Efficacy of Qingpeng Ointment Phonophoresis for Knee Joint Military Training Injuries: A Post-Print

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Abstract

Background: Knee joint injuries are common military training-related injuries that severely affect soldiers' combat effectiveness. In recent years, the prevention and treatment of military training injuries have become increasingly important. Ultrasound therapy and Qingpeng ointment are commonly used treatments for sports injuries, but research on their combined application is limited. Objective: To analyze the clinical efficacy of Qingpeng ointment phonophoresis in the treatment of military training-induced knee joint injuries. Methods: A total of 56 patients with knee joint injuries treated at the Fifth Garrison Outpatient Department of the General Hospital of the Western Theater Command of the Chinese People's Liberation Army from May 2022 to July 2022 were enrolled. Random numbers were generated using IBM-SPSS 25.0 statistical software for random grouping into a control group (n=24) and a treatment group (n=28). The control group received ultrasound therapy with a conventional coupling agent, while the treatment group received Qingpeng ointment phonophoresis, once daily, with 10 sessions constituting one treatment course, for a total of two courses. The Lysholm Knee Score, Visual Analogue Scale (VAS) score, Hamilton Depression Scale (HAMD-17) score, and knee joint range of motion were compared between the two groups before and after treatment. Results: Before treatment, there were no statistically significant differences between the two groups in Lysholm Knee Score, VAS score, HAMD-17 score, or knee joint range of motion ($P>0.05$). After two treatment courses, the passive range of motion of the knee joint in the treatment group was superior to that in the control group ($P<0.05$). After two treatment courses, both groups showed higher Lysholm Knee Scores and lower VAS scores compared with before treatment ($P<0.05$). Compared with before treatment, the treatment group exhibited increased active and passive range of motion of the knee joint after two treatment courses ($P<0.05$); the HAMD-17 score of patients in the treatment group also decreased after two treatment courses compared with before treatment (P<0.05). Conclusion: Both Qingpeng ointment phonophoresis and conventional coupling agent ultrasound therapy can significantly increase the Lysholm Knee Score and improve knee joint function, as well as reduce VAS scores and alleviate pain in patients with knee joint injuries. As a special coupling agent for ultrasound therapy, Qingpeng ointment offers certain therapeutic advantages over conventional coupling agents.

Full Text

Preamble

Effect of Qingpeng Ointment Combined with Ultrasound Penetration in the Treatment of Knee Injury Induced by Military Training

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Abstract

Background: Knee injuries are common military training injuries that seriously affect soldiers' combat effectiveness. Ultrasound therapy and Qingpeng ointment are commonly used treatments for sports injuries, but few studies have investigated their combined application.

Objective: To analyze the clinical efficacy of Qingpeng ointment ultrasound penetration in treating knee injuries caused by military training.

Methods: Fifty-six patients with knee injuries treated at the Fifth Pentry Outpatient Clinic of the General Hospital of Western Theater Command PLA from May 2022 to July 2022 were randomly divided into a control group (n=24) and a treatment group (n=28) using IBM-SPSS 25.0 statistical software. The control group received ultrasound therapy with ordinary coupling agent, while the treatment group received Qingpeng ointment ultrasound penetration therapy, once daily for 10 sessions per course, with two courses total. Lysholm Knee Score Scale (LKSS), Visual Analogue Scale (VAS) score, Hamilton Depression Scale-17 (HAMD-17) score, and knee joint range of motion were compared between the two groups before and after treatment.

Results: Before treatment, there were no statistically significant differences between the two groups in LKSS, VAS score, HAMD-17 score, or knee joint mobility (P>0.05). After two treatment courses, passive knee joint range of motion in the treatment group was superior to that in the control group (P<0.05). After two courses, both groups showed higher LKSS and lower VAS scores compared to before treatment (P<0.05). Compared with baseline, the treatment group showed increased active and passive knee joint range of motion after two courses (P<0.05), and decreased HAMD-17 scores (P<0.05).

Conclusion: Both Qingpeng ointment ultrasound penetration therapy and ordinary coupling agent ultrasound therapy can significantly increase LKSS to improve knee function and reduce VAS scores to alleviate pain in patients with knee injuries. As a special coupling agent for ultrasound therapy, Qingpeng ointment demonstrates certain therapeutic advantages over ordinary coupling agents.

