopedics*, *5*(3), 351–61. https://doi.org/10.5312/wjo.v5.i3.351

Bandy, D.W., & Sanders, B. (2013). *Therapeutic Exercise for Physical Therapy Assistants.* ((3thed) Philadelphia : Wolters Kluwer/Lippincott Williams & Wilkins Health.

Bannuru, R. R., Osani, M. C., Vaysbrot, E. E., Arden, N. K., Bennell, K., Bierma-Zeinstra, S. M. A., Kraus, V.B., Lohmander, L.S., Abbott, J.H., Bhandari, M., Blanco, F.J., Espinosa, R., Haugen, I.K., Lin, J., Mandl, L.A., Moilanen,

E., Nakamura, N., Snyder-Mackler, L., Trojian, T., Underwood, M., McAlindon, T.E., & McAlindon, T. E. (2019). OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. *Osteoarthritis Cartilage, 27*(11), 1578–1589. https://doi.org/10.1016/j.joca.2019.06.011

Bartholdy, C., Juhl, C., Christensen, R., Lund, H., Zhang, W., & Henriksen, M. (2017). The role of muscle strengthening in exercise therapy for knee osteoarthritis: A systematic review and meta-regression analysis of randomized trials. *Semin Arthritis Rheum. 47*(1), 9-21. https://doi.org/10.1016/j.semarthrit.2017.03.007

Bean, J.F, Kiely, D.K., Herman, S., Leveille, S.G., Mizer, K., Frontera, W.R, & Fielding, R. A. (2002). The relationship between leg power and physical performance in mobility-limited older people. *Journal of the American Geriatrics Society*, *50*(3), 461–7. https://doi.org/10.1046/j.1532-5415.2002.50111.x

Berenbaum, F., & Walker, C. (2020). Osteoarthritis and inflammation: a serious disease with overlapping phenotypic patterns. *Postgraduate Medicine*, *132*(4), 377–384. https://doi.org/10.1080/00325481.2020.1730669

Blagojevic, M., Jinks, C., Jeffery, A., & Jordan, K.P. (2010). Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis Cartilage. 18*(1), 24-33. https://doi.org/10.1016/j.joca.2009.08.010

Bonan, I., & Carson, P. (2009). Rôle de la rééducation dans le traitement de la gonarthrose (Role of physical therapy in the treatment of gonarthrosis). *La Revue du praticien, 59*(9), 1246–7. French.

Braun, H. J., & Gold, G. E. (2012). Diagnosis of osteoarthritis: imaging. *Bone*, *51*(2), 278–88. https://doi.org/10.1016/j.bone.2011.11.019

Brosseau, L., Taki, J., Desjardins, B., Thevenot, O., Fransen, M., Wells, G.A., Mizusaki, Imoto, A., Toupin-April, K., Westby, M., Álvarez, Gallardo, I.C., Gifford, W., Laferrière, L., Rahman, P., Loew, L., De Angelis, G., Cavallo, S., Shallwani, S.M., Aburub, A., Bennell, K.L., Van der Esch, M., Simic, M., McConnell, S., Harmer, A., Kenny, G.P., Paterson, G., Regnaux, J.P., Lefevre-Colau, M.M., & McLean, L. (2017). The Ottawa panel clinical practice guidelines for the management of knee osteoarthritis. Part two: strengthening exercise programs. *Clinical Rehabilitation*, *31*(5), 596–611. https://doi.org/10.1177/0269215517691084

Bruyère, O., Honvo, G., Veronese, N., Arden, N.K., Branco, J., Curtis, E.M., Al-Daghri, N.M., Herrero-Beaumont, G., Martel-Pelletier, J., Pelletier, J.P., Rannou, F., Rizzoli, R., Roth, R., Uebelhart, D., Cooper, C., & Reginster, J.Y. (2019). An updated algorithm recommendation for the management of knee osteoarthritis from the European society for clinical and economic aspects of osteoporosis. osteoarthritis and musculoskeletal diseases

(ESCEO*). Semin Arthritis Rheum*, *49*(3), 337-350. https://doi.org/10.1016/j.semarthrit.2019.04.008

Dulay, G. S., Cooper, C., & Dennison, E. M. (2015). Knee pain, knee injury, knee osteoarthritis & work. *Best Practice & Research Clinical Rheumatology*, *29*(3), 454-61. https://doi.org/10.1016/j.berh.2015.05.005

Dunleavy, K., & Slowik, K. A. (2018). *Therapeutic exercise prescription.* (1thed) Elsevier.

Fitzgerald, G. K., & Oatis, C. (2004). Role of physical therapy in management of knee osteoarthritis. *Current opinion in rheumatology*, *16*(2), 143–7. https://doi.org/10.1097/00002281-200403000-00013.

