Integrated efriction method and injury level evaluation strategy for effective ACL knee injury recovery

Método integrado de efricción y estrategia de evaluación del nivel de lesión para una recuperación efectiva de la lesión de rodilla del LCA

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Abstract

Introduction: Knee injuries, particularly following anterior cruciate ligament (ACL) surgery, are common among athletes and carry a high risk of recurrence when rehabilitation is incomplete. Many rehabilitation programs prioritize short-term recovery while overlooking long-term functional support.
Objective: This study aimed to evaluate the effectiveness of effleurage massage combined with self-directed exercise education in improving recovery outcomes and reducing recurrence risk in athletes with post-ACL knee injuries.
Methodology: A mixed-methods design was applied using purposive sampling of 30 athletes treated at the MCO Arif Clinic. Knee injuries were confirmed through X-rays, MRI, and medical records. Participants received 30-minute effleurage massage sessions over three weeks, alongside structured self-training education. Pre- and post-intervention assessments measured pain, range of motion (ROM), muscle strength, edema, balance, and functional activity.
Results: The intervention significantly reduced pain and knee edema while improving flexion-extension ROM and muscle strength. Statistical analysis showed a significant decrease in edema (mean difference = 3.79 cm; $t(29) = 111.96$; $p < .001$). Participants who received exercise education demonstrated additional improvements in balance and functional movement, indicating enhanced rehabilitation outcomes.
Discussion: The findings support previous evidence that manual therapy enhances circulation and reduces swelling, and suggest that combining massage with structured exercise produces synergistic benefits for joint stability and function.
Conclusions: An integrated rehabilitation approach using effleurage massage and self-directed exercise effectively improves recovery and functional performance in athletes after ACL surgery while potentially reducing recurrence risk.

Keywords

Integrated approach; massage method; injury evaluation; ACL recovery; knee injury.

Resumen

Introducción: Las lesiones de rodilla, particularmente después de una cirugía del ligamento cruzado anterior (LCA), son comunes entre los atletas y conllevan un alto riesgo de recurrencia cuando la rehabilitación es incompleta. Muchos programas de rehabilitación priorizan la recuperación a corto plazo y pasan por alto el apoyo funcional a largo plazo.
Objetivo: Este estudio tuvo como objetivo evaluar la efectividad del masaje con efleurage combinado con educación autodirigida sobre ejercicios para mejorar los resultados de recuperación y reducir el riesgo de recurrencia en atletas con lesiones de rodilla posteriores al LCA.
Metodología: Se aplicó un diseño de métodos mixtos mediante muestreo intencional de 30 atletas tratados en la Clínica MCO Arif. Las lesiones de rodilla se confirmaron mediante radiografías, resonancia magnética y registros médicos. Los participantes recibieron sesiones de masaje effleurage de 30 minutos durante tres semanas, junto con educación estructurada de autoaprendizaje. Las evaluaciones previas y posteriores a la intervención midieron el dolor, el rango de movimiento (ROM), la fuerza muscular, el edema, el equilibrio y la actividad funcional. Resultados: La intervención redujo significativamente el dolor y el edema de rodilla al tiempo que mejoró la ROM de flexión-extensión y la fuerza muscular. El análisis estadístico mostró una disminución significativa del edema (diferencia de medias = 3,79 cm; $t(29) = 111,96$; $p < .001$). Los participantes que recibieron educación sobre el ejercicio demostraron mejoras adicionales en el equilibrio y el movimiento funcional, lo que indica mejores resultados de rehabilitación. Discusión: Los hallazgos respaldan la evidencia previa de que la terapia manual mejora la circulación y reduce la hinchazón, y sugieren que combinar el masaje con ejercicio estructurado produce beneficios sinérgicos para la estabilidad y la función de las articulaciones. Conclusiones: Un enfoque de rehabilitación integrado que utiliza masaje de efleurage y ejercicio autodirigido mejora efectivamente la recuperación y el rendimiento funcional en atletas después de una cirugía de LCA, al tiempo que reduce potencialmente el riesgo de recurrencia.

Palabras clave

Abordaje integrado; método de masaje; evaluación de lesiones; recuperación del LCA; lesión de rodilla.

Introduction

The knee joint plays a vital role in supporting the body's weight and mobility, particularly for athletes who undergo intensive training and competition. High-impact, repetitive physical activity increases the risk of injury, particularly to the anterior cruciate ligament (ACL). ACL injuries affect not only the anatomical structure, but also decrease physiological function and limit sports and daily activities, increasing the potential for long-term disability. Therefore, a systematic, thorough and evaluation-based approach to ACL injury recovery is required to ensure effective rehabilitation and prevent repeated injuries (Hasan, 2024).

A comprehensive evaluation is key to knee injury recovery as it considers muscle strength, joint range of motion, pain levels and quality of life. Research shows that structured exercise programmes incorporating resistance therapy and exercises with variations in range of motion can significantly improve body function (Matykiewicz, 2021; Silva, 2021). Additionally, physiological changes such as increased hamstring muscle flexibility through resistance training support injury recovery (Kawama, 2022). Exercise-based interventions involving additional equipment, such as elastic or elongation bands, have also been shown to improve strength and mobility in certain age groups (Kim, 2022).