Keywords: Knee joint; Knee injuries; Military training injury; Qingpeng ointment; Ultrasonic waves; Comparative effectiveness research

Introduction

Knee joint sports injuries include both bony and soft tissue damage, with common lesions involving meniscus, ligaments, osteochondral structures, synovial membrane, bursae, and other soft tissues, as well as articular cartilage injury and bone contusion. Research on knee joint sports injuries in China has primarily focused on athlete populations, with statistics showing an anterior cruciate ligament (ACL) injury incidence of 0.47% [1]. Knee joint sports injuries are also the most common type of sports injury in military training. Guo Cui [2] reported that knee injuries accounted for 19.33% of physical training injuries in armed police soldiers. Zhao Ruting et al. [3] conducted an epidemiological survey on knee injuries caused by military training, finding that among 3,135 officers and soldiers, the incidence of knee training injuries was 10.0%, with recruits reaching as high as 69.4%. Common clinical manifestations of knee joint injuries include joint pain and swelling, often accompanied by joint effusion and locking symptoms, leading to limited knee joint mobility that can severely affect patients' daily activities. Moreover, knee joint sports injuries represent a significant risk factor for the development of knee osteoarthritis [4]. Current treatment primarily focuses on symptomatic management with analgesics and cartilage-protecting drugs, while rehabilitation therapy has gradually become an important treatment modality.

Qingpeng ointment is a classic Tibetan medicine with analgesic, anti-inflammatory, anti-edema, antioxidant, and microcirculation-promoting effects. It is widely used to treat various osteoarthropathies such as degenerative joint disease, fractures, gout, and lateral humeral epicondylitis, demonstrating significant analgesic effects [5]. Ultrasound therapy is a common physical therapy modality in rehabilitation medicine that has been applied for over 40 years in treating musculoskeletal disorders including tendinitis, tenosynovitis, epicondylitis, bursitis, and osteoarthritis, with definite therapeutic effects on knee joint injuries [6]. Ultrasound drug penetration therapy is a type of ultrasound treatment. First used in 1954 to treat polyarthritis of the hand [7], it has since been widely applied in treating various skin and musculoskeletal diseases. Ultrasound drug penetration therapy avoids the first-pass effect in the liver, offers convenient control of drug delivery speed, reduces adverse drug reactions, and eliminates injection pain [8]. This study investigates the effect of Qingpeng ointment combined with ultrasound therapy on knee injuries caused by military training, aiming to explore an efficient and safe treatment method for knee joint injuries.

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1. Subjects and Methods

1.1 Study Subjects

This prospective, single-blind, randomized controlled trial selected 56 patients with knee joint injuries admitted to the Fifth Pentry Outpatient Clinic of the General Hospital of Western Theater Command PLA from May 2022 to July 2022. Random grouping was performed using IBM-SPSS 25.0 statistical software to generate random numbers. Subjects were numbered according to enrollment order and randomly assigned to either the treatment group or control group after enrollment. This study was approved by the Ethics Committee of the General Hospital of Western Theater Command PLA (Approval No.: 2022EC2-ky049).

1.2 Diagnostic Criteria

1.2.1 Western Medicine Diagnostic Criteria: (1) Military training injury criteria were established with reference to the "Diagnostic Criteria and Prevention Principles for Military Training Injuries" [9]: History of military training and acute/chronic injury; Physical examination showing specific injury symptoms and signs, or auxiliary examinations revealing abnormal changes related to the injury. (2) Diagnostic criteria were formulated with reference to the "Diagnostic and Therapeutic Efficacy Criteria for TCM Diseases and Syndromes" [10] and "Practical Sports Medicine" [11]: Clear history of knee joint sprain; Varying degrees of knee joint swelling, pain, local tenderness, and accompanying movement disorders; X-ray examination excluding fractures, dislocations, and bone diseases.

