Application of Electroacupuncture Combined with Rehabilitation Training Program in Patients with Knee Osteoarthritis of Cold-dampness Obstruction Syndrome

Liangyun ZHOU[1,2], Guohui XU[1], Jie ZHANG[1], Hao XU[3], Minghui HANG[3], Miaomiao LIU[1], Yongjun WANG[3]*

1. Huadong Hospital Affiliated to Fudan University, Shanghai 200040, China; 2. School of Rehabilitation Medicine, Shanghai University of Traditional Chinese Medicine, Shanghai 201203, China; 3. Longhua Hospital Affiliated to Shanghai University of Traditional Chinese Medicine, Shanghai 200032, China

Abstract [**Objectives**] To explore the effects of electroacupuncture combined with rehabilitation training on knee joint function, three-dimensional (3D) gait, and inflammatory markers in patients with knee osteoarthritis (KOA) of cold-dampness obstruction syndrome. [**Methods**] A total of 162 KOA patients admitted to Huadong Hospital Affiliated to Fudan University from January 2021 to May 2023 were enrolled and randomly divided into an electroacupuncture group and a control group, with 81 patients in each group. The control group received routine rehabilitation training, while the electroacupuncture group received electroacupuncture treatment in addition to the same rehabilitation training, both for 4 weeks. The efficacy, syndrome scores, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Lysholm Knee Score (LKS), 3D gait parameters, and levels of inflammatory markers were compared between the two groups. [**Results**] Following treatment, the total effective rate in the electroacupuncture group was 92.59%, which was significantly higher than 77.78% observed in the control group ($P<0.05$). Additionally, the electroacupuncture group exhibited lower TCM syndrome scores ($P<0.05$), reduced WOMAC scores, and elevated LKS scores compared to the control group ($P<0.05$). Gait parameters, including step frequency, step speed, stride length, initial ground contact flexion angle, maximum swing phase extension angle, and support phase extension angle, were all higher in the electroacupuncture group. Additionally, the sagittal plane maximum abduction moment was lower in the electroacupuncture group. Inflammatory markers showed that interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α) were lower in the electroacupuncture group, while transforming growth factor-β1 (TGF-β1) was higher ($P<0.05$). [**Conclusions**] Electroacupuncture combined with rehabilitation training effectively enhances clinical efficacy, alleviates symptoms, improves knee joint mobility and walking ability, enhances knee function scores, and reduces inflammatory levels, contributing to the rapid recovery of knee joints in KOA patients.

Key words Knee osteoarthritis (KOA), Cold-dampness obstruction syndrome, Electroacupuncture, Rehabilitation training, Knee function scores, Gait, Inflammation, Clinical effects, Walking ability

1 Introduction

Knee osteoarthritis (KOA) is a chronic musculoskeletal disorder characterized by joint pain, stiffness, and functional impairment resulting from synovial inflammation of the knee joints[1]. Knee pain, audible snapping, swelling, and limited mobility are the predominant symptoms reported by individuals diagnosed with KOA. In severe cases, these symptoms may culminate in joint deformity, which, if left untreated, can ultimately result in the loss of joint function or disability, thereby significantly affecting the quality of life[2]. Common treatment modalities for KOA encompass oral pharmacotherapy, intra-articular injections, and surgical interventions; however, these approaches are not without limitations. Prolonged administration of non-steroidal anti-inflammatory drugs (NSAIDs) has the potential to adversely affect hepatic and renal function. Additionally, the pain and extended recovery period associated with intra-articular injections or surgical procedures may contribute to significant distress among patients[3]. KOA is classified within the categories of bone paralysis and tendon paralysis in traditional Chinese medicine (TCM). The primary etiology of this condition is attributed to the invasion of wind, cold, and dampness, which leads to paralysis within the meridians. This results in impaired qi and blood circulation, manifesting as joint pain, stiffness, and restricted mobility. Cold-dampness obstruction syndrome is a prevalent form of KOA[4]. Electroacupuncture is a form of physical therapy that is derived from traditional acupuncture. It has been shown to be a rapid and effective method for alleviating pain, reducing swelling, and managing effusion in patients. Furthermore, it offers significant advantages in the treatment of KOA[5]. This study examines the therapeutic effects of electroacupuncture combined with rehabilitation training on knee joint function, gait, and inflammation in patients diagnosed with KOA, aiming to establish a clinical foundation for the treatment of KOA utilizing the combination of electroacupuncture and rehabilitation training.

2 Information and methods

2.1 General information A total of 162 patients diagnosed with KOA who were admitted to the Huadong Hospital Affiliated to Fudan University between January 2021 and May 2023 were selected for this study. The participants were assigned to either the electroacupuncture group or the control group using a simple randomization method, resulting in 81 cases in each group. In the electroacupuncture group, there were 36 males and 45 females. According to imaging grading, there were 24 cases classified as grade I, 31 cases as grade II, and 26 cases as grade III. The

Received: January 20, 2025 Accepted: March 10, 2025

Supported by General Program of the National Natural Science Foundation of China (81973883); Three-Year Action Plan Project for Enhancing Clinical Skills and Clinical Innovation Capabilities of Municipal Hospitals (SHDC2020CR1010A).