ACL rehabilitation programmes are increasingly effective when structured using a multidisciplinary approach that incorporates initial evaluation, exercise intervention and final evaluation. Personalising exercise has been shown to improve functional capacity and prevent re-injury (Maestroni, 2025). Additional modalities, such as post-operative cryotherapy, have also been shown to be effective in reducing pain and swelling and improving walking patterns (Jung & Lee, 2024; B. Lee, 2024). Long-term resistance training has also been shown to reduce stress, improve body composition and extend range of motion in different conditions (J. G. Lee, 2022).

Recovery evaluation instruments utilising technology can improve measurement precision. The cyber-physical systems concept provides opportunities to optimise rehabilitation processes through more accurate, data-driven monitoring and recovery strategies (Kara, 2025). Integrating this concept with traditional and modern rehabilitation approaches can produce a more comprehensive evaluation.

Several other studies have also highlighted the contribution of exercise therapy to improving quality of life. Rehabilitative exercises prescribed to patients undergoing major surgery, such as mastectomies, have been shown to improve joint range of motion while reducing discomfort (Majed, 2022). Simple exercises involving joint range movements during haemodialysis have been shown to reduce fatigue and improve dialysis adequacy (Malini, 2022). In different contexts, the virtual embodiment approach in orthopaedic rehabilitation has a positive impact on physical function and range of motion (Matamala-Gomez, 2022).

The development of pharmacological interventions targeting chronic pain also supports optimal recovery. For instance, dexmedetomidine has been reported to have potential in alleviating chronic visceral pain and enhancing physical performance . In the case of ACL reconstructive surgery, follow-up measures such as the excision of cyclopean lesions may provide a solution when patients experience complications that hinder full recovery (Money et al., 2024). These diverse findings demonstrate that the success of ACL rehabilitation is determined by multiple factors and requires an integrative, layered approach tailored to the needs of the patient.

This study is urgent due to the importance of effective rehabilitation strategies in preventing re-injury, improving athletes' quality of life, and providing an integrated recovery model that can be applied in healthcare and sports services. Previous studies have highlighted various limitations, such as differences in range of motion in women (Freiberger, 2024), resistance exercise in patients with lumbar pain (Golonka, 2021) and hypertrophic adaptation through variations in the long muscle range of motion (Moreno, 2024). Other studies have demonstrated the efficacy of corrective exercises for athletes with scapular dysfunction (Naderifar, 2022), range-of-motion exercises for enhancing the physiological stability of hypertensive patients (Nursalam, 2020) and the development of pneumatic devices for enhancing ankle mobility (Okamoto, 2022). However, few studies have integrated manual therapies, such as effleurage massage, into a comprehensive evaluation system throughout the recovery process. This study therefore offers an integrated approach targeting not only pain reduction, but also improvements in muscle strength, range of motion, balance and functional activity post-ACL surgery.

Compared to other massage techniques, effleurage may be considered more advantageous in the early stages of post-ACL rehabilitation because it applies gentle, rhythmic, and superficial pressure that supports circulation and lymphatic return without imposing excessive mechanical stress on recently operated tissues. Unlike deep tissue or friction massage, which may provoke discomfort or inflammation in vulnerable structures, effleurage facilitates pain modulation, reduces muscle guarding, and promotes relaxation through parasympathetic activation. This makes it particularly suitable for post-surgical patients who require gradual functional restoration while minimizing the risk of aggravating healing tissues.

This study aims to analyse the effectiveness of effleurage massage in reducing pain, increasing muscle strength and improving joint range of motion in athletes after ACL surgery. Additionally, this study will evaluate recovery outcomes using comprehensive instruments through an integrative approach covering the pre-therapy, therapy and post-therapy stages. Furthermore, it is expected that this study will make a scientific contribution to the development of effective, efficient and sustainable strategies for rehabilitating knee injuries, particularly in athletes who require optimal recovery in order to return to full activity.

Method

This study employs a mixed methods research (MMR) approach based on a pragmatic paradigm (Creswell & Creswell, 2017). This paradigm emphasizes the practical consequences of research and focuses on research questions rather than adherence to a single philosophical tradition. This paradigm enables researchers to integrate quantitative and qualitative methods to gain a more comprehensive understanding of the research problem. In this study, the pragmatic approach supports combining objective clinical measurements with contextual clinical observations to evaluate recovery after ACL surgery. Using a one-group pretest–posttest design, the study combines quantitative methods (visual analog scale, goniometer measurement, muscle strength testing, and drawer test) with qualitative methods (knee examination checklist).

Participants

The respondents consisted of 30 soccer athletes who had undergone ACL surgery and were selected using purposive sampling at the MCO Arif Clinic in Semarang, Indonesia. Inclusion criteria included being in the recovery phase and being able to participate in an effleurage massage program and periodic evaluations. Participants were generally of productive age, exercised regularly, and experienced pain, limited range of motion, and muscle weakness.