1.2.2 Traditional Chinese Medicine Diagnostic Criteria: Met the diagnostic criteria for tendon injury (acute soft tissue injury) with qi stagnation and blood stasis syndrome in the "Guiding Principles for Clinical Research of New Chinese Medicines" (2002 edition): (1) Clear history of knee joint sprain; (2) Main symptoms: local pain and swelling; (3) Secondary symptoms: local stabbing pain; fixed pain location; ecchymosis or hematoma; limited joint mobility; (4) Tongue and pulse: dark purple tongue or with ecchymosis, wiry and choppy pulse. Criteria (1) and (2) were required, plus at least one item from (3), combined with tongue and pulse findings for diagnosis.

1.3 Inclusion and Exclusion Criteria

Inclusion Criteria: (1) Met Western medicine diagnostic criteria for knee joint injury; (2) Met TCM diagnostic criteria for qi stagnation and blood stasis syndrome; (3) Musculoskeletal ultrasound examination showing visible soft tissue injury; (4) X-ray examination excluding fracture or dislocation; (5) Age 18-65 years; (6) Static Visual Analogue Scale (VAS) score $\geq$ 4 points; (7) Subjects understood the research purpose, fully complied with the research protocol, and signed informed consent.

Exclusion Criteria: (1) Static VAS score $\geq$ 8 points; (2) Soft tissue injury accompanied by important bone or joint lesions, or with open wounds; (3) Known allergy to medical coupling agents or Qingpeng ointment; (4) Received corticosteroids (systemic or local) or long-acting non-steroidal anti-inflammatory drugs within 2 days before the clinical study; (5) Joint effusion reaching moderate or greater amount; (6) Combined with severe primary diseases such as cardiovascular or cerebrovascular diseases; (7) Severe musculoskeletal system diseases (unstable limb fractures, joint tendon contractures, etc.); (8) Currently receiving other analgesic treatments or participating in other drug clinical trials; (9) Other conditions deemed unsuitable for inclusion by researchers.

1.4 Sample Size Estimation

Based on efficacy and statistical requirements, with α=0.05, β=0.2, equivalence standard δ=0.15, and average effective rate P=0.8, the sample size was calculated as N=12.365\$$\times 0.8 \times (1-0.8) \div 0.15$^{2}\$=88 cases. However, due to limitations in manpower, funding, and time, this study planned to include a total of 56 cases, divided into two groups of 28 cases each. The treatment group received Qingpeng ointment ultrasound penetration therapy, while the control group received ordinary coupling agent with ultrasound therapy.

1.5 Intervention Methods

Ultrasound therapy was performed using a WED-100 ultrasound therapeutic apparatus with the moving method. Patients assumed a position that fully exposed the injured area, with the knee joint pain point selected as the treatment site. The control group received ultrasound therapy with ordinary coupling agent, while the treatment group received ultrasound penetration therapy with Qingpeng ointment (Tibet Linzhi Qizheng Pharmaceutical Co., Ltd.). During treatment, the probe should move slowly along straight or circular paths in the treatment area at approximately 1 cm/s, with energy set at 0.75-2.5 W/cm^2. Each treatment lasted 5 minutes, once daily. After completing 5 treatments, a 2-day interval was required before the next treatment. A total of 10 treatments constituted one course, with the treatment concluding after completing 2 courses (20 treatments total). During treatment, the dosage was adjusted according to patients' subjective feelings to ensure warmth and comfort; if obvious soreness or stinging discomfort occurred, the treatment dosage was immediately reduced. After treatment, the knee joint was cleaned.

1.6 Outcome Measures

1.6.1 Lysholm Knee Score Scale (LKSS): Proposed by Swedish scholars Lysholm and Gillquist in 1982 [12], LKSS is widely used for various knee joint conditions. Patients score based on subjective symptoms, requiring 3-5 minutes to complete. The scale contains 8 items: limping, support, locking, pain, instability, swelling, stair climbing, and squatting. Each item has different value ranges, with a total score of 100 points. Scores >84 indicate normal joint function, 66-84 indicate fair joint function, and <65 indicate poor joint function [13]. The scale's overall Cronbach's α coefficient is 0.68, with an intraclass correlation coefficient (ICC) of 0.82, demonstrating good convergent and discriminant validity [14]. Assessments were conducted before treatment, after 1 treatment course, and after treatment completion, with each evaluation performed after patients completed the corresponding treatment phase.