Fransen, M., McConnell, S., Harmer, A. R., van der Esch, M., Simic, M., & Bennell, K. L. (2015a). Exercise for osteoarthritis of the knee: a Cochrane systematic review. *British journal of sports medicine*, *49*(24), 1554-1557. https://doi.org/10.1136/bjsports-2015-095424

Fransen, M., McConnell, S., Harmer, A. R., van der Esch, M., Simic, M., & Bennell, K. L. (2015b). Exercise for osteoarthritis of the knee. *The Cochrane Database of Systematic Reviews, 1*(1), CD004376. https://doi.org/10.1002/14651858.CD004376.pub3

GBD 2021 Osteoarthritis Collaborators. (2023). Global, regional, and national burden of osteoarthritis, 1990–2020 and projections to 2050: a systematic analysis for the Global Burden of Disease Study 2021, *The Lancet Rheumatology*, *5,*(9),e508-e522, https://doi.org/10.1016/S2665-9913(23)00163-7

Germain-Calais, B. & Germain, F. (2024). *Anatomie pentru miscare. Introducere în analiza tehnicilor corporale.* Volumul I*,* Ediţia a III-a revizuită. Polirom.

Herbert, R. D., de Noronha, M., & Kamper, S. J. (2011). Stretching to prevent or reduce muscle soreness after exercise. *Cochrane database of systematic reviews*, *6*(7), CD004577. https://doi.org/10.1002/14651858.CD004577.pub3

Hunter, D.J., & Bierma - Zeinstra, S. (2019). Osteoarthritis. *Lancet, 393*(10182), 1745-1759. https://doi.org/10.1016/s0140-6736(19)30417-9

Kalu, M.E., Dal Bello-Hass, V., Griffin, M., Boamah, A.S., Harris, E. J., Zaide, M., Rayner, G.D., Khattab, N., Bhatt, V., Goodin, C., Song, (Beth) J.W., Smal, J., & Budd, N. (2022). Physical mobility determinants among adults:a scoping review of self-reported and performance-based measures. *European Journal of Physiotherapy*, *25*(9), 1-18. https://doi.org/10.1080/21679169.2022.2153303

Kellgren, J.H., & Lawrence, J.S. (1957). Radiological assessment of osteo-arthrosis. *Annals of the rheumatic diseases*, *16*(4), 494–502. https://doi.org/10.1136/ard.16.4.494.

Kisner, C., Borstad, J., & Colby, L., (Eds.). (2023). *Therapeutic exercise: Foundations and techniques.* (8th ed.) F. A. Davis Company - PT Collection

Kisner, C., Colby, L. A., Borstad, J. (2018). *Therapeutic Exercise: Foundations and Techniques* (7thed) F. A. Davis Company – PT Collection

Kolasinski, S. L., Neogi, T., Hochberg, M. C., Oatis, C., Guyatt, G., Block, J., Callahan, L., Copenhaver, C., Dodge, C., Felson, D., Gellar, K., Harvey, W.F., Hawker, G., Herzig, E., Kwoh, C.K., Nelson, A.E., Samuels, J., Scanzello, C., White, D., Wise, B., Altman. R.D., DiRenzo, D., Fontanarosa, J., Giradi, G., Ishimori, M., Misra, D., Shah, A.A., Shmagel, A.K., Thoma, L.M., Turgunbaev, M., Turner, A.S., & Reston, J. (2020). 2019 American College of Rheumatology/Arthritis Foundation guideline for the management of osteoarthritis of the hand, hip, and knee. *Arthritis & Rheumatology, 72*(2), 220–233. https://doi.org/10.1002/art.41142

Kroon, F. P., van der Burg, L. R., Buchbinder, R., Osborne, R. H., Johnston, R. V., & Pitt, V. (2014). Self-management education programmes for osteoarthritis. *The Cochrane Database of Systematic Reviews, 2014*(1), CD008963. https://doi.org/10.1002/14651858.CD008963.pub2

La Grow, S., Yeung, P., Towers, A., Alpass, F., & Stephens, C. (2013). The impact of mobility on quality of life among older persons. *Journal of Aging and Health*, *25*(5), 723-736. https://doi.org/10.1177/0898264313490198

Levangie, P.K., & Norchin, C.C. (2011). *Joint structure and function: A comprehensive analysis*. (5thed.) F. A. Davis Company.