Procedure

The research procedure consisted of four stages: (1) a pre-test to identify the initial knee condition, (2) a 30-minute effleurage massage intervention focused on the quadriceps and hamstrings combined with self-training education. (3) post-test is performed after three weeks with repeated measurements , and (4) report the results for analysis.

Instrument

Instruments used in this study include field observation, Visual Analogue Scale (VAS), goniometer, drawer test, Straight Leg Raise (SLR), and knee examination checklist. All instruments were subjected to content validity through expert assessment and construct validity testing prior to data collection. In addition, reliability testing is carried out using inter-rater reliability procedures and retesting to ensure measurement consistency. These instruments were chosen because they are valid, reliable, and clinically relevant for detecting physiological and functional changes in knee conditions following rehabilitation interventions. Physical Activity Quiz

Data analysis

Data analysis was conducted using a mixed descriptive-comparative approach. Quantitative Data were analyzed by comparing pre-and post-test pain scores, range of motion, and muscle strength within and between groups, while qualitative data from checklist observations and assessments were evaluatively

analyzed to describe functional changes. This analysis strategy was used to assess the effectiveness of effleurage massage in reducing pain, improving muscle function, and accelerating recovery of knee activity in athletes post-ACL surgery.

The checklist of knee examinations and functional activity instruments was developed by the researchers and subjected to content validation through an expert assessment involving three specialists in sports rehabilitation and orthopedic physiotherapy. The content validity index (CVI) for all items ranges from 0.80 to 0.95, which indicates good content validity. Construct validity for functional activity checklists was tested using item-total correlation, with correlation coefficients ranging from 0.71 to 0.89. Reliability testing was performed prior to the main study using inter-assessor reliability and retesting procedures on a pilot sample of 10 ACL postoperative patients. The inter-assessor reliability coefficient (ICC) ranged from 0.85 to 0.92 for ROM, muscle strength, and balance measures, while the retest reliability coefficient for VAS and functional activity scores ranged from 0.83 to 0.90. The internal consistency of the functional activity checklist is confirmed by the Cronbach's Alpha coefficient of 0.82. These results indicate that the instruments used in the study are valid and reliable for assessing changes in knee condition and functional recovery.

Table 1. Validated Knee Examination Instrument Checklist for Each Session (T0–T6)

No	Aspects Examined	Indicators / Assessment Criteria	Instrument / Method	Validity–Reliability Evidence
1	Pain	Score 0–10 (0 = no pain, 10 = very severe pain)	Visual Analogue Scale (VAS)	Content validity index (CVI ≥ 0.80); test–retest reliability (r ≥ 0.85)
2	Joint Range of Motion	Flexion …° / Extension …° (measured in degrees)	Goniometer	Inter-rater reliability (ICC ≥ 0.90)
3	Muscle Strength	Straight Leg Raise angle (°); strength grade 0–5	SLR test; Manual Muscle Test	Inter-rater reliability (ICC ≥ 0.88)
4	Ligament Stability	Positive / Negative	Drawer Test	Content validity (expert judgment); inter-rater agreement (κ ≥ 0.80)
5	Edema (Swelling)	None / Mild / Moderate / Severe	Observation + Palpation	Content validity (CVI ≥ 0.80)
6	Activity Function	Walking, stair climbing, squatting, sport activities	Functional Activity Checklist	Construct validity (r ≥ 0.70); Cronbach's α ≥ 0.80
7	Balance	One-leg standing duration; knee motion dynamics	Balance Test Protocol	Inter-rater reliability (ICC ≥ 0.85)
8	Other Clinical Signs	Redness, local heat, crepitation sound	Clinical Observation Checklist	Content validity (CVI ≥ 0.80)

Results

The results showed that athletes who had undergone ACL surgery and received the effleurage massage intervention experienced positive changes in several aspects of recovery. There was a significant decrease in pain, as measured by the VAS, accompanied by an increase in leg muscle strength, as measured by the SLR test. Additionally, improvements in knee joint range of motion were observed through goniometer measurements, as well as improvements in motor function and balance that support daily activities. Observations also noted a reduction in oedema, which contributed to improved knee mobility. Overall, these findings suggest that an integrative approach incorporating effleurage massage is more effective in accelerating recovery than a single intervention.

Table 2. Results of pain measurements using a VAS

Evaluation Stages	T0	T1	T2	T3	T4	T5	T6
Silence Painful	4	4	3	2	2	0	0
Press Painful	5	5	3	2	2	0	0
Motion Pain	6	6	5	3	3	1	1

The results of the study measuring aspects of knee pain using the Visual Analogue Scale (VAS) showed a significant reduction following effleurage massage. Initially in the moderate category with a score of 4–5, silence pain and press pain gradually decreased until they reached 0 at the end of the measurement period, meaning that the pain had disappeared completely. Meanwhile, motion pain, initially classified as severe with a score of 6, decreased dramatically until it reached a score of 1, indicating mild pain. These changes suggest that effleurage massage is an effective method of controlling pain by stimulating

the nervous system, accelerating tissue healing and improving patient comfort during the post-ACL recovery period.