1.6.2 Visual Analogue Scale (VAS): VAS is used not only to measure pain intensity but also to assess pain relief degree [15] and other aspects such as emotional and functional levels. Patients mark on a 0-10 line according to their subjective feelings, where 0 represents no pain and 10 represents severe pain. Pain severity is divided into three grades: 1-3 points for mild pain not affecting work or life; 4-6 points for moderate pain affecting work but not life; and 7-10 points for severe pain affecting both work and life. Assessment timing was the same as for LKSS.

1.6.3 Hamilton Depression Scale-17 (HAMD-17): Developed by Hamilton in 1960 [16], HAMD-17 is the most commonly used depression measurement scale in clinical assessment of depressive states. This study used the 17-item version, divided into 5 major factor categories: anxiety/somatization, weight, cognitive impairment, retardation, and sleep disorder. Scores of 0-7 indicate no depression; 8-17 indicate mild depression; 18-24 indicate moderate depression; and >24 indicate severe depression. Assessment timing was the same as for LKSS.

1.6.4 Range of Motion (ROM): ROM refers to the movement range of a joint from starting to ending position. Joint mobility can be divided into active range of motion (AROM) and passive range of motion (PROM). AROM is measured by the patient actively contracting muscles to complete movement without assistance, while PROM is measured by passive completion with external force such as examiner assistance. Bilateral knee joint AROM and PROM were measured before treatment, after 1 treatment course, and after treatment completion. Measurement timing was the same as for LKSS.

1.7 Quality Control

(1) A scientific, rigorous, and standardized clinical research and implementation process operation protocol was formulated. (2) Researchers received unified training to improve intra-observer and inter-observer consistency, ensuring reliable clinical research conclusions. (3) Patients' daily medication use and rehabilitation treatment were strictly recorded. (4) During the trial, patients were prohibited from using technical methods and drugs related to the study treatment to ensure patient compliance. (5) Data collection staff were blinded to group allocation to ensure authentic and reliable final results.

1.8 Statistical Methods

Data analysis was performed using IBM-SPSS 25.0 statistical software. Normally distributed measurement data were expressed as ($\bar{x}\pm s$), with between-group comparisons using independent t-tests and before-after comparisons using paired t-tests. Non-normally distributed measurement data were expressed as $M(P_{25}, P_{75})$, with between-group comparisons using Mann-Whitney U tests and within-group before-after comparisons using Wilcoxon signed-rank tests. $P<0.05$ was considered statistically significant.

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2. Results

2.1 Comparison of General Data Between the Two Groups

Four cases dropped out during the study in the control group, leaving 24 cases completing ordinary coupling agent ultrasound therapy; 28 cases in the treatment group completed Qingpeng ointment ultrasound penetration therapy. All patients were male. The control group had an average disease course of (18.7$±4.4)*months*, *age*(23.8±2.3)*years*, *height*(175.2±4.9)*cm*, *andweight*(70.4±7.1)*kg*.*Thetreatmentgroupha* kg. There were no statistically significant differences between the two groups in disease course, age, height, or weight (t_{course}=0.052, t_{age}=2.299, t_{height}=-0.623, t_{weight}=0.295; P>0.05), indicating comparability.

2.2 Comparison of LKSS Between the Two Groups Before and After Treatment

There were no statistically significant differences in LKSS between the two groups before treatment or after two treatment courses (P>0.05). After two treatment courses, both groups showed higher LKSS compared to before treatment, with statistically significant differences (P<0.05), see Table 1 .

Table 1 Comparison of LKSS scores between the two groups before and after treatment (x̄±s, points)

<table>
<tr><th>Group</th><th>n</th><th>Before Treatment</th><th>After 2 Courses</th><th>t_{paired}</th><th>P</th></tr>
<tr><td>Control</td><td>24</td><td colspan="4">76.92$±12.02|82.88±9.23| < 0.001|||Treatment|28|78.50±8.24|82.36±$6.93</td></tr>
</table>

2.3 Comparison of VAS Scores Between the Two Groups Before and After Treatment

There were no statistically significant differences in VAS scores between the two groups before treatment or after two treatment courses (P>0.05). After two treatment courses, both groups showed lower VAS scores compared to before treatment, with statistically significant differences (P<0.05), see Table 2 .