Lorig, K. R., Ritter, P., Stewart, A. L., Sobel, D. S., Brown, B. W., Jr., Bandura, A., Gonzalez, V. M., Laurent, D. D., & Holman, H. R. (2001). Chronic disease self-management program: 2-year health status and health care utilization outcomes. *Medical care, 39*(11), 1217–23. https://doi.org/10.1097/00005650-200111000-00008

Magnusson K, Turkiewicz, A., & Englund, M. (2019). Nature vs nurture in knee osteoarthritis - the importance of age, sex and body mass index. *Osteoarthritis Cartilage, 27*(4), 586–592. https://doi.org/10.1016/j.joca.2018.12.018

Mahir, L., Belhaj, K., Zahi, S., Azanmasso, H., Lmidmani, F., & El Fatimi, A. (2016). Impact of knee osteoarthritis on the quality of life. *Annals of physical and rehabilitation medicine*, *59*, e159. https://doi.org/10.1016/j.rehab.2016.07.355

McGregor, R. A., Cameron-Smith, D., & Poppitt, S. D. (2014). It is not just muscle mass: a review of muscle quality, composition and metabolism during ageing as determinants of muscle function and mobility in later life. *Longev & healthspan*, *3*(1), 9. https://doi.org/10.1186/2046-2395-3-9

McWilliams, D. F., Leeb, B. F., Muthuri, S. G., Doherty, M., & Zhang, W. (2011). Occupational risk factors for osteoarthritis of the knee: a meta-analysis. *Osteoarthritis Cartilage*, *19*(7), 829–39. https://doi.org/10.1016/j.joca.2011.02.016

Messier, S. P., Gutekunst, D. J., Davis, C., & DeVita, P. (2005). Weight loss reduces knee-joint loads in overweight and obese older adults with knee osteoarthritis. *Arthritis and rheumatism*, *52*(7), 2026–32. https://doi.org/10.1002/art.21139

Nelson, G.A., & Kokkonen, J. (2022). *Anatomia stretchingului* (3nd ed., translation). Lifestyle Publishing.

Raposo. F., Ramos, M., & Lúcia Cruz, A. (2021). Effects of exercise on knee osteoarthritis: A systematic review. *Musculoskeletal Care. 19*(4), 399-435. https://doi.org/10.1002/msc.1538

Rayahin, J. E., Chmiel, J. S., Hayes, K. W., Almagor, O., Belisle, L., Chang, A. H., Moisio, K., Zhang, Y., & Sharma, L. (2014). Factors associated with pain experience outcome in knee osteoarthritis. *Arthritis care & research*, *66*(12), 1828–35. https://doi.org/10.1002/acr.22402

Rosadi, R., Jankaew, A., Wu, P. T., Kuo, L. C., & Lin, C. F. (2022). Factors associated with falls in patients with knee osteoarthritis: A cross-sectional study. *Medicine (Baltimore)*, *101*(48), e32146. https://doi.org/10.1097/MD.0000000000032146

Segal, N. A., Glass, N. A., Felson, D. T., Hurley, M., Yang, M., Nevitt, M., Lewis, C.E., & Torner, J. C. (2010). Effect of quadriceps strength and proprioception on risk for knee osteoarthritis. *Medicine and science in sports and exercise*, *42*(11), 2081-8. https://doi.org/10.1249/MSS.0b013e3181dd902e

Shumway- Cook, A., Woollacott, H. M., Rachwani, J., & Santamaria, V. (2023). *Motor control: translating research into clinical practice (6th ed.)*. Lippincott Williams & Wilkins, a Wolters Kluwer business. https://pt.lwwhealthlibrary.com/book.aspx?bookid=3185&sectionid=0

Si, J., Sun, L., Li, Z., Zhu, W., Yin, W., & Peng, L. (2023). Effectiveness of home-based exercise interventions on pain, physical function and quality of life in individuals with knee osteoarthritis: A systematic review and meta-analysis. *Journal of Orthopaedic Surgery and Research, 18*(1), 503. https://doi.org/10.1186/s13018-023-04004-z

Skou, S. T., & Roos, E. M. (2017). Good Life with osteoArthritis in Denmark (GLA:D™): evidence-based education and supervised neuromuscular exercise delivered by certified physiotherapists nationwide. *BMC Musculoskeletal Disorders, 18*, (1), 72. https://doi.org/10.1186/s12891-017-1439-y

Skou, S.T., & Roos, E.M. (2019). Physical therapy for patients with knee and hip osteoarthritis: supervised, active treatment is current best practice. *Clin Exp Rheumatol. 37 Suppl 120*(5), 112-117.

Sowers, M. R., & Karvonen-Gutierrez, C. A. (2010). The evolving role of obesity in knee osteoarthritis. *Current opinion in rheumatology*, *22*(5), 533–537. https://doi.org/10.1097/BOR.0b013e32833b4682

Uivaraseanu, B., Vesa, C. M., Tit, D. M., Abid, A., Maghiar, O., Maghiar, T. A., Hozan, C., Nechifor, A. C., Behl, T., Patrascu, J. M., & Bungau, S. (2022). Therapeutic approaches in the management of knee osteoarthritis (Review). *Experimental and therapeutic medicine*, *23*(5), 328. https://doi.org/10.3892/etm.2022.11257