Table 3. Results of the straight leg raises examination

Evaluation Stages	Flexibility	Extension
T 0	90	90
T1	80	80
T2	85	90
T 3	65	85
T4	75	90
T5	70	90
T6	80	90

The results of the straight leg raise (SLR) test showed a gradual increase in leg muscle strength following the intervention. At the initial stage (T0), the patient had limited flexibility and an extension value of 90°, indicating a decrease in muscle function. However, after receiving the effraction massage intervention alongside self-training, there was consistent improvement, with flexibility and extension increasing to near-normal values of 80°–90° in the final stage (T6). These results suggest that combining effleurage massage with a self-directed exercise programme effectively restores muscle contraction, increases strength and supports post-ACL knee joint stability.

Table 4. Results check the ROM using Goniometer

Evaluation Stages	Active Movement
T 0	S 15° - 1 5 ° - 18 0 °
T1	S 15° - 1 5 ° - 16 0 °
T2	S 10° - 1 0 ° - 17 5 °
T 3	S 10° - 1 0 ° - 16 5 °
T4	S 5° - 5 ° - 12 0 °
T5	S 0° - 0 ° - 12 5 °
T6	S 0° - 0 ° - 13 0 °

The results of the joint range of motion (ROM) evaluation using a goniometer showed a progressive increase during the intervention process. In the initial stage (T0), the patient exhibited limited movement with a ROM of approximately 15°–180°, caused by postoperative pain and inflammation. Alongside therapy, there was gradual improvement until, by the final measurement (T6), the patient was able to achieve a ROM of 0°–130°, close to normal conditions. This improvement was influenced by a combination of interventions, including patella mobilisation and Short Arc Quads exercises, as well as a reduction in oedema. These factors contributed overall to the restoration of knee function and increased the patient's ability to be active.

Table 5. Edema Results (Knee Circumference)

Subject	Edema T0 (cm)	Edema T6 (cm)
1	4.2	0.4
2	3.8	0.2
3	4.0	0.0
4	4.5	0.5
5	4.1	0.3
6	3.9	0.2
7	4.3	0.4
8	3.7	0.1
9	4.0	0.0
10	3.6	0.2
11	4.4	0.5
12	4.1	0.3
13	3.8	0.1
14	3.5	0.0
15	4.0	0.2
16	4.2	0.3
17	3.9	0.2
18	4.1	0.1
19	4.5	0.4
20	3.7	0.1

21	4.0	0.0
22	3.6	0.2
23	4.3	0.3
24	3.8	0.1
25	4.1	0.2
26	3.9	0.1
27	4.4	0.4
28	3.7	0.0
29	4.0	0.2
30	3.8	0.1

Based on the data from Table 5, all 30 subjects showed a decrease in knee edema after the effleurage massage intervention. Initially (T0), the difference in knee circumference between the injured and normal sides was 3.5–4.5 cm, indicating moderate to severe swelling. After the intervention (T6), edema values decreased consistently for all subjects, ranging from 0.0 to 0.5 cm, indicating that swelling had almost completely disappeared. These results demonstrate a significant clinical improvement in post-operative anterior cruciate ligament (ACL) knee swelling.

Figure 1. Main anatomical components of the knee joint

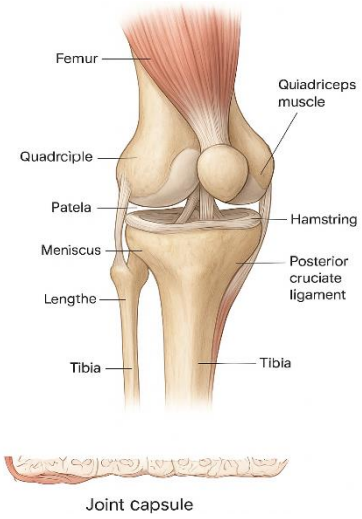

Table 6. Paired t-Test Results for Knee Edema (T0 vs T6)

Variable	Mean Difference (cm)	SD	t	df	p (2-tailed)
Edema (T0–T6)	3.79	0.19	111.96	29	< .001

The results of the paired samples t-test (Table 6) revealed a statistically significant decrease in knee edema from baseline (T0) to post-intervention (T6). The mean edema difference was 3.79 cm (SD = 0.19), with a t-value of 111.96 and $p < .001$ (two-sided). These results suggest that effleurage massage significantly reduces knee swelling in athletes after ACL surgery. This large and consistent decrease in edema contributes clinically to increased joint mobility, decreased pain, and accelerated recovery of knee function.

Table 7. Results of functional activity (Step-Up Test, 10 repetitions)

Evaluation Stages	Time (seconds)
T0	25
T1	23
T2	21
T3	20
T4	19
T5	18
T6	17

The results of the functional activity test using the Step-Up Test (10 repetitions) showed a significant improvement in performance throughout the evaluation stage. Initially, the patient took 25 seconds to complete the test, but after the intervention, this time gradually decreased until reaching 17 seconds in the final stage (T6). This reduction in execution time indicates the restoration of fundamental movement abilities, an enhancement in motor proficiency, and the patient's preparedness to resume physical activities, including sports.

