Proceedings of ICSPHS 2026 Symposium: Ethics, Law, and Psychology: Interdisciplinary Reconstruction of Humanities in Medicine
DOI: 10.54254/2753-7048/2026.ZJU32109

Pathological Mechanisms and Cutting-edge Rehabilitation Therapies for Knee Osteoarthritis

Jiayin Li

Vanke Meisha Academy, Shenzhen, China
ArielJiayinLi123@outlook.com

Abstract. Knee osteoarthritis (KOA) is a prevalent chronic joint condition that primarily affects middle-aged and elderly individuals. It is characterized by pain, stiffness, and functional limitation, which greatly impacts day-to-day life. This report seeks to present a description of KOA pathological process and rehabilitation plan. From a Western perspective, KOA involves progressive cartilage degeneration, chronic low-grade inflammation, and abnormal mechanical loading, whereas traditional Chinese medicine categorizes KOA as a form of "Bi syndrome" and emphasizes syndrome differentiation to perform individualized treatment. According to these mechanisms, several rehabilitation strategies are proposed, including kinesiotherapy, physiotherapy, biomechanical intervention, etc. Aerobic exercises and strength training have a crucial role to play in the management of pain and functional recovery, whereas electrical stimulation is among the non-pharmacological pain management strategies offered by the physiotherapy methods. Also, biomechanical interventions will decrease joint loading by correcting alignment and traditional Chinese medicine is also complementary and provides adhesive value, including acupuncture, moxibustion, and external treatment. In general, a personalized rehabilitation plan is the key to successful KOA rehabilitation and long-term improvement of joint functions and recovery.

Keywords: knee osteoarthritis, rehabilitation therapies, pathological mechanisms.

1. Introduction

Knee osteoarthritis (KOA) is a type of chronic joint-related disorder, and its frequency keeps rising with age [1]. Its most common occurrence is in middle-aged and elderly populations. The increasing prevalence of KOA is consistent with the ageing of the world population and therefore it is a significant national health issue. The symptoms comprise pain, stiffness, and impaired knee movement that may reduce people's daily activities and quality of life.

Traditionally, wear and tear in the knee joint was regarded as the main reason for KOA [2]. Nevertheless, recent studies show that it can be caused by various factors, such as cartilage destruction, inflammation, abnormal mechanical strain, etc. [1,2]. Currently, there is no clear cut cure to KOA, and the majority of treatment strategies aim at reducing symptoms and magnitude of pain other than providing a full-fledged cure. Non-surgical rehabilitation exercise programs are very instrumental in the management of the condition [2].

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2753-7048/2026.ZJU32109

The highlight of the paper is to make a detailed description of KOA; it includes pathology and various rehabilitation interventions, such as kinesiotherapy, physical therapy, biomechanical intervention, and treatment of traditional Chinese medicine [1-3].

2. Pathological mechanism

KOA's pathological mechanism is important for informing the development of therapeutic measures and rehabilitation strategies [1]. Western medicine and traditional Chinese medicine hold different views on the etiology and progression of KOA, which provide complementary information for clinical management [2-4].

Chronic low-grade inflammation also contributes to the pathogenesis. Molecular evidence is demonstrated by synovial inflammation and high concentrations of cytokines including IL-1β, TNF-α, and IL-6. Subchondral bone remodeling and abnormal mechanical loads (e.g., from joint malalignment and obesity) further propel the disease process.

According to traditional Chinese medicine, KOA can be defined as a form of knee bi syndrome caused by invasion of wind, cold, or dampness [3]. It is also classified into patterns such as wind-cold-dampness obstruction, phlegm-stasis obstruction in the collaterals (italicized as a TCM term) and liver-kidney deficiency [3]. These categories emphasize the necessity of personalized diagnosis and treatment, and traditional Chinese medicine provides a methodology for selecting specific interventions, such as acupuncture, moxibustion, and herbal treatment, to target both superficial symptoms and root causes.

3. Extensive rehabilitation treatment

3.1. Kinesiotherapy

Kinesiotherapy is of significant importance in the treatment of KOA, as it is well-known to help reduce pain, enhance joint function, and stabilize disease progression. Current KOA interventions include cardio (aerobic) exercise and strength training, which target symptom management and recovery respectively.