Liangyun ZHOU, master's degree candidate. * Corresponding author. Yongjun WANG, doctoral degree, chief physician.

participants' ages ranged from 51 to 65 years, with a mean age of (57.35 ± 2.12) years. The duration of the disease varied from 1 to 6 years, with a mean duration of (3.15 ± 0.87) years. Additionally, there were 44 cases involving the left side and 37 cases involving the right side. In the control group, there were 33 males and 48 females. The imaging classification revealed 22 cases of grade I, 34 cases of grade II, and 25 cases of grade III. The participants' ages ranged from 52 to 67 years, with a mean age of (58.01 ± 2.67) years. The duration of the disease varied from 1 to 5 years, with an average duration of (2.79 ± 0.73) years. Additionally, the distribution of cases was 41 on the left side and 40 on the right side. The comparison of general information between the two groups did not yield statistically significant results ($P > 0.05$) and was found to be comparable. This study received approval from the Ethics Committee of the hospital (Ethics Approval No.: 20200065).

2.2 Diagnostic criteria The diagnostic criteria for Western medicine were based on the *Osteoarthritis Diagnostic and Treatment Guidelines* (2018 Edition)[6]. These criteria included the following: the patient must be over 50 years of age; there should be a recurrence of knee pain within the past month; X-ray imaging must reveal joint space narrowing, the formation of osteophytes at the joint margins, and subchondral bone sclerosis; the duration of morning stiffness should be 30 min or less; and the patient must exhibit a crepitating sound in the affected joint during movement. The diagnostic criteria for TCM were based on the *Guidelines for the Diagnosis and Treatment of Knee Osteoarthritis in Traditional Chinese Medicine* (2020 Edition)[7], which was utilized to establish the identification criteria for the cold-dampness obstruction syndrome. The primary syndromes included severe joint pain that was exacerbated by cold temperatures and alleviated by warmth, along with unfavorable flexion of the joints. Secondary syndromes consisted of significant pain in the lower back and body, accompanied by a pale red tongue, a white greasy coating, and a moist, slow pulse.

2.3 Inclusion criteria The inclusion criteria for the study were as follows: participants must be at least 18 years of age, with no restrictions on gender; they must meet the diagnostic criteria for cold-dampness obstruction syndrome type KOA as defined by both Chinese and Western medicine; they must have no prior history of surgical intervention for KOA and must be in a state of remission; they must not have received steroid treatment, either orally or via injection, within the past 2 months; and they must have voluntarily provided informed consent.

2.4 Exclusion criteria The exclusion criteria for the study were delineated as follows: pregnant and lactating women; individuals with secondary gout attributable to medications or renal failure; patients with infectious knee diseases; those who have previously undergone tibial osteotomy or artificial joint replacement; and individuals currently receiving physiotherapy or surgical interventions.

2.5 Disengagement and rejection criteria The criteria for disengagement and rejection included: inability to cooperate with the study due to physical reasons; voluntary withdrawal from the study for other reasons; and the occurrence of serious illness or significant adverse reactions during treatment.

2.6 Treatment methods The control group underwent conventional rehabilitation training, which included heel lifts, static squatting exercises, supine knee extensions, towel roll exercises, straight leg raises, and supine foot positioning on a straight surface. Each exercise was performed for 10 repetitions per set, with a total of 3 sets conducted in the morning and 3 sets in the afternoon. A rest period of 30 sec was observed between sets, and the training was conducted five times per week. The electroacupuncture group received treatment utilizing electroacupuncture (Hangzhou Ji'entang Biomedical Technology Co., Ltd., Model: XYD-I) in addition to the standard care provided to the control group. The acupoints selected for the affected limbs included Yinshi (ST33), Xuehai (SP10), Shangxuehai, Dubi (ST35), Liangqiu (ST34), Zusanli (ST36), Neixiyan (EX-LE4), and Yinlingquan (SP9). A 1.5-inch Andean acupuncture needle with dimensions of 0.30 mm × 40 mm was employed for the acupuncture procedure. The acupoints Yinshi, Xuehai, Liangqiu, Zusanli, and Yinlingquan were needled directly to a depth of 1.0 – 1.2 inches, while Shangxuehai, located approximately 1 inch above Xuehai, was inserted at a diagonal depth of 1.5 inches towards Xuehai. The needle tip of Neixiyan was oriented towards the center of the knee, and the needle tip of Dubi was directed inward at a depth of 0.5 – 1.0 inch. Following insertion, the needles were retained after being gently twisted in small increments using a neutral supplementation and draining technique until the local needle sensation subsided. The needles were then connected to the Huatuo SDZ-II electro-acupuncture instrument, and the treatment was administered using a sparse and dense wave frequency of 20/100 Hz for a duration of 30 min. Patients underwent treatment once weekly for 6 d, followed by a 1 d rest period. Both groups received treatment over a span of 4 weeks.

2.7 Observation indicators

2.7.1 Syndrome score. Prior to and following treatment, the patients' TCM syndrome points were evaluated in accordance with the *Syndrome and Efficacy Evaluation of New Traditional Chinese Medicine Drugs*[8]. The primary syndrome, characterized by severe joint pain that is exacerbated by cold and alleviated by warmth, as well as unfavorable joint flexion and extension, was classified into four categories based on severity: none (0 point), light (2 points), medium (4 points), and heavy (6 points). Similarly, the secondary syndrome, along with tongue and pulse assessments, were categorized as none (0 point), light (1 point), medium (2 points), and heavy (3 points) according to their respective degrees. The average scores for the primary syndrome, secondary syndrome, tongue and pulse were calculated to represent their respective conditions.