Table 8. Balance Result (Single Leg Support)

Evaluation Stages	Injured Knee (seconds)	Normal Knee (seconds)
T0	5	15
T1	7	15
T2	9	16
T3	11	16
T4	12	16
T5	13	16
T6	15	16

A balance test involving a single-leg stand showed significant improvements in cases of knee injury. In the initial stage (T0), standing on the injured knee for more than 5 seconds was not possible, whereas the normal knee stabilises within 15–16 seconds. As the intervention progresses, standing time on the injured knee continues to increase until it reaches 15 seconds in the final stage (T6), which is equivalent to a normal knee. This improvement indicates recovery of proprioception, neuromuscular coordination and postural control following injury, which plays an important role in restoring stability and function to enable athletes to return to activity and exercise.

Discussion

The results of this study corroborate previous findings that massage effleurage can reduce pain and promote tissue repair by increasing neuromuscular stimulation and blood circulation. The significant reduction in pain is consistent with gate control theory, which suggests that mechanical stimulation from massage can inhibit the transmission of pain impulses through large-diameter nerve fibres (Rahiminezhad, 2022). Integrating effleurage massage with patellar mobilisation exercises and short-arc quadriceps activation has been shown to be more effective than a single intervention, consistent with reports that combining passive and active exercises improves muscle strength and functional recovery (Irsyad et al., 2024).

The increased muscle strength and range of motion (ROM) observed in the study support the existing literature emphasising the importance of both agonist and antagonist muscle mobilisation and activation exercises. For instance, early ROM exercises following a mastectomy have been reported to be both safe and beneficial (de Almeida Rizzi, 2020), while independent exercises performed at home have been shown to enhance handheld strength and the ability to perform daily activities (Sahin, 2023). Active exercises such as short arc quads are also relevant to studies showing improved knee joint function in patients with mobility limitations (Yang, 2021).

The results of measuring an increase in active knee ROM from T0 to T6 align with research on the variation in range of motion during resistance exercises that affect muscle strength and performance (Sadacharan, 2021; Tsoukos, 2024). Patellar mobilisation reduces pain and stiffness, which is consistent with studies examining the effects of instrument-assisted soft tissue mobilisation on improved stability and balance (Park, 2020). Furthermore, the increased circulation and oxygen flow resulting from active exercise corroborates the notion that physical activity can enhance metabolic responses, hasten recovery and mitigate inflammation (Dewangga, 2025; Trecroci, 2020).

The improvement of edema through knee circumference measurements in this study is relevant to studies that assess the use of technology in rehabilitation, for example smart knee brace to monitor ROM and movement speed(Riffitts, 2022). Aspects of pain and inflammation reduction are also consistent with pharmacological or nutritional interventions such as the combination of lipoic acid and EPA to improve muscle recovery (Abd, 2023). In addition, exercise-based rehabilitation strategies also support

study results in different populations, such as premature infants who get passive exercise (El-Farrash, 2020) or postoperative burn reconstruction patients (Chen, 2024).

The results of the evaluation of active knee ROM (LGS) showed an increase in flexion and extension movements, from T0 with a value of S 15°-15°-180°, to T4 with a value of S 5°-5°-120°, to T6 with a value of S 0°-0°-130°. This increase in ROM is also influenced by the reduction of pain and edema, so that the patient is able to actively move the knee without significant resistance, and is strengthened by pelvic muscle exercises to maintain knee balance. As a supporting measure, the knee circumference measurement is also carried out before the use of a goniometer to assess the swelling of the right knee compared to the left knee. Edema is a sign of inflammation, and interventions in the form of exercises are carefully administered so as not to create excessive pressure so that the knee can reach an extension of up to 180°. This decrease in inflammation is also influenced by the patient's independent exercise program, as well as education about the examination. The findings of this study corroborate reports that various forms of exercise, ranging from aqua walking Yang, (2021) suspension exercise Rad, (2022), to aerobic activity (Šarabon, 2020), have a role in increasing ROM and reducing pain in different groups. Manual interventions such as the snapping maneuver for axillary syndrome (Sandrin, 2023) as well as manipulation and dry needling techniquesm Young, (2022) show similar effectiveness in supporting joint function.

This research makes a new contribution by integrating manual therapy (effleurage), active exercise and a layered evaluation process from pre- to post-intervention. This approach is more comprehensive than previous studies, which have tended to focus on a single indicator such as strength (Busch, 2021), flexibility (Fonta, 2021) or physical performance (Frank &(Frank, 2025). The implications for the field are that more efficient sports rehabilitation services will be developed, in which patients will not only receive passive therapy, but will also be actively involved through self-education and exercise programmes. This can increase patient independence while reducing the risk of re-injury. However, this study has some limitations that need to be considered. Firstly, the sample size was relatively small at 30 participants, so generalising the results to a wider population should be approached with caution. Secondly, the intervention lasted only three weeks, so it was not possible to assess the long-term effectiveness of therapy. Thirdly, the evaluation instruments used focus more on clinical measurements than psychological aspects such as motivation and athlete confidence, even though these can affect the recovery process.