3.1.1. Cardio exercise

Aerobic exercise is one of the major strategies for KOA rehabilitation and is recommended in various international guidelines as an agent for pain relief and function enhancement. Nevertheless, the following difficulties emerge in clinical practice: it is challenging to select an appropriate individualized regimen among various types of aerobic exercises to ensure the sustainability of therapeutic outcomes in the long term, and inappropriate exercise may result in painful experiences and patient withdrawal [5].

Aerobic exercise improves pain and joint function in KOA patients by reducing pain. Previous studies assessed overweight KOA patients who reported pain during weight-bearing exercises. The researchers used a body weight-supported treadmill intervention program (12 weeks, 2 sessions/week, 30 minutes/session, 12% body weight support) and evaluated patients at baseline, immediately after the intervention, and at least 6 months after the intervention. It is important to note that 6 respondents reported complete pain relief (VAS = 0), and 9 respondents reported less pain than at baseline.

A network meta-analysis conducted by Cai evaluated the impact of aerobic exercises such as land walking, bicycling, backward walking, and underwater exercises on pain levels or joint function.

DOI: 10.54254/2753-7048/2026.ZJU32109

The results showed that underwater running was ranked most effective (SUCRA = 87.1%), although not all comparisons reached statistical significance, followed by underwater walking (SUCRA = 58.6%) and land walking (SUCRA = 55.9%). Cycling was most effective for joint stiffness, while walking was most effective for joint function (SUCRA = 77.3% and 79.3%, respectively). In this meta-analysis, the effectiveness of various aerobic interventions was compared, and it was found that different types of exercises can target different therapeutic effects [4].

3.1.2. Strength training

In addition to aerobic exercise, strength training is an effective KOA intervention. Unlike aerobic exercise, strength training focuses more on enhancing joint stability. Muscle weakness is considered a common and important cause of abnormal joint stiffness, impaired function, and pain, so targeted knee muscle strengthening is clinically significant.

Some research showed that exercise therapy did not significantly reduce key biomechanical load indicators during gait; instead, slight increases were observed in the first peak knee adduction moment, peak knee flexion moment, and maximal knee joint compression force following exercise interventions.

3.2. Physiotherapy

A 2021 study used tDCS. The intention-to-treat analysis revealed that there was a more significant decrease in Brief Pain Inventory (BPI) scores in the active tDCS group compared to the sham group ($P < 0.001$). There was also a significant increment in conditioned pain modulation (CPM)-pressure in the knee and CPM-pain in the hand. These were not maintained at follow-up. The intervention was fairly acceptable without any severe adverse effects [5].

W-TENS device was compared with weak opioids as another study on the treatment of moderate chronic KOA pain and severe. Findings showed that W-TENS were better and more effective than weak opioids in the patients who were being studied. By three months, there were significantly lower treatment-related adverse events in the W-TENS group as well as a significantly lower level of pain intensity compared to the opioid group. Secondary outcome measures of quality of life and joint functioning also supported W-TENS, which points to the fact that this approach to pain management is a safe and non-pharmacological alternative [6].

3.3. Biomechanical therapy

Contrary to other approaches used in rehabilitation, biomechanical therapy is aimed at minimizing the mechanical load on the affected knee, which results in an increase in the functionality of the joint and the elimination of pain. The study was done to investigate the impact of foot orthosis, ankle-foot orthosis (AFO) and knee orthosis on the pain level, functional capacity, quality of life, and the alignment of the knee among patients with medial knee osteoarthritis (MKOA). To determine the outcomes, it was found that knee orthosis and AFO brought significant differences ($p < 0.05$) but foot orthosis did not bring any significant differences ($p > 0.05$) [7]. Altogether, biomechanical interventions could be regarded as an effective complementary intervention in the KOA rehabilitation programs.

DOI: 10.54254/2753-7048/2026.ZJU32109

3.4. Traditional Chinese medicine treatment

The TCM interventions are founded on the premises of the holistic concept and syndrome differentiation-based treatment, which has inimitable benefits in terms of pain relief, joint functioning, and the quality of life. Conversely, traditional Western medicine pharmaceutical treatment is usually constrained by side effects like gastrointestinal or hepatorenal toxicity, which is escalating clinicians to exploring alternative mediums of TCM externality, which seems to offer just basic, convenient, efficacious, and cost-effective usage. Researches are ongoing into the clinical efficacy and the biologic mechanisms of application of various therapies, including acupoint, tuina, warm acupuncture and moxibustion, creating a more robust evidence-based medicine basis of their application. This part is oriented to the representative therapies including acupuncture, warm acupuncture and moxibustion, tuina coupled with a variety of external therapies and acupoint application coupled with Chinese herbal fumigation and washing, as well as reviewing the recent research advances, they clarify comprehensively the effect of relevant therapies to improve clinical symptoms, control inflammatory and bone metabolism factors and enhance local microcirculation.