2.7.2 Knee function. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[9] and the Lysholm Knee Score (LKS)[10] were employed to assess the knee function of patients both prior to and following treatment. The WOMAC scale was comprised of 24 items that assessed three dimensions: pain, stiffness, and joint function. Each item was scored on a scale from

0 to 4, reflecting the severity of symptoms, with 0 indicating no symptoms and 4 indicating very severe symptoms. The cumulative score could reach a maximum of 96 points, with higher scores indicating a greater severity of KOA. The LKS scale comprised 8 dimensions: pain, swelling, limping, bracing, stair climbing, squatting, instability, and locking of the knee. The total score on this scale was 100 points, with lower scores indicating a diminished capacity for the patient to engage in daily activities.

2.7.3 3D gait analysis. Prior to and following treatment, gait data from the patients were collected and analyzed utilizing the Swedish Qualisys 3D motion acquisition and analysis system. The analysis primarily encompassed temporal-spatial parameters (step frequency, step speed, stride length), kinematic parameters (initial ground contact flexion angle, maximum swing phase extension angle, support phase extension angle), as well as mechanical parameters (coronal plane maximum abduction moment, sagittal plane maximum abduction moment).

2.7.4 Joint fluid indicators. Prior to and following treatment, 3 mL of fasting venous blood was obtained from the patients. The serum was subsequently analyzed for interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), and transforming growth factor-β1 (TGF-β1) utilizing enzyme-linked immunosorbent assay (ELISA) kits sourced from Shanghai Enzyme-linked Biotechnology Co., Ltd.

2.8 Determination criteria for clinical effects In reference to the *Evaluation of Syndrome and Efficacy of New Chinese Medicines*[8], clinical control was defined as the absence of abnormalities in X-ray imaging, a complete resolution of clinical symptoms associated with KOA, and normal joint mobility. An effective effect was indicated by notable improvements in X-ray findings, a reduction in clinical symptoms of KOA, and unrestricted joint function. The treatment was deemed ineffective as it did not conform to the specified criteria. Overall effective rate (%) = (Number of clinical control cases + Number of markedly effective cases + Number of effective cases)/Total number of cases × 100%.

2.9 Statistical methods The statistical software SPSS 24.0 was employed for data analysis. Categorical variables, including gender, imaging grading, and the location of the affected limb, were presented as percentages (%). The chi-square (χ^2) test was utilized for group comparisons of these categorical variables. Continuous variables, such as disease duration, syndrome score, and WOMAC score, were reported as means ± standard deviation ($\bar{x} \pm s$), with the independent *t*-test applied for comparisons between groups. A *P*-value less than 0.05 was considered indicative of statistical significance.

3 Results and analysis

3.1 Comparison of efficacy The total effective rate observed in the electroacupuncture group was significantly higher than that in the control group, with a statistically significant difference noted ($P < 0.05$, Table 1).

Table 1 Comparison of the efficacy of patients in two groups ($n = 81$) case (%)

Group	Clinical control	Markedly effective	Effective	Ineffective	Total effective
Control	20 (24.69)	25 (30.86)	18 (22.22)	18 (22.22)	63 (77.78)
Electroacupuncture	31 (38.27)	28 (34.57)	16 (19.75)	6 (7.41)	75 (92.59)*

NOTE Compared to the control group, $^*P < 0.05$.

3.2 Comparison of TCM syndrome score Following treatment, the TCM syndrome scores for the primary syndrome, secondary syndrome, and the assessments of tongue and pulse in KOA patients in both groups exhibited a reduction compared to pre-treatment scores. Furthermore, the TCM syndrome scores for the primary syndrome, secondary syndrome, and the evaluations of tongue and pulse in the electroacupuncture group were significantly lower than those observed in the control group, with a statistically significant difference noted ($P < 0.05$, Table 2).

Table 2 Comparison of TCM syndrome score of patients in two groups ($n = 81$, $\bar{x} \pm s$, point)

Group		Primary syndrome	Secondary syndrome	Tongue and pulse
Control	①	3.69 ± 0.84	1.54 ± 0.42	1.54 ± 0.41
	②	1.98 ± 0.41*	0.85 ± 0.28*	0.87 ± 0.25*
Electroacupuncture	①	3.65 ± 0.83	1.51 ± 0.40	1.52 ± 0.39
	②	1.35 ± 0.28*△	0.49 ± 0.16*△	0.41 ± 0.12*△

NOTE ①. Prior to treatment; ②. Following treatment; Compared to the same group prior to treatment, $^*P < 0.05$; compared to the control group following treatment, $^{\Delta}P < 0.05$. The same below.

3.3 Comparison of knee functions Following treatment, the WOMAC scores for both groups exhibited a reduction compared to pre-treatment levels, while the LKS scores demonstrated an increase. Notably, the WOMAC scores in the electroacupuncture group were significantly lower than those in the control group, and the LKS scores were significantly higher than those in the control group, with the differences reaching statistical significance ($P < 0.05$, Table 3).