The implications of this study can be divided into three categories. In practical terms, the study provides a comprehensive and straightforward model for post-ACL knee rehabilitation in sports healthcare services. Theoretically, the study reinforces the idea that manual therapy interventions, especially effleurage massage, are more effective when combined with thorough patient evaluation and education. Subsequent studies are recommended to expand the sample size, extend the monitoring period and include psychological and social dimensions in the evaluation, to obtain a more comprehensive picture of recovery.

Self-directed exercises can enhance balance in patients who have undergone ACL surgery by providing more frequent and individualized practice than patients who only receive clinic-based therapy. Regular independent practice reinforces neuromuscular control, improves proprioception, and promotes postural stability—all of which are essential for dynamic balance. Patients limited to supervised therapy in the clinic, on the other hand, may have fewer repetitions and less opportunity to integrate balance skills into daily activities. Therefore, incorporating structured, self-directed exercises alongside clinical therapy can accelerate functional recovery and reduce the risk of re-injury.

This study confirms that integrating massage effleurage, patellar mobilisation and active exercises such as short-arc quadriceps contractions increases range of motion (ROM), reduces pain and improves knee function. These results align with a range-of-motion, exercise-based rehabilitation approach that has been shown to restore joint function in post-breast cancer patients through mirror therapy (Yuan, 2021). Furthermore, this study's relevance is strengthened when linked to biomechanical studies highlighting the mechanisms of knee injuries in table tennis athletes due to landing patterns and fatigue, demonstrating the importance of through appropriate recovery strategies (Zhang, 2024). Thus, this study enriches the literature on knee rehabilitation with a holistic evaluation model that is applicable to the principles of improving performance and quality of life in various patient populations, as well as in athletes (Silbergleit, 2020; Sjattar, 2022; Thomas, 2020; Vicente-Mampel, 2024).

Conclusions

Combining effraction massage with a comprehensive evaluation and self-training programme can reduce pain, increase muscle strength, improve joint range of motion, reduce oedema and improve functional activity and balance. This provides a foundation for using this method as an effective, non-invasive therapy option for patients undergoing post-ACL surgery. Further research could involve expanding the number of participants to increase the validity of the findings, conducting long-term evaluations to assess the sustainability of the therapeutic effects and combining effriction massage with other rehabilitation modalities, such as hydrotherapy or neuromuscular training, to achieve the best possible results. Additionally, integrating technologies such as motion analysis and wearable sensors could provide more detailed, objective data on patient development.

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References

Abd, H. J. (2023). Effect of physical exercise using α-lipoic acid (ALA) and eicosapentaenoic acid (EPA) on physical fitness, recovery, and performance in young weightlifters. *Sport Tk*, *12*(2). https://doi.org/10.6018/sportk.557061

Busch, A. M. (2021). Comparison of the effects of static-stretching and tubing exercises on acute shoulder range of motion in collegiate baseball players. *International Journal of Sports Physical Therapy*, *16*(1), 207–215. https://doi.org/10.26603/001c.18862

Chen, N. (2024). Impact Of Multiple Skin Expansion On Functional Recovery And Patient Satisfaction In Scar Reconstruction Surgery Following Neck Burn: Implications For Physical Rehabilitation And Sports Performance. *Revista Internacional De Medicina Y Ciencias De La Actividad Fisica Y Del Deporte*, *24*(1), 96–115. https://doi.org/10.15366/rimcafd2024.98.1.007

de Almeida Rizzi, S. K. L. (2020). Early Free Range-of-Motion Upper Limb Exercises After Mastectomy and Immediate Implant-Based Reconstruction Are Safe and Beneficial: A Randomized Trial. *Annals of Surgical Oncology*, *27*(12), 4750–4759. https://doi.org/10.1245/s10434-020-08882-z

Dewangga, M. W. (2025). Cold Water Immersion's Role in Enhancing Recovery Speed in Female Soccer Players After Matches: A Study of Physical Performance and Molecular Responses. *Balneo and Prm Research Journal*, *16*(2). https://doi.org/10.12680/balneo.2025.821

El-Farrash, R. A. (2020). Passive Range-of-Motion Exercise and Bone Mineralization in Preterm Infants: A Randomized Controlled Trial. *American Journal of Perinatology*, *37*(3), 313–321. https://doi.org/10.1055/s-0039-1678559

Fonta, M. (2021). Acute effects of static self-stretching exercises and foam roller self-massaging on the trunk range of motions and strength of the trunk extensors. *Sports*, *9*(12). https://doi.org/10.3390/sports9120159

Frank, E. (2025). The Effect of an American Football Practice on Physical and Cognitive Performance and Recovery. *Journal of Strength and Conditioning Research*. https://doi.org/10.1519/JSC.0000000000005214

Freiberger, C. (2024). Hip Range of Motion During Passive and 1-Leg Exercises Is Greater in Women: A Meta-analysis and Systematic Review. *Arthroscopy Journal of Arthroscopic and Related Surgery*, *40*(2), 495–512. https://doi.org/10.1016/j.arthro.2023.04.006