Researchers tested acupuncture versus oral celecoxib capsules in a randomized controlled study that involved He Wenhua into the study of knee osteoarthritis. Acupuncture, a recommended, long-standing Chinese customary medicine, has a proven effect of improving the mobility of the joints and reducing pains amongst patients of KOA [8]. The researchers randomized a total of 72 patients; they all took celecoxib orally (in 2 weeks) or received acupuncture at acupoints of the knee surrounding the joint (Yanglingquan (GB34), Yinlingquan (LR9) and the Ashi Points). The findings demonstrated that the two groups realized similar effects in minimizing the WOMAC scores and the VAS scores, where pain relief and improvement of joint functions were significant in the two groups. It is important to note that, the laser speckle imaging technology was used in this study to measure quantitatively the superficial microcirculation blood perfusion in five regions of interest in the area of the local knee joint. The research also discovered acupuncture could increase local blood perfusion in various parts significantly and its therapeutic action was similar to first-line Western medicine which offered objective imaging methods in demonstrating the mechanism by which acupuncture could be effective in its therapeutic effects by improving local blood perfusion misunderstanding.

Warm acupuncture and moxibustion treatment integrates physical stimulus of acupuncture with the heating property of moxibustion and adjuvant usage of the method on the foundation of the conventional western medicine has proven to be better in clinical results. Researchers such as Yang Rongrong conducted a 2-week clinical trials to determine the role of warm acupuncture and moxibustion as an additional treatment of KOA. Sixty respondents will be selected randomly to either receive routine pharmaceutical management or subscribe to a blend treatment combining the Western with warm acupuncture. Outcome assessment occurred through measurement of serum inflammatory levels, bone metabolism indices, knee functional tests, quality of life and intensity of pain using visual analogue scale. The combination of warm acupuncture and moxibustion therapy to this group demonstrated better results in terms of therapy, such as improvement of knee functionality and better quality of life assessment results. These patients as well recorded lower indices of joint discomfort and lower TCM symptoms assessment compared with the group that was administered Western medicine alone. With references to biological markers, this treatment method has been identified to increase serum levels of bone repairing and metabolism supporting factors, such as osteoprotegerin, fibroblast growth factor-2 and insulin-like growth factor-1. At the same time, it decreased the concentration of the inflammation and cartilage degeneration markers, including interleukin-8, C-reactive protein, matrix metalloproteinase-3, interleukin-17, COMP,

DOI: 10.54254/2753-7048/2026.ZJU32109

CTX-II. This implies that warm acupuncture and moxibustion do not only have the capability of improving the subjective symptoms and functions of patients but also psychological therapeutic effect by balancing the inflammatory response of the body and maintaining bone metabolites balance [9].

Another significant TCM external therapy is called Tuina and is frequently used together with other therapies to increase their effectiveness. According to a review carried out by Tang Xiao et al., the research progress of the tuina was systematically summarized into the presence of multiple modalities with acupuncture, acupotomy, Chinese herbal fumigation, hot compress, herbal ointment massage, and exercise therapy of KOA [10]. There has been evidence that tuina combining with warm acupuncture and moxibustion is more effective than monotherapy in relieving discomfort, improving joint mobility and reducing the stiffness, and significantly lowering blood concentrations of the inflammatory factors such as tumor necrosis factor-alpha and interleukin-1beta. Furthermore, the used regimen of tuina and acupotomy is highly effective in terms of the improvement of the knee functionality and alleviation of pain, which successfully decreases the levels of matrix metalloproteinase-3, interleukin-6 and tumor necrosis factor-alpha in serum. Furthermore, tuina as a whole with Chinese herbal fumigation or hot compress has the ability to stimulate local blood circulation, eliminate stasis and inflammation with the combined effects of heat and drugs. This regimen with the use of familiar exercise therapies like Baduanjin and Yijinjing assists in boosting the stability of the muscles surrounding the knee joint, enhance proprioception and prevent inflammatory response. These holistic forms of therapy reflect the TCM principle of therapeutic meridians implicating that the therapy will be pain-free in the absence of a blockaged meridian and to facilitate the circulation of qi and blood smoothly in the body and get rid of all the obstruction through a variety of channels.