Table 2 Comparison of VAS scores between the two groups before and after treatment (x̄±s, points)

<table>
<tr><th>Group</th><th>n</th><th>Before Treatment</th><th>After 2 Courses</th><th>t_{paired}</th><th>P</th></tr>
<tr><td>Control</td><td>24</td><td colspan="4">4.75$±0.98|2.58±0.83| <0.001 0.001|||Treatment|28|4.64±0.83|2.39±$0.88</td></tr>
</table>

2.4 Comparison of Knee Joint Flexion-Extension Range of Motion Before and After Treatment

There were no statistically significant differences in active knee joint range of motion between the two groups before treatment or after two treatment courses (P>0.05). Compared with baseline, the treatment group showed increased active knee joint range of motion after two courses, with statistically significant differences (P<0.05); the control group showed no statistically significant difference in active knee joint range of motion before and after treatment (P>0.05), see Table 3 .

Before treatment, there were no statistically significant differences in passive knee joint range of motion between the two groups (P>0.05). After two treatment courses, passive knee joint range of motion in the treatment group was superior to that in the control group, with statistically significant differences

(P<0.05). Compared with baseline, the treatment group showed increased passive knee joint range of motion after two courses (P<0.05); the control group showed no statistically significant difference in passive knee joint range of motion before and after treatment (P>0.05), see Table 4 .

Table 3 Comparison of active range of motion between the two groups before and after treatment (x̄±s)

<table>
<tr><th>Group</th><th>n</th><th>Before Treatment</th><th>After 2 Courses</th><th>t_{paired}</th><th>P</th></tr>
<tr><td>Control</td><td>24</td><td colspan="4">126.79°$±6.12°|127.86°±5.75°|−1.295|||Treatment|28|127.29°±6.42°|129.79°±$6.67°</td></tr>
</table>

Table 4 Comparison of passive range of motion between the two groups before and after treatment (x̄±s)

<table>
<tr><th>Group</th><th>n</th><th>Before Treatment</th><th>After 2 Courses</th><th>t_{paired}</th><th>P</th></tr>
<tr><td>Control</td><td>24</td><td colspan="4">139.64°$±7.06°|139.82°±6.05°|−0.238|||Treatment|28|138.00°±7.31°|141.04°±$5.51°</td></tr>
</table>

2.5 Comparison of HAMD-17 Scores Between the Two Groups Before and After Treatment

There were no statistically significant differences in HAMD-17 scores between the two groups before treatment or after two treatment courses (P>0.05). Compared with baseline, HAMD-17 scores in the treatment group decreased after two courses, with statistically significant differences (P<0.05); the control group showed no statistically significant difference in HAMD-17 scores before and after treatment (P>0.05), see Table 5 .

Table 5 Comparison of HAMD-17 scores between the two groups before and after treatment (x̄±s, points)

Group	n	Before Treatment	After 2 Courses	Z_{paired}	P
Control	24	0(0,1.0)	0(0,1.0)		
Treatment	28	1.0(0,2.0)	0(0,1.0)		

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3. Discussion

In peacetime, military training is considered the core duty of armed forces, aiming to cultivate soldiers' military literacy and enhance combat effectiveness. Training injuries seriously damage soldiers' health and reduce military strength.

Surveys indicate that the incidence of training injuries among armed police soldiers in a certain region is as high as 25.3%, with injured parts mainly involving bones, muscles, ligaments, and other structures [17]. Due to the complexity of military training, the prevention and treatment of military training injuries have become increasingly important, representing an urgent issue in contemporary military medicine and related fields. In recent years, military training injuries have attracted high attention from scholars both within and outside the military [18]. Improving officers' and soldiers' awareness of military training injuries, reducing their incidence, and enhancing troop combat effectiveness are current priorities for military medical workers.