Golonka, W. (2021). Isolated lumbar extension resistance exercise in limited range of motion for patients with lumbar radiculopathy and disk herniation—clinical outcome and influencing factors. *Journal of Clinical Medicine*, *10*(11). https://doi.org/10.3390/jcm10112430

Hasan, B. B. (2024). The Effect of Rehabilitative Exercises in Improving (the range of motion, muscle strength, and the degree of pain) for Football Players After ACL Surgery. *International Journal of Disabilities Sports and Health Sciences*, *7*(2), 381–388. https://doi.org/10.33438/ijdshs.1399146

Irsyad, N. Y., Nasrulloh, A., Sulistyono, Kurniawan, A. T., & Munir, A. (2024). Development of media-based training program android application: physical condition of leg muscle strength in futsal sports in the general period. *Fizjoterapia Polska*, *24*(5), 436–444. https://doi.org/10.56984/8zg020cs0gf

Jung, J., & Lee, K. (2024). Comparative Analysis of Research and Development Productivity among European Countries. *Institute for Future Growth*, *10*(2), 129–157. https://doi.org/10.29143/kuifg.2024.10.2.129

Kara, I. (2025). Cyber-physical systems: Strategies for enhancing availability, recovery, and auditing for optimal performance. *Security and Privacy of Cyber Physical Systems Emerging Trends Technologies and Applications*, 481–491. https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=105014301919&origin=inward

Kawama, R. (2022). Acute changes in passive stiffness of the individual hamstring muscles induced by resistance exercise: effects of contraction mode and range of motion. *European Journal of Applied Physiology*, *122*(9), 2071–2083. https://doi.org/10.1007/s00421-022-04976-6

Kim, M. (2022). Effectiveness of elongation band exercise on the upper limb strength and range of motion among older adults. *Journal of Exercise Rehabilitation*, *18*(2), 110–116. https://doi.org/10.12965/jer.2244080.040

Lee, B. (2024). Effects of an Early Exercise Program with Cryotherapy on Range of Motion, Pain, Swelling, and Gait in Patients with Total Knee Arthroplasty: A Randomized Controlled Trial. *Journal of Clinical Medicine*, *13*(5). https://doi.org/10.3390/jcm13051420

Lee, J. G. (2022). Effects of Resistance Exercise Program on Pain, Stress, Range of Motion, and Body Composition of Older Adults: A Randomized Controlled Trial. *Alternative Therapies in Health and Medicine*, *28*(7), 95–103. https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=85139804278&origin=inward

Maestroni, L. (2025). Optimizing Physical Recovery in Male Field Sport Athletes Following Anterior Cruciate Ligament Reconstruction: Residual Deficits, Performance Targets, and Training Strategies. *Strength and Conditioning Journal*. https://doi.org/10.1519/SSC.0000000000000911

Majed, M. (2022). The Impact of Therapeutic Exercises on the Quality of Life and Shoulder Range of Motion in Women After a Mastectomy, an RCT. *Journal of Cancer Education*, *37*(3), 843–851. https://doi.org/10.1007/s13187-020-01894-z

Malini, H. (2022). The Effect of Intradialytic Range of Motion Exercise on Dialysis Adequacy and Fatigue in Hemodialysis Patients. *Journal of Nursing Research*, *30*(4). https://doi.org/10.1097/jnr.0000000000000506

Matamala-Gomez, M. (2022). Impact of virtual embodiment and exercises on functional ability and range of motion in orthopedic rehabilitation. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-08917-3

Matykiewicz, P. (2021). The bench press exercise performed with increased range of motion allows for greater bar velocities. *Journal of Physical Education and Sport*, *21*(4), 1737–1743. https://doi.org/10.7752/jpes.2021.04220

Money, A. J., Pullen, W. M., Safran, M. R., Abrams, G. D., & Sherman, S. L. (2024). Surgical Excision of a Cyclops Lesion After ACL Reconstruction in an Elite College Athlete. *Video Journal of Sports Medicine*, *4*(6). https://doi.org/10.1177/26350254241293462

Moreno, E. N. (2024). Does Performing Resistance Exercise with a Partial Range of Motion at Long Muscle Lengths Maximize Muscle Hypertrophic Adaptations to Training? *Journal of Science in Sport and Exercise*. https://doi.org/10.1007/s42978-024-00301-z

Naderifar, H. (2022). Effect of Selected Corrective Exercises on Glenohumeral Rotation range of Motion in Overhead Athletes with Scapular Dyskinesis. *Studia Sportiva*, *16*(1), 54–62. https://doi.org/10.5817/StS2022-1-6

Nursalam, N. (2020). The effect of range of motion exercise on blood pressure, pulse and sleep quality among hypertensive patients. *International Journal of Innovation Creativity and Change*, *13*(6), 220–234. https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=85087361125&origin=inward

Okamoto, H. (2022). Development of Pneumatic Exercise Device for the Range of Motion in the Ankle Joint. *2022 IEEE SICE International Symposium on System Integration Sii 2022*, 585–589. https://doi.org/10.1109/SII52469.2022.9708828