Table 3 Comparison of knee functions of patients in two groups ($n = 81$, $\bar{x} \pm s$, point)

Group		WOMAC score	LKS score
Control	Prior to treatment	48.71 ± 6.73	52.93 ± 5.46
	Following treatment	28.52 ± 3.67*	62.42 ± 5.87*
Electroacupuncture	Prior to treatment	49.36 ± 6.68	53.76 ± 5.21
	Following treatment	13.49 ± 2.86*△	69.37 ± 6.14*△

3.4 Comparison of 3D gait analysis Following treatment, the step frequency, step speed, stride length, initial ground contact flexion angle, maximum swing phase extension angle, and support phase extension angle exhibited significant increases in both groups compared to pre-treatment measurements. Conversely, the sagittal plane maximum abduction moment demonstrated a significant decrease than that observed prior to treatment. Furthermore, the

electroacupuncture group showed higher values for step frequency, step speed, stride length, initial ground contact flexion angle, maximum swing phase extension angle, and support phase extension angle when compared to the control group, while also exhibiting a lower sagittal plane maximum abduction moment (Table 4). These differences were statistically significant ($P<0.05$).

Table 4 Comparison of 3D gait analysis of patients in two groups ($n=81$, $\bar{x}\pm s$)

Group		A//step/min	B//m/s	C//m	D//°	E //°	F //°	G//N·m	H//N·m
Control	Prior to treatment	84.16±6.34	0.84±0.17	0.48±0.07	15.11±4.93	51.31±5.24	4.97±1.38	0.95±0.42	1.58±0.54
	Following treatment	91.77±6.29*	1.03±0.20D*	0.56±0.09*	17.25±5.61*	56.21±6.33*	6.52±2.07*	1.08±0.44	1.39±0.51*
Electroacupuncture	Prior to treatment	85.45±5.71	0.83±0.15	0.50±0.08	14.97±4.76	50.79±5.16	4.91±1.26	1.01±0.45	1.53±0.55
	Following treatment	96.36±6.42*△	1.19±0.16*△	0.65±0.08*△	19.47±6.13*△	59.46±6.98*△	8.01±2.25*△	1.13±0.48	1.12±0.49*△

NOTE A. Step frequency; B. Step speed; C. Stride length; D. Initial ground contact flexion angle; E. Maximum swing phase extension angle; F. Support phase extension angle; G. Coronal plane maximum abduction moment; H. Sagittal plane maximum abduction moment.

3.5 Comparison of serum inflammatory indicators After treatment, serum inflammatory markers IL-6 and TNF-α exhibited a reduction compared to pre-treatment levels in both groups. Conversely, TGF-β1 levels were elevated post-treatment in both groups. Notably, the serum levels of IL-6 and TNF-α in the electroacupuncture group were significantly lower than those observed in the control group, while TGF-β1 levels were significantly higher in the electroacupuncture group compared to the control group, with statistical significance established ($P<0.05$, Table 5).

Table 5 Comparison of serum inflammatory indicators of patients in two groups ($n=81$, $\bar{x}\pm s$, ng/L)

Group		IL-6	TNF-α	TGF-β1
Control	①	71.85±7.82	49.11±6.58	38.72±4.68
	②	24.78±3.41*	13.04±2.55*	57.23±7.66*
Electroacupuncture	①	72.13±7.66	50.78±6.43	39.41±4.89
	②	31.69±3.83*△	21.25±3.38*△	49.47±6.85*△

NOTE ①. Prior to treatment; ②. Following treatment.

4 Discussion

The earliest references to KOA within the framework of TCM can be traced back to the *Emperor's Classic of Internal Medicine*, which identifies wind, cold, dampness, and pathogenic factors as significant contributors to the onset of paralysis. The interplay of joint strain, advanced age, physical deterioration, and deficiencies in liver and kidney function culminates in a deficiency of blood and qi, which adversely affects the health of muscles and bones. Furthermore, the invasion of wind-cold and dampness leads to the stagnation of cold within the muscles and bones, obstructing the flow of meridians. Prolonged stagnation results in the tendons and bones becoming deprived of nourishment, causing impaired blood circulation, which manifests as joint pain, soreness, swelling, and restricted mobility, ultimately leading to chronic and difficult-to-treat conditions. Consequently, therapeutic approaches should prioritize the dispersal of cold, the elimination of dampness, and the alleviation of pain[11]. Electroacupuncture is an external therapeutic modality rooted in TCM, which has evolved from conventional acupuncture practices. This technique has been shown to promote the repair and regeneration of bone tissues, while also enhancing the absorption of inflammation and improving blood circulation within the human knee joints. Additionally, electroacupuncture is believed to facilitate the unblocking of meridians and collaterals, alleviate cold, and eliminate dampness. These properties confer significant advantages in improving the clinical symptoms associated with KOA. However, further investigation is warranted to elucidate the combined effects of electroacupuncture and conventional rehabilitation training on therapeutic efficacy, knee joint function, gait, and serological indices in KOA patients.

In this study, electroacupuncture was administered at the acupoints of Yinshi, Xuehai, Shangxuehai, Dubi, Liangqiu, Zusanli, Neixiyan, and Yinlingquan. Notably, Yinshi is associated with the stomach meridian of the foot-yangming, and acupuncture at this point has been shown to enhance conditions related to yin-cold diseases. Dubi is classified as a point on the stomach meridian of the foot-yangming. Acupuncture at this point is known to enhance blood circulation, regulate qi, and alleviate pain. Zusanli serves as a key junction on the stomach meridian of the foot-yangming; acupuncture at this location can dispel cold and dampness, address paralysis-related pain, and tonify both qi and blood, while also promoting the hydration of muscles and bones. Yinlingquan is associated with the spleen meridian of the foot taiyin; acupuncture at this point is beneficial for strengthening the spleen and promoting diuresis, as well as relieving muscle rigidity and activating the collateral channels[12-13]. In this study, the patient exhibited a pattern of cold-dampness obstruction syndrome, and the primary objective of the treatment was to eliminate cold and dampness. Consequently, electroacupuncture was employed to treat KOA patients. Specific acupuncture points, including Yinshi and Yinlingquan, were utilized to dispel cold and dampness, thereby enhancing the elimination of these conditions through the promotion of local blood and lymphatic circulation. Additionally, acupuncture at points such as Xuehai, Shangxuehai, and Zusanli was found to activate blood circulation and alleviate blood stasis, which in turn improved local microcirculation, increased blood supply to the knee joint, and mitigated pain associated with blood stasis resulting from cold and dampness. The synergistic effects of multiple acupuncture points facilitated the unblocking of meridians, activation of blood circulation, and removal of blood stasis, leading to a significant reduction in knee pain. Furthermore, the warming effect of electroacupuncture effectively dispelled cold and alleviated stiffness and pain in the joints induced by cold, thereby contributing to the overall therapeutic goals of dispersing cold, eliminating dampness, and promoting the flow of qi and blood. The findings of this study indicate that the total effective rate of treat-

ment in the electroacupuncture group surpassed that of the control group. Additionally, the TCM syndrome scores for primary syndrome, secondary syndrome, as well as tongue and pulse assessments were significantly lower in the electroacupuncture group compared to the control group. These results suggest that the combination of electroacupuncture and rehabilitation training may effectively alleviate the clinical symptoms of joint pain in patients diagnosed with KOA. An analysis of the underlying mechanisms reveals that the continuous stimulation of acupoints through pulsed current effectively activates the endocrine system and the autonomic nervous system. This process facilitates the release of hormones and neurotransmitters, which in turn regulates the secretion of cytokines. Additionally, it activates the mitogen-activated protein kinase (MAPK) signaling pathway, thereby modulating the inflammatory response and diminishing the inflammatory stimulation of the knee joints[14]. Acupuncture points serve as sites for the infusion of qi and blood, as well as locations where dampness may become stagnant. The practice of acupuncture can improve the efficacy of meridian unblocking while simultaneously tonifying the liver and benefiting the kidneys. The WOMAC scale is a self-assessment tool designed to evaluate arthritis in the lower limbs, specifically targeting the knee and hip joints. Additionally, the LKS scale has been employed to assess ligament injuries, cartilage disorders, and various other knee joint diseases[15]. The findings of this study indicate that the WOMAC score and the LKS score of the electroacupuncture group were significantly superior to those of the control group. This suggests that the combination of electroacupuncture and rehabilitation training is more effective in enhancing knee function in KOA patients. Guo Yan *et al.*[16] demonstrated that acupuncture points, including Xuehai and Liangqiu, were effective in improving synovial hyperplasia, enhancing joint flexion and extension functions, and significantly reducing WOMAC scores. These findings align closely with the results of the present study. The underlying reason may be attributed to the roles of the Liangqiu and Xuehai points, which serve as the origin and termination points for the associated muscles. These points are believed to facilitate the opening of collaterals and alleviation of pain, enhance blood circulation, eliminate blood stasis, promote recovery and strengthening of muscle function, stabilize the joints, and expedite the restoration of knee joint functionality in patients[17].

Research has indicated that KOA patients experience asymmetric loading of the lower limbs as a result of joint pain, swelling, and other associated symptoms. Consequently, these patients may unconsciously tilt their trunks and hips in an effort to maintain balance while ambulating, leading to the manifestation of an abnormal gait[18]. The present study analyzed the gait characteristics of two groups of patients. The results indicated that the electroacupuncture group exhibited significantly greater improvements in step frequency, step speed, stride length, initial ground contact flexion angle, maximum swing phase extension angle, support phase extension angle, and sagittal plane maximum abduction moment compared to the control group. These findings suggest that the combination of electroacupuncture and rehabilitation training is more effective in enhancing gait in KOA patients. While conventional rehabilitation training is effective in promoting blood circulation and preventing muscle atrophy by facilitating the self-recovery of joints, electroacupuncture has the potential to remodel the innervation function of skeletal muscle nerves. This intervention enhances neuromuscular responsiveness, stimulates increased synaptic activity, and improves the efficiency of neuromuscular conduction. Consequently, electroacupuncture can significantly enhance gait in KOA patients and may serve a complementary therapeutic role alongside conventional rehabilitation training. Electroacupuncture combined with rehabilitation training has been shown to assist patients in reducing joint inflammation and pain, restoring the balance of internal forces within the joints, decelerating the degeneration of articular cartilage, and promoting its self-repair[19]. Furthermore, relevant studies indicate that electroacupuncture can effectively enhance the joint loading capacity of KOA patients and alleviate their symptoms, and also significantly improves patients' gait cycle, step speed, and unilateral support[20-21].