Table 1. Efficacy comparison table of traditional Chinese medicine external therapies for knee osteoarthritis

Therapeutic Approach	Key Indicator Improvements	Mechanism of Action	Ref.
Acupuncture Therapy	WOMAC and VAS scores are significantly reduced; superficial blood perfusion in multiple local regions of the knee joint is notably increased	Improves local microcirculatory disorders, dredges meridians and regulates qi-blood	[8]
Warm Acupuncture	Clinical effective rate is significantly higher than that of the Western medicine alone group; VAS scores and TCM syndrome scores are more remarkably reduced;	Regulates inflammatory response (reduces IL-17, IL-8, etc.), stabilizes bone metabolism balance (increases IGF-1, OPG, etc.)	[9]
Tuina Manipulation	Compared with single therapy, more significantly reduces inflammatory markers, achieves more obvious improvement in joint function	Dredges meridians, promotes blood circulation to remove blood stasis, resists inflammation and relieves pain; combined therapies exert synergistic effects	[10]
Acupoint Application	The treatment group demonstrated a more substantial rise in scores across every domain of the SF-36 health survey. Additionally, a greater reduction was observed in both WOMAC and visual analog scale ratings.	Inhibits inflammatory response (reduces IL-6), alleviates oxidative stress (increases IL-10, SOD)	[11]

Researchers were involved in a clinical study to evaluate the use of herbal fumigation in combination with acupoints to treat KOA and its influence on a number of blood parameters. This combination of the external treatment combines the thermal, transdermal absorption and the stimulation of acupoints. Sixty-eight people were left to either an oral injection of ibuprofen or an additional treatment group which was treated repeatedly with use of herbal fumigation and application of acupoints. To apply acupoints, medicines like Evodia rutaecarpa, Angelica dahurica and Asarum sieboldii were used on acupoints like Dubi (ST35) and Zusanli (ST36). The formula of Chinese herbal fumigation and washing included several kinds of medicinal raw materials like Cyathula officinalis, Chaenomeles sinensis, Notopterygium incisum and Angelica pubescens. The

DOI: 10.54254/2753-7048/2026.ZJU32109

results reflected an extremely high clinical efficacy rate of the treatment group over the controls. Concerning the assessment scales, there were more significant reductions in WOMAC and VAS scores, as well as in all types of this survey of SF-36, in this group. This pushes its advantages in terms of pain relief, improved joint performance, as well as the overall quality of life improvement. In the mechanism exploration level, the treatment group also exhibited a more apparent decrease of the serum concentration of the pro-inflammatory factor interleukin-6 after treatment whereas the serum levels of the anti-inflammatory factor interleukin-10 and the antioxidant factor superoxide dismutase significantly rose. This implies that combined therapy can have its therapeutic effect (See table 1).

4. Conclusion

This paper focuses on knee osteoarthritis (KOA), a chronic disease characterized by pain, stiffness, and limited function, and has established a relatively systematic achievement system in two major aspects: pathological interpretation and rehabilitation intervention. In terms of pathological mechanisms, the integration of Western medicine theories of cartilage degeneration, chronic low-grade inflammation, and abnormal mechanical load, along with the syndrome differentiation and classification system of "bi syndrome" in traditional Chinese medicine, has laid a theoretical foundation for understanding the multi-dimensional nature of the disease and implementing individualized interventions. In terms of rehabilitation strategies, multi-path achievements have been made centering on core symptoms: exercise therapy has established the fundamental role of aerobic training and strength training in relieving pain and improving function; within rehabilitation medicine, wearable transcutaneous electrical nerve stimulation and transcranial direct current stimulation offer viable alternatives for non-pharmacological pain management; biomechanical interventions correct force lines and reduce joint load through orthoses and other means to alleviate mechanical pain; external treatment methods of traditional Chinese medicine have shown unique value. Therapies such as acupuncture, warm acupuncture, tuina, and external application of traditional Chinese medicine have achieved significant curative effects in pain management and functional recovery through multiple mechanisms including dredging meridians, regulating qi and blood, anti-inflammation, and improving bone metabolism, forming a comprehensive rehabilitation mode with complementary advantages to Western medicine methods. Looking forward to the future, technological development targeting the core symptoms of KOA will show a trend of in-depth integration and paradigm evolution. The overall direction will move toward a higher degree of precision, integration, and intelligence: individualized diagnosis and treatment plans based on multi-omics, biomechanics, and imaging will become increasingly mature; advances in rehabilitation engineering and biomaterials technology are expected to spawn more intelligent and adaptable wearable assistance and tissue repair strategies; digital medical and remote monitoring platforms will promote the standardization and sustainability of home-based rehabilitation; the path of integration of traditional Chinese and Western medicine will move from empirical integration to mechanism interpretation and standardization, seeking synergistic effects at the level of neuro-immune-metabolic network regulation.