Park, J. H. (2020). Physical performance and inflammation responses during and after the jiu-jitsu stimulated match according to recovery treatment methods. *Exercise Science*, *29*(3), 214–224. https://doi.org/10.15857/ksep.2020.29.3.214

Rad, Y. M. (2022). Is the novel suspension exercises superior to core stability exercises on some EMG coordinates, pain and range of motion of patients with disk herniation? *Sport Sciences for Health*, *18*(2), 567–577. https://doi.org/10.1007/s11332-021-00848-2

Rahiminezhad, E. (2022). A randomized controlled clinical trial of the effects of range of motion exercises and massage on muscle strength in critically ill patients. *BMC Sports Science Medicine and Rehabilitation*, *14*(1). https://doi.org/10.1186/s13102-022-00489-z

Riffitts, M. (2022). Evaluation of a Smart Knee Brace for Range of Motion and Velocity Monitoring during Rehabilitation Exercises and an Exergame. *Sensors*, *22*(24). https://doi.org/10.3390/s22249965

Sadacharan, C. M. (2021). Effect of large versus small range of motion in the various intensities of eccentric exercise-induced muscle pain and strength. *International Journal of Exercise Science*, *14*(7), 1–18. https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=85102566843&origin=inward

Sahin, E. I. (2023). Investigation of the effects of upper extremity home exercises on grip strength, range of motion, activity performance, and functionality in individuals with systemic sclerosis: a randomized controlled trial. *Revista Da Associacao Medica Brasileira*, *69*(9). https://doi.org/10.1590/1806-9282.20230252

Šarabon, N. (2020). Acute effects of aerobic activity, static stretching, and explosive exercises on muscular performance and range of motion of young soccer players. *International Journal of Sports Science and Coaching*, *15*(5), 706–716. https://doi.org/10.1177/1747954120942895

Silbergleit, A. K. (2020). Association of Neck Range of Motion and Skin Caliper Measures on Dysphagia Outcomes in Head and Neck Cancer and Effects of Neck Stretches and Swallowing Exercises. *Dysphagia*, *35*(2), 360–368. https://doi.org/10.1007/s00455-019-10037-6

Silva, K. L. S. (2021). The impact of exercise training on calf pump function, muscle strength, ankle range of motion, and health-related quality of life in patients with chronic venous insufficiency at different stages of severity: A systematic review. *Jornal Vascular Brasileiro*, *20*. https://doi.org/10.1590/1677-5449.200125

Sjattar, E. L. (2022). Development of Supportive-Educative Range of Motion Exercise for Post-stroke Patients: A Pilot Study. *Home Health Care Management and Practice*, *34*(2), 92–100. https://doi.org/10.1177/10848223211035713

Thomas, A. (2020). Effect of muscle energy techniques V/S active range of motion exercises on shoulder function post modified radical neck dissection in patients with head and neck cancer-A randomized clinical trial. *Asian Pacific Journal of Cancer Prevention*, *21*(8), 2389–2393. https://doi.org/10.31557/APJCP.2020.21.8.2389

Trecroci, A. (2020). Effects of different training interventions on the recovery of physical and neuromuscular performance after a soccer match. *Journal of Strength and Conditioning Research*, *34*(8), 2189–2192. https://doi.org/10.1519/jsc.0000000000003269

Tsoukos, A. (2024). Fatigue and Metabolic Responses during Repeated Sets of Bench Press Exercise to Exhaustion at Different Ranges of Motion. *Journal of Human Kinetics*, *91*, 61–76. https://doi.org/10.5114/jhk/185524

Vicente-Mampel, J. (2024). Effects of ankle position during the Nordic Hamstring exercise on range of motion, heel contact force and hamstring muscle activation. *Sports Biomechanics*, *23*(11), 2359–2371. https://doi.org/10.1080/14763141.2021.2025416

Yang, S. S. (2021). Effect of aqua walking exercise on knee joint angles, muscular strength, and visual analogue scale for patients with limited range of motion of the knee. *Journal of Exercise Rehabilitation*, *17*(4), 265–269. https://doi.org/10.12965/jer.2142432.216

Young, B. A. (2022). Immediate Effects of Adding Dry Needling to Thoracic Manipulation and Exercise in Cervical Range of Motion for Adults With Neck Pain: A Randomized Clinical Trial. *Journal of Manipulative and Physiological Therapeutics*, *45*(7), 531–542. https://doi.org/10.1016/j.jmpt.2022.10.002

Yuan, R. Z. (2021). Effects of free range-of-motion upper limb exercise based on mirror therapy on shoulder function in patients after breast cancer surgery: study protocol for a randomized controlled trial. *Trials*, *22*(1). https://doi.org/10.1186/s13063-021-05789-2

Zhang, P. (2024). Investigation research on the mechanism of knee joint injury in table tennis players landing before and after fatigue during stroke play. *Mcb Molecular and Cellular Biomechanics*, *21*(3). https://doi.org/10.62617/mcb252

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