IL-6 has the potential to disrupt the equilibrium between matrix metalloproteinases and their inhibitors in cartilage tissue. This dysregulation can result in cartilage degeneration and defects, which may indicate pathological alterations within the knee joint of patients diagnosed with KOA. TNF-α is a significant inflammatory mediator in KOA, as it contributes to the degradation of collagen and proteoglycans in cartilage tissues through the activation of the nuclear factor-κB (NF-κB) signaling pathway, ultimately resulting in cartilage degeneration. TGF-β1 is crucial for preserving the morphology and functionality of articular chondrocytes. It mitigates the inflammatory response by antagonizing IL-6 and TNF-α in the context of KOA pathology. Additionally, TGF-β1 promotes collagen synthesis and chondrocyte proliferation, contributing to the repair of cartilage[22-23]. According to the study, IL-6 and TNF-α exhibit a negative correlation with the knee function score, specifically the American Knee Society Knee Score (KSS), in KOA patients. As the levels of IL-6 and TNF-α increase, there is a corresponding decline in knee function among these patients. Furthermore, TGF-β is also negatively correlated with the severity of the disease in KOA patients; as TGF-β levels rise, the severity of the disease in these patients tends to worsen[24-25]. According to Wei Hewei *et al.*[26], the levels of TNF-α in KOA patients diagnosed with the cold-dampness obstruction syndrome were significantly elevated compared to those observed in the other three types: liver-kidney yin deficiency, spleen-kidney yang deficiency, and qi stagnation with blood stasis. In this study, significant improvements in the levels of IL-6, TNF-α, and TGF-β1 were observed in the electroacupuncture group. These findings suggest that the combination of electroacupuncture and rehabilitation training may effectively enhance the inflammatory status of KOA patients and promote the reparative potential of articular cartilage. The observed effects may be attributed to the stimulation of acupoints such as Dubi, Neixiyan, and Yinlingquan, which can alleviate swelling and pain, improve the local inflammatory response, and reduce knee joint edema. Additionally, acupoints like Zusanli and Xuehai may play a role in regulating qi and blood flow, thereby enhancing the nutritional supply to the knee joint and facilitating the recovery of joint function. The mechanism of action may be associated with the inhibition of inflammatory mediators such as IL-6 and TNF-α, as

well as matrix metalloproteinases, through the application of electroacupuncture. Additionally, this process may influence the expression of apoptotic genes in chondrocytes[27]. Numerous studies have demonstrated that electroacupuncture treatment can significantly elevate the levels of TGF-β1 while concurrently reducing the levels of IL-6 and TNF-α in the synovial fluid of KOA patients. This modulation of cytokine levels is associated with alleviation of clinical symptoms, including joint pain, and contributes to the improvement of knee joint function[28]. KOA is a chronic condition, and it is essential to consider the long-term prognosis within the scope of investigation. This study has several limitations, including a relatively small sample size and a limited follow-up duration. Future research should involve a large-scale, prospective multicenter trial to further validate the long-term therapeutic efficacy of electroacupuncture in KOA patients. Such studies would provide a more comprehensive foundation for the application of electroacupuncture in the management of this condition.

In conclusion, electroacupuncture has been demonstrated to be effective in the treatment of KOA patients. This intervention significantly enhances 3D gait performance, mitigates the inflammatory response, and facilitates the functional recovery of the knee joint.

References

[1] SONG YC, WU SB, HU GF, *et al.* Clinical observation of Biqi Capsules combined with blade acupuncture in treatment of knee osteoarthritis[J]. Chinese Traditional and Herbal Drugs, 2021, 52(22): 6923 – 6927. (in Chinese).

[2] YAN ZH, ZHANG YS. Effect of continuous adductor canal block combined with local infiltration on the analgesic effect and early rehabilitation after total knee arthroplasty in elderly patients[J]. Infection · Inflammation · Repair, 2021, 22(4): 224 – 227. (in Chinese).

[3] ZHOU G, ZHAO MW, CAO YP, *et al.* Multicenter cross-sectional study of quality of life and nonsurgical treatment in patients with knee osteoarthritis[J]. National Medical Journal of China, 2022, 102(35): 2799 – 2805. (in Chinese).

[4] FU MR, HE LF, LYU J, *et al.* Meta-analysis of efficacy and safety of Hulisan Capsules in treatment of knee osteoarthritis[J]. China Journal of Chinese Materia Medica, 2022, 47(19): 5365 – 5374. (in Chinese).

[5] CHEN RL, DENG KF, WEI XC, *et al.* Effect of electro-acupuncture on pain relief and joint function in patients with knee osteoarthritis: A meta-analysis[J]. Chinese Journal of Tissue Engineering Research, 2020, 24(21): 3438 – 3444. (in Chinese).

[6] The Joint Surgery Branch of the Chinese Orthopaedic Association. Chinese guideline for diagnosis and treatment of osteoarthritis (2018 Edition)[J]. Chinese Journal of Orthopaedics, 2018, 38(12): 705 – 715. (in Chinese).

[7] CHEN WH. Guidelines for the diagnosis and treatment of knee osteoarthritis in traditional Chinese medicine (2020 Edition)[J]. The Journal of Traditional Chinese Orthopedics and Traumatology, 2020, 32(10): 1 – 14. (in Chinese).

[8] SHANG HC, WANG BH, ZHANG BL. Syndrome and efficacy evaluation of new traditional Chinese medicine drugs[J]. Traditional Chinese Drug Research and Clinical Pharmacology, 2004, 15(5): 365 – 368. (in Chinese).

[9] ANGST F, EWERT T, LEHMANN S, *et al.* The factor subdimensions of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) help to specify hip and knee osteoarthritis. A prospective evaluation and validation study[J]. Journal of Rheumatology, 2005, 32(7): 1324 – 1330.

[10] LIN JN, SUN XF, RUAN DK. Evaluation of knee joint function by Lysholm knee scoring scale[J]. Chinese Journal of Bone and Joint Injury, 2008, 23(3): 230 – 231. (in Chinese).

[11] ZHANG YZ, LIANG C, BAO CL, *et al.* Clinical observation of Zhuang medicine medicated thread moxibustion combined with acupuncture in the treatment of knee osteoarthritis of cold-damp obstruction syndrome type[J]. Journal of Guangzhou University of Traditional Chinese Medicine, 2021, 38(12): 2656 – 2662. (in Chinese).

[12] LI YF, WANG CY, WANG HL, *et al.* An analysis of rules of point selection in treating knee arthritis in great compendium of acupuncture and moxibustion[J]. Henan Traditional Chinese Medicine, 2020, 40(8): 1170 – 1173. (in Chinese).

[13] LI LY, PENG X, REN J, *et al.* Therapeutic efficacy of fire needling around the knee combined with acupuncture in early and middle stages of knee osteoarthritis[J]. China Journal of Modern Medicine, 2021, 31(4): 9 – 14. (in Chinese).

[14] ZHENG YM, LI LL, CHEN HM. Therapeutic effect and mechanism of electroacupuncture onrabbit model of knee arthritis[J]. Acta Universitatis Medicinalis Anhui, 2023, 58(6): 914 – 919. (in Chinese).

[15] ZHAO YR, LI YH, MA QL, *et al.* Progress in the application of evaluation criteria for clinical efficacy of acupuncture in the treatment of knee osteoarthritis[J]. Acupuncture Research, 2022, 47(8): 734 – 737, 743. (in Chinese).

[16] GUO Y, ZENG H, WANG YZ, *et al.* Effect and safety evaluation of different frequency of fire needling on knee osteoarthritis with cold-dampness obstruction syndrome: A randomize-controlled, double-blinded clinical trial[J]. Journal of Traditional Chinese Medicine, 2022, 63(15): 1442 – 1448. (in Chinese).

[17] ZHOU ZQ, YANG YJ, MA XD, *et al.* Mechanism of electroacupuncture penetration needling for relieving synovial inflammation of knee osteoarthritis through TLR4/MyD88/NF-κB signal pathway[J]. Acupuncture Research, 2023, 48(4): 353 – 358, 365. (in Chinese).

[18] ZHANG SP, ZHU QG, CHENG YB, *et al.* Yijinjing exercise on gait biomechanics in patients with knee osteoarthritis: A randomized controlled trial[J]. China Journal of Traditional Chinese Medicine and Pharmacy, 2023, 38(10): 5081 – 5086. (in Chinese).

[19] XU HF, ZHAO GP, YANG JJ, *et al.* Three-dimensional finite element analysis of electroacupuncture for patients with knee osteoarthritis during ascent and descent stair[J]. Chinese Journal of Biomedical Engineering, 2021, 40(3): 321 – 329. (in Chinese).

[20] FU SX, HOU MJ, LI ZH, *et al.* Effects of electro-acupuncture on vertical ground reaction force and impulse symmetry of patients with knee osteoarthritis during stair climbing[J]. Journal of Medical Biomechanics, 2020, 35(4): 335 – 341. (in Chinese).

[21] LI Y, ZHANG YH, SHEN LY, *et al.* Effect of electroacupuncture stimulation in the innervation zone on knee function score in elderly patients with knee osteoar-thritis[J]. Geriatrics & Health Care, 2023, 29(4): 794 – 797. (in Chinese).

[22] GUO Y, ZHANG X, ZHAO Z, *et al.* NF-κB/HDAC1/SREBP1c pathway mediates the inflammation signal in progression of hepatic steatosis [J]. Acta Pharmaceutica Sinica B, 2020, 10(5): 825 – 836.

[23] HU H, LI LT, LIU YW, *et al.* Effect of modified simiaosan on inflammatory factors and neuropeptide substances of patients with synovitis of knee joint and damp-heat obstruction collateral syndrome[J]. Chinese Journal of Experimental Traditional Medical Formulae, 2020, 26(6): 97 – 102. (in Chinese).

[24] LI JF. Study on the correlation between the expression of tumor necrosis factor: A and interleukin-6 in joint synovium and knee osteoarthritis with bone marrow edema[D]. Zunyi: Zunyi Medical University, 2021. (in Chinese).

(To page 70)

parisons revealed statistically significant improvements ($P < 0.05$) in weight, TCM symptom scores, BMI, and waist circumference in both groups. Further analysis showed statistically significant intergroup differences ($P < 0.05$) in all metrics except waist circumference improvement, which exhibited no significant disparity between groups. In the treatment group, 16 cases achieved marked effectiveness, 15 showed effectiveness, and none were ineffective, yielding a total effective rate of 100%. In contrast, the control group had 9 markedly effective cases, 17 effective cases, and 4 ineffective cases, with a total effective rate of 86.67%. This comparative result demonstrates that the combined therapy of herbal patching and acupuncture is more effective than acupuncture alone paired with non-medicated patching.

4 Conclusion

Multiple research findings demonstrate that TCM external treatments exhibit remarkable efficacy in obesity treatment. Compared to Western medical drug treatments, TCM external treatments offer advantages of fewer side effects, higher safety, and greater reliability. However, current research on the mechanisms of action of TCM external treatments remains insufficient, and their clinical application shows individual variations. Therefore, future efforts should focus on strengthening fundamental experimental research to investigate their mechanisms in depth, while further standardizing operational techniques to enhance clinical outcomes. Additionally, most existing studies are single-center or small-sample investigations, lacking broad representativeness. Future initiatives should actively promote multicenter, large-sample clinical studies to scientifically validate the efficacy and safety of TCM external treatments, thereby providing stronger evidence-based support for their clinical application.

References

[1] QI YX, HUANG WY. Research progress on traditional Chinese medicine treatment of simple obesity[J]. Research of Integrated Traditional Chinese and Western Medicine, 2023, 15(3): 191 - 194. (in Chinese).

[2] XING N, HE SH. Traditional Chinese medicine treatment of simple obesity[J]. Lishizhen Medicine and Materia Medica Research, 2006, 17(10): 2046 - 2047. (in Chinese).

[3] HE JW, PEI Z, QIAN T, *et al.* Expert consensus on clinical diagnosis and treatment of simple obesity in Chinese children with integrated traditional Chinese and western medicine[J]. Chinese Journal of Integrated Traditional and Western Pediatrics, 2023, 15(1): 1 - 7. (in Chinese).

[4] YANG ZZ, GAN XL. Dietary nutrition regulation for simple obesity[J]. Food Industry, 2017, 11(9): 76 - 77. (in Chinese).

[5] XU BG. Differential treatment of simple obesity with acupuncture[J]. Zhejiang Journal of Traditional Chinese Medicine, 2003, 13(1): 22 - 23. (in Chinese).

[6] MA XL. Discussion on traditional Chinese medicine treatment of simple obesity based on syndrome differentiation[J]. Beijing Journal of Traditional Chinese Medicine, 2005, 4(2): 125 - 126. (in Chinese).

[7] ZHANG QJ, ZHANG HX, WANG HY, *et al.* Efficacy of electroacupuncture plus auricular plaster therapy in treating simple obesity and its influence on resistin and blood lipid level[J]. Shanghai Journal of Acupuncture and Moxibustion, 2008, 27(3): 8 - 10. (in Chinese).

[8] LI DJ. Acupuncture and comprehensive therapy in the treatment of simple obesity[J]. Journal of Clinical Acupuncture and Moxibustion, 2011, 27(8): 81 - 83. (in Chinese).

[9] XIE YY. Observation on the efficacy of acupuncture in the treatment of simple obesity[D]. Liaoning: Liaoning University of Traditional Chinese Medicine, 2008: 7 - 9. (in Chinese).

[10] SU J, SHEN SE. Clinical observation of 32 cases of simple obesity with acupuncture[J]. Journal of Nanjing University of Traditional Chinese Medicine, 2005, 21(4): 262 - 263. (in Chinese).

[11] CAO WP. The clinical acupuncture research about the effect of strengthen the spleen to dampness to cure Simple Obesity[D]. Nanjing: Nanjing University of Traditional Chinese Medicine, 2014: 22 - 24. (in Chinese).

[12] ZHANG K. The clinical study about the effect of message on curing Simple Obesity[D]. Jinan: Shandong University of Traditional Chinese Medicine, 2004: 28 - 29. (in Chinese).

[13] XIE YJ, YANG DH, ZHAN HS, *et al.* The clinical study of manipulative therapy on simple obesity: A report of 106 cases[J]. Chinese Manipulation & Qi Gong Therapy, 2002, 18(4): 5. (in Chinese).

[14] CAO CM. Observation on the efficacy of acupoint catgut embedding in the treatment of 150 cases of simple obesity[J]. New Chinese Medicine, 2006, 38(8): 62 - 63. (in Chinese).

[15] LIU YM, SU HP. Clinical observation on acupoint catgut embedding for the treatment of simple obesity[J]. Liaoning Journal of Traditional Chinese Medicine, 2008, 35(4): 599 - 600. (in Chinese).

[16] SUN YT, GONG Y, LI LP, *et al.* Therapeutic observation of acupoint thread-embedding for simple obesity of various syndromes[J]. Shanghai Journal of Acupuncture and Moxibustion, 2014, 33(4): 323 - 325. (in Chinese).

[17] LIANG XY. Observation on simple obesity treated with acupoint sticking combined with acupuncture therapy[D]. Guangzhou: Guangzhou University of Traditional Chinese Medicine, 2022: 43 - 44. (in Chinese).

(From page 67)

[25] DUAN DB, ZHANG SY. Changes of serum TGF-β1, TIMP-1, TNF-α and IL-17 in patients with knee osteoarthritis and their relationship with disease severity[J]. Chinese Journal of Laboratory Diagnosis, 2023, 27(7): 825 - 828. (in Chinese).

[26] WEI HW, LUO YM, ZHENG WF. Research on TCM syndrome of knee osteoarthritis and its relativity with expressions of inflammatory cytokines IL-6, TNF-α[J]. Liaoning Journal of Traditional Chinese Medicine, 2015, 42(7): 1167 - 1169. (in Chinese).

[27] HUANG DE, QIN Y, LIN MN, *et al.* Clinical efficacy of different waves of electroacupuncture on knee osteoarthritis and its effect on TGF-β1 in joint fluid[J]. Chinese Acupuncture & Moxibustion, 2020, 40(4): 370 - 374. (in Chinese).

[28] LIN FX. Effect of electroacupuncture combined with comprehensive rehabilitation on pain, joint function and TGF-β1 level of joint fluid in patients with knee osteoarthritis[J]. Journal of Clinical and Pathological Research, 2022, 42(4): 917 - 923. (in Chinese).