Qingpeng ointment is a classic formula of Tibetan medicine with a long history. Its main components include nine Tibetan medicinal herbs: Oxytropis, Rheum sublanceolatum, Tinospora sinensis, Aconitum pendulum, Benzoin, Musk, Terminalia chebula, Terminalia bellirica, and Phyllanthus emblica. Originating in the 16th century, it is primarily used to treat various rheumatic joint diseases, with analgesic, anti-inflammatory, anti-edema, antioxidant, and microcirculation-improving effects. Due to its good efficacy, high safety, and convenient use, Qingpeng ointment is now widely used to treat various osteoarthropathies such as degenerative joint disease, fractures, and lateral humeral epicondylitis. Studies have shown that Qingpeng ointment exerts its effects by regulating inflammatory mediators, possibly by inhibiting secretion of inflammatory factors such as interleukin-1α (IL-1α) [19], interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α) [20], reducing inflammatory cell infiltration; decreasing prostaglandin E2 (PGE2) [21], serum NO, and substance P [22] content; inhibiting the NO-cGMP pain pathway [23] to reduce pain substance increase, lower central pain sensitivity, and decrease peripheral pain transmission to the central nervous system, thereby alleviating pain. Additionally, Qingpeng ointment can significantly reduce vascular endothelial growth factor and inducible nitric oxide synthase expression in hind limbs of adjuvant arthritis rats [24], reducing synovial angiogenesis in rheumatoid arthritis and thus protecting articular cartilage.

Ultrasound therapy is a common physical therapy modality in rehabilitation medicine that has been applied for over 40 years in treating musculoskeletal disorders such as tendinitis, tenosynovitis, epicondylitis, bursitis, and osteoarthritis, with advantages of safety, non-invasiveness, and convenience. Ultrasound therapeutic apparatuses reduce inflammation, eliminate edema, relieve pain, improve mobility, and promote tissue healing through mechanical vibration, thermal effects, and cavitation [25-26]. Ultrasound drug penetration therapy is a type of ultrasound treatment. First used in 1954 to treat polyarthritis of the hand, it has since been widely applied in treating various skin and musculoskeletal diseases [27-28]. Also known as phonophoresis, ultrasound drug penetration therapy utilizes ultrasound to facilitate medium diffusion and alter cell membrane permeability, enabling drugs in the carrier to penetrate through skin or mucosa. It avoids the first-pass effect in the liver, facilitates control of drug delivery speed, reduces adverse drug reactions, and eliminates injection pain [8]. As a comprehensive physical therapy, its exact mechanism of action is not fully understood, though its thermal effects are clear. The molecular mechanism remains unclear but is believed to involve increased cell membrane permeability and enhanced metabolite transport [29-30]. Studies have shown that non-steroidal anti-inflammatory drugs maintain stable drug components under ultrasound action, making them suitable for treating soft tissue injuries and musculoskeletal diseases [31]. The optimal frequency for drug penetration ultrasound is 0.5-1.5 MHz, with optimal intensity of 1.5-4.0 W/cm^2 and duration of 10 minutes. This study used energy of 0.75-2.5 W/cm^2 and treatment time of 5 minutes, consistent with previous research parameters.

This study included 56 patients with knee joint military training injuries, with 24 receiving Qingpeng ointment ultrasound penetration therapy and 28 receiving ordinary coupling agent ultrasound therapy. Results showed that both Qingpeng ointment ultrasound penetration therapy and ordinary coupling agent ultrasound therapy could significantly increase LKSS to improve knee function and reduce VAS scores to alleviate pain. Compared with the ordinary coupling agent ultrasound therapy group, the Qingpeng ointment ultrasound penetration therapy group showed increased knee joint range of motion, but the increase was small and not clinically significant. On the other hand, compared with the ordinary coupling agent ultrasound therapy group, the Qingpeng ointment ultrasound penetration therapy group showed decreased HAMD-17 scores, specifically in three items: depressed mood, difficulty falling asleep, and work and interests. Existing surveys on depression in military personnel show that the overall incidence of depression among Chinese soldiers is 18.1% (mild 8.6%, moderate 4.4%, severe 5.1%) [32]. The incidence of depression among soldiers in special regions, periods, or operations is even higher, such as combat troops where the incidence reaches 60.65% [33], showing a trend that heavier military tasks and harsher environments correlate with higher depression rates [34]. Training injuries are a risk factor for depression among Chinese soldiers, with depression levels significantly positively correlated with soldiers' illness or injury status [35]. This study's subjects were military academy cadets whose injuries affected their lives and studies, particularly senior cadets facing graduation military training assessments. Knee joint training injuries could limit their training and assessment, generating anxiety. Therefore, psychological aspects should be an important focus in treatment. The reason for better emotional improvement in the Qingpeng ointment ultrasound penetration therapy group compared with the ordinary coupling agent ultrasound therapy group may be that the treatment group achieved some improvement in pain and knee function, and although the differences between groups were not statistically significant, there was a trend toward difference, which subsequently enhanced patients' positive psychology toward their disease.