Ultimately, the goal of technological evolution is to gradually shift from the current mode dominated by symptom control and functional compensation to an ecological system of early intervention, structural modification, and full-cycle health management, thus realizing a fundamental leap from "disease treatment" to "functional enhancement" and "health promotion".

DOI: 10.54254/2753-7048/2026.ZJU32109

References

[1] Giorgino, R., Albano, D., Fusco, S., Peretti, G.M., Mangiavini, L. and Messina, C. (2023) Knee osteoarthritis: Epidemiology, pathogenesis, and mesenchymal stem cells—What else is new? An update. International Journal of Molecular Sciences, 24(7), 6405.

[2] Jang, S., Lee, K. and Ju, J.H. (2021) Recent updates of diagnosis, pathophysiology, and treatment on osteoarthritis of the knee. International Journal of Molecular Sciences, 22(5), 2619.

[3] Zeng, L., Zhou, G., Yang, W. and Liu, J. (2023) Guidelines for the diagnosis and treatment of knee osteoarthritis with integrative medicine based on traditional Chinese medicine. Frontiers in Medicine, 10, 1260943.

[4] Li, Y., Zhang, X., Wang, Y., Liu, X., Zhang, L., Wang, H. and Chen, L. (2021) Network meta-analysis of the effects of different aerobic exercises on patients with knee osteoarthritis. Chinese Journal of Sports Medicine, 40(10), 785–794.

[5] Tavares, D.R.B., Okazaki, J.E.F., Santana, M.V.A., Pinto, A.C.P.N., Tutiya, K.K., Gazoni, F.M., Pinto, C.B., Santos, F.C., Fregni, F. and Trevisani, V.F.M. (2021) Motor cortex transcranial direct current stimulation effects on knee osteoarthritis pain in elderly subjects with dysfunctional descending pain inhibitory system: A randomized controlled trial. Brain Stimulation, 14(3), 477–487.

[6] Maheu, E., Soriot-Thomas, S., Noël, E., Ganry, H., Lespessailles, E. and Cortet, B. (2022) Wearable transcutaneous electrical nerve stimulation (actiTENS®) is effective and safe for the treatment of knee osteoarthritis pain: A randomized controlled trial versus weak opioids. Therapeutic Advances in Musculoskeletal Disease, 14, 1759720X211066233.

[7] Mahmoodi, M., Arazpour, M. and Mousavi, M.E. (2024) Comparing the effects of lower limb orthoses on knee pain, function, quality of life, and knee joint alignment in people with medial knee osteoarthritis. Journal of Rehabilitation and Assistive Technologies Engineering, 11, 20556683241277179.

[8] He, W.-H., Dong, X.-H., Zhou, J., Cheng, S.-R., Zeng, F., Li, Z.-J. and Liang, F.-R. (2021) Effects of Acupuncture on Clinical Symptoms and Local Superficial Microcirculatory Blood Perfusion of the Patients with KOA. World Science and Technology-Modernization of Traditional Chinese Medicine, 23(1), 190–196.

[9] Yang, R.-R., Guo, P. and Zhang, H.-H. (2024) Efficacy of Warm Acupuncture and Moxibustion in Adjuvant Treatment of KOA Patients Based on Knee Function, Pain Degree and Quality of Life. Liaoning Journal of Traditional Chinese Medicine, 51(7), 152–155.

[10] Tang, W., Liu, J.-C., Tuolihanai, A., Yakupu, Y., Dai, Z.-H. and Yueriguli, K. (2024) Progress of Research on the Treatment of Osteoarthritis of the Knee by Massage Combined with Other External Treatments of Traditional Chinese Medicine. Reflexotherapy and Rehabilitation Medicine, 5(7), 192–195.

[11] Liu, Y.-X. and Hu, S.-X. (2022) Efficacy of Acupoint Application Combined with Traditional Chinese Medicine Fumigation in the Treatment of Knee Osteoarthritis and Its Effects on VAS, WOMAC, SF-36 Scores and IL-6, IL-10, SOD Levels. TCM Research, 35(5), 17–21.