ERKAN KOZANOGLU et al. [36] studied ibuprofen cream combined with ultrasound penetration therapy at a frequency of 1 MHz and power of 1 W/cm^2 for 5 minutes, totaling 10 treatments. Compared with ordinary coupling agent ultrasound therapy for knee osteoarthritis, both groups showed no significant improvement in Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores, but pain scores, knee joint range of motion, 20-meter walking time measurements, and all global assessment scores significantly improved, with no statistical differences between groups. Although this study differed in disease type, the ultrasound therapy approach was similar, and our results are consistent, showing no between-group differences. AKINBO et al. [37] compared the efficacy of diclofenac sodium phonophoresis, methyl salicylate phonophoresis, and conventional ultrasound in patients with knee osteoarthritis, finding more obvious clinical improvement in the diclofenac sodium group, possibly due to diclofenac sodium's higher molecular weight and better ultrasound permeability. Another study compared gel-type and cream-type ibuprofen combined with ultrasound therapy for knee osteoarthritis, finding that gel-type ibuprofen was more effective than cream-type, indicating that gel formulations have higher ultrasound transmission capacity than cream formulations [38]. Previous studies comparing different coupling agents' transmission potential also showed that cream and ointment formulations have lower transmissivity [39], while gel coupling media have higher transmissivity [40-41]. Studies have shown that gel formulations have lower reflection attenuation coefficients and higher acoustic impedance matching, resulting in higher transmission capacity [40-41]. On the other hand, poor transmissivity of cream formulations may be due to air entrapment in the formulation [39]. These studies reflect the importance of drug formulation in ultrasound drug penetration therapy, with gel formulations being superior to cream formulations. Qingpeng ointment is a cream formulation, which may be one reason why this trial showed no difference in efficacy between the two groups.

The average disease course of included subjects in this study was 19 months, indicating chronic-phase patients whose treatment effects are poorer than acute-phase patients and require longer treatment duration. Patients' LKSS scores were all above 65 points, indicating fair knee function, and VAS scores were 4-6 points, indicating moderate pain. All included patients had pain from knee joint injuries caused by military training, which originates from cartilage and synovial tissues. Synovial inflammation causes low-grade inflammation with fewer immune cells, cytokines, and other inflammatory mediators. Since Qingpeng ointment's mechanism of action involves reducing inflammatory factors and cytokines to improve pain, ultrasound therapy played the primary therapeutic role in this trial.

In summary, compared with ordinary coupling agent ultrasound therapy, Qingpeng ointment ultrasound penetration therapy for knee joint military training injuries did not demonstrate superior therapeutic effects. One reason may be that Qingpeng ointment is a cream formulation with low skin permeability. Another reason is that most included patients were in the chronic phase with pain as the main symptom, without obvious joint mobility dysfunction or psychological disorders, thus showing non-significant improvement. Additionally, this study has limitations: (1) It is a single-center prospective study with a small sample size and short treatment duration. Future multi-center, large-sample randomized controlled trials with longer treatment periods and additional positive control groups of different therapies are needed for further validation. (2) The study subjects did not have a single disease type, affecting treatment consistency and consequently impacting the objectivity, accuracy, and rigor of the research conclusions. Future studies should classify knee joint injury types.

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Note: Figure translations are in progress. See original paper